Winnebago River Watershed

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Winnebago River Watershed Restoration and Protection Strategy Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key terms and abbreviations

Assessment Unit Identifier (AUID): The unique water body identifier for each river reach comprised of the U.S. Geological Survey (USGS) eight-digit **Hydrologic Unit Code** plus a three-character code unique within each HUC.

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

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

Civic Engagement: The process of collecting public and stakeholder input for the development of restoration and protection strategies.

Hydrologic Unit Code (HUC): A HUC is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Minnesota River Basin is assigned a HUC-4 of 0702 and the Winnebago River Watershed is assigned a HUC-8 of 07080203.

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

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

Intensive Watershed Monitoring (IWM): the collection of surface water quality data across a watershed for the purpose of assessing the quality of its natural resources.

Limited Resource Value (LRV) Waters: Waters that have previously demonstrated that the existing and potential aquatic community is severely limited and cannot achieve aquatic life standards. While not being protective of aquatic life, LRV waters are still protected for industrial, agricultural, navigation and other uses. Class 7 waters are also protected for aesthetic qualities (e.g., odor), secondary body contact, and groundwater for use as a potable water supply. To protect these uses, Class 7 waters have standards for bacteria, pH, dissolved oxygen and toxic pollutants.

Monitoring: The collection of water quality data in lakes and streams to assess their condition.

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

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

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

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

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

Water Quality: The chemical and biological condition of lakes and streams that affects our ability to recreate and the ability of lakes and streams to support aquatic life, such as fish and macroinvertebrates.

Executive summary

This Watershed Restoration and Protection Strategy (WRAPS) for the Winnebago River Watershed (07080203) is, at its core, a strategic document that outlines the critical areas and fundamental best strategies required to restore the health of the watershed's shallow lakes and streams.

The goal of this document is to accurately describe the existing characteristics, condition, and water quality trends of important water resources in the watershed, and to lay out strategies for a restoration based approach that will enhance the existing condition of these resources. This document also targets critical areas in the watershed in an attempt to guide the allocation of funds and efforts of future conservation practices to the places on the ground where they are most needed and will do the most good.

Located along the Iowa/Minnesota Border, the Minnesota portion of the Winnebago River Watershed drains almost 25,000 acres of land that is comprised predominately of row crops. The Minnesota portion of the watershed represents less than 10% of the total 440,444 acre Winnebago River Watershed. After crossing the Minnesota/Iowa border, the Winnebago River flows southward through Forest City and Mason City, before joining the Shell Rock River at Rockford, Iowa upstream of the Cedar River. The recommendations and guidance put forth within this document accounted for the potential impact to downstream water resources including the Shell Rock River and the Cedar River.

The watershed is home to the communities of Emmons (population 366), and Conger (population 135) (Minnesota State Demographic Center Department of Administration 2017). The watershed contains two shallow lakes (Bear Lake and State Line Lake). Both lakes are managed by the DNR Shallow Lakes Program Wildlife Management Section to improve water quality and habitat conditions, with a primary focus on providing waterfowl habitat and a northern pike/yellow perch fishery.

From 2015 to 2016, intensive watershed monitoring (IWM) was conducted by the Minnesota Pollution Control Agency (MPCA) to collect data across this watershed for the purpose of assessing the quality of its natural resources. Streams in the watershed were characterized by high phosphorus (P) concentrations, subsequently high concentrations of chlorophyll-a (Chl-*a)* and biochemical oxygen demand (BOD), and high Escherichia Coli (*E. coli)* concentrations downstream of the two lakes. Fish and/or macroinvertebrate bio assessments on streams in the Winnebago River Watershed were characterized by low Index of Biological Integrity (IBI) scores for fish and/or macroinvertebrates (FIBI and MIBI). Assessment of data from IWM resulted in two lakes being listed as impaired for not meeting aquatic recreation uses, and four streams listed as impaired for not meeting aquatic life and/or aquatic recreation uses.

The conclusions from the Winnebago River Stressor Identification (SID) Study were that the primary stressors causing fish and macroinvertebrate community impairments within the watershed include excess nitrates, eutrophication (P), low dissolved oxygen (DO), habitat loss, excess total suspended solids (TSS), and flow alteration. These stressors provide a backdrop for the targeting of restoration strategies in the watershed.

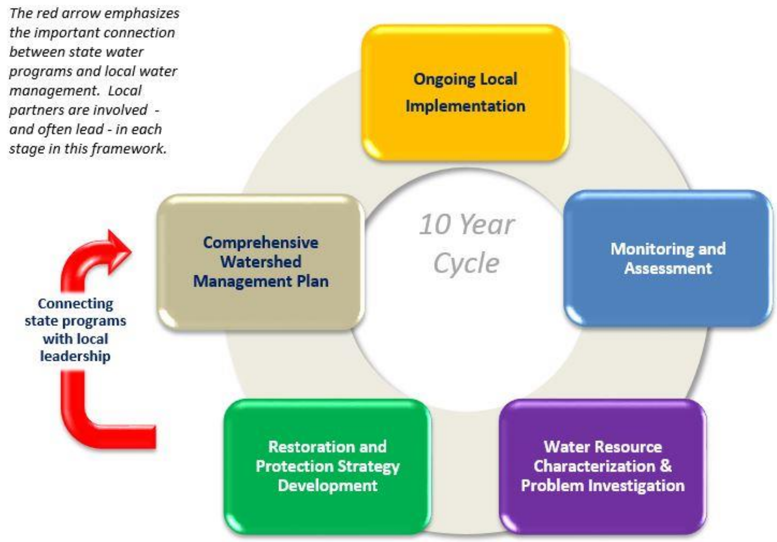
The overall water quality goal for the Winnebago River Watershed is to restore waters to meet or positively exceed water quality standards. Priority areas for this watershed were determined based on input from local partners, output from Hydrological Simulation Program - Fortran (HSPF) – a water quality model, and input from the Freeborn Soil and Water Conservation District (SWCD) and Freeborn County on the locations of all existing and proposed best management practices (BMPs) in the watershed. Strategies for determining areas of the watershed to focus on were determined based upon results from a targeting exercise for surface water quality improvement. This exercise compared the estimated load reduction from all existing and proposed BMPs in relation to required total maximum daily load (TMDL) nutrient reductions and Minnesota Nutrient Reduction Strategy (NRS) P and nitrogen (N) load reduction goals.

Strategies for addressing the identified issues in the Winnebago River Watershed are focused on agricultural fields, public and private ditches, residential septic systems, and animal feedlots. Examples of practices include managing nutrient and manure applications on agricultural fields, expanding the implementation of soil health practices, increasing watershed water storage through wetland restorations, retrofitting sections of existing ditches to two-stage ditches, and ensuring compliance of septic systems and animal feedlots. Additional practices and strategies are outlined in Section 3.

As an accompaniment to the implementation of these strategies, it is recommended that a coordinated monitoring program be developed by local and state organizations in this watershed to better understand the impairments in the watershed, and to be able to determine over time if actions being taken are improving them.

What is the WRAPS Report?

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



As part of the watershed approach, the MPCA developed a process to identify and address threats to water quality in each of these major watersheds. This process is called Watershed Restoration and Protection Strategy (WRAPS) development. WRAPS reports have two parts: impaired waters have strategies for restoration, and waters that are not impaired have strategies for protection.

Waters not meeting state standards are listed as impaired and TMDL studies are developed for them. TMDLs are incorporated into WRAPS. In addition, the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health, including both protection and restoration efforts. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to identify strategies for addressing point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution, this report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans. This report also serves as the basis for addressing the U.S. Environmental Protection Agency's (EPA) Nine Minimum Elements of watershed plans, to help qualify applicants for eligibility for Clean Water Act Section 319 implementation funds.

Purpose	•Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning •Summarize watershed approach work done to date including the following reports: • *Winnebago River and Upper Wapsipinicon River Watershed Monitoring and Assessment Report* • *Winnebago River Watershed Biotic Stressor Identification* • *Winnebago River Watershed Total Maximum Daily Load*
Scope	•Impacts to aquatic recreation and impacts to aquatic life in streams •Impacts to aquatic recreation in lakes
Audience	•Local working groups (local governments, SWCDs, watershed management groups, etc.) •State agencies (MPCA, DNR, BWSR, etc.)

Users' Guide

This WRAPS report summarizes past monitoring, water quality assessments, and other water quality studies that have been conducted in the Winnebago River Watershed. In addition, it outlines ways for local groups to prioritize projects that can be implemented in the watershed to improve water quality. The WRAPS report contains a large amount of information. The purpose of the following table is to provide a Quick Reference guide for users to quickly identify what information can be found in each section of the report.

Table 1. WRAPS Report Quick Reference Guide

Section		Description	Pages
Summaries of Past Monitoring and Water Quality Studies			
1	Watershed Background	A brief description of the Winnebago River Watershed.	1
2.1	Watershed Condition Status	A summary of how fishable, swimmable and usable the lakes and streams are in the watershed.	8
2.2	Water Quality Trends	A summary of lakes and streams with improving or declining water quality based on at least 10 years of monitoring data.	19
2.3	Stressors and sources	A summary of stressors (something that adversely impacts or causes fish and/or macroinvertebrate communities in streams to become unhealthy) and sources of pollutants (such as phosphorus, bacteria or sediment) to lakes and streams, including point sources (such as sewage treatment plants) or non-point sources (such as runoff from the land).	19
2.4	TMDL Summary	A summary of Total Maximum Daily Load (TMDL) studies in the watershed. A TMDL is a calculation of how much pollutant a lake or stream can receive before it becomes unfishable, unswimmable, or unusable.	45
2.5	Protection Considerations	A summary of lakes and streams in the watershed that are not impaired but are either close to becoming impaired or of exceptionally high quality and need to be protected.	48
Prioritizing and implementing restoration and protection			
3.1	Targeting of Geographic Areas	A summary of the results from different tools that were used to identify, locate and prioritize restoration and protection projects in the watershed.	49
3.2	Public Participation	A summary of input meetings with local partners in the watershed on the development of the WRAPS report.	54
3.3	Restoration & Protection Strategies	Tables identifying projects in the watershed that restore or protect water quality.	56
4	Monitoring Plan	A plan for ongoing water quality monitoring to fill data gaps, determine changing conditions, and gauge implementation effectiveness.	80

1. Watershed background and description

The Winnebago River Watershed contains two Hydrologic Unit Code (HUC)-10 subwatersheds that collectively drain 71 square miles of southwestern Freeborn County, and a very small (less than one square mile) portion of southeastern Faribault County. Bear Lake, located four miles south of Conger, is the beginning of the Winnebago River, also called Lime Creek. North of the lake, Steward Creek is the largest headwater tributary to the lake. Tributaries in this watershed generally consist of small, ditched subwatersheds.

The Winnebago River Watershed is entirely within the Western Corn Belt Plains (WCBP) Ecoregion. The WCBP is one of the most productive areas in the world for corn and soybeans due to a combination of nearly level to gently rolling topography, ample rainfall during the growing season, and fertile soils (Figure 1). Historically the Winnebago watershed was covered with tall-grass prairies, scattered oak-savannahs, and prairie-pothole wetlands.

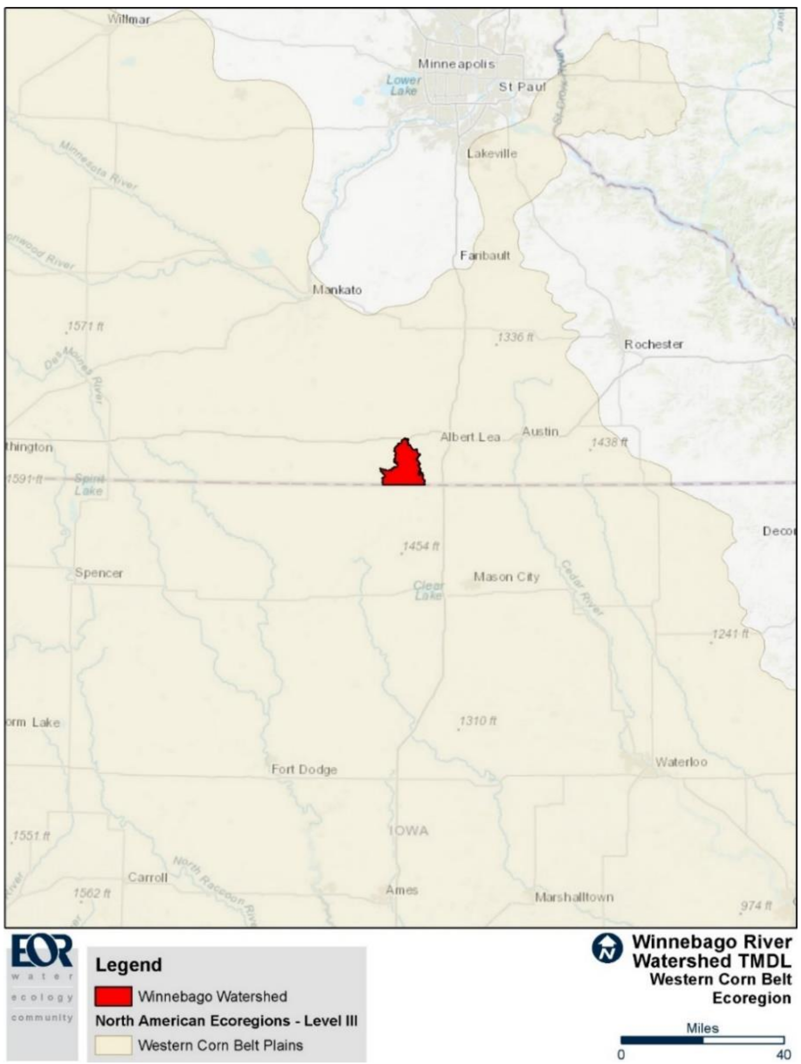


Figure 1. The Western Corn Belt Plains is primarily (>75%) used for cropland agriculture, and much of the remainder is in forage for livestock.

Analysis of Soil Survey Geographic Database (SSURGO) soil map units with drainage classes of either "poorly drained" or "very poorly drained" suggest approximately 28,700 acres of wetland, 54.9% of the Winnebago Watershed, were present prior to European settlement. Currently, less than 4% of the watershed is comprised of wetlands. Remaining wetlands have largely been degraded by excessive nutrient inputs and arrival of invasive aquatic plants. Restoring wetlands in the watershed would increase water storage on the land and contribute to better water quality throughout the watershed.

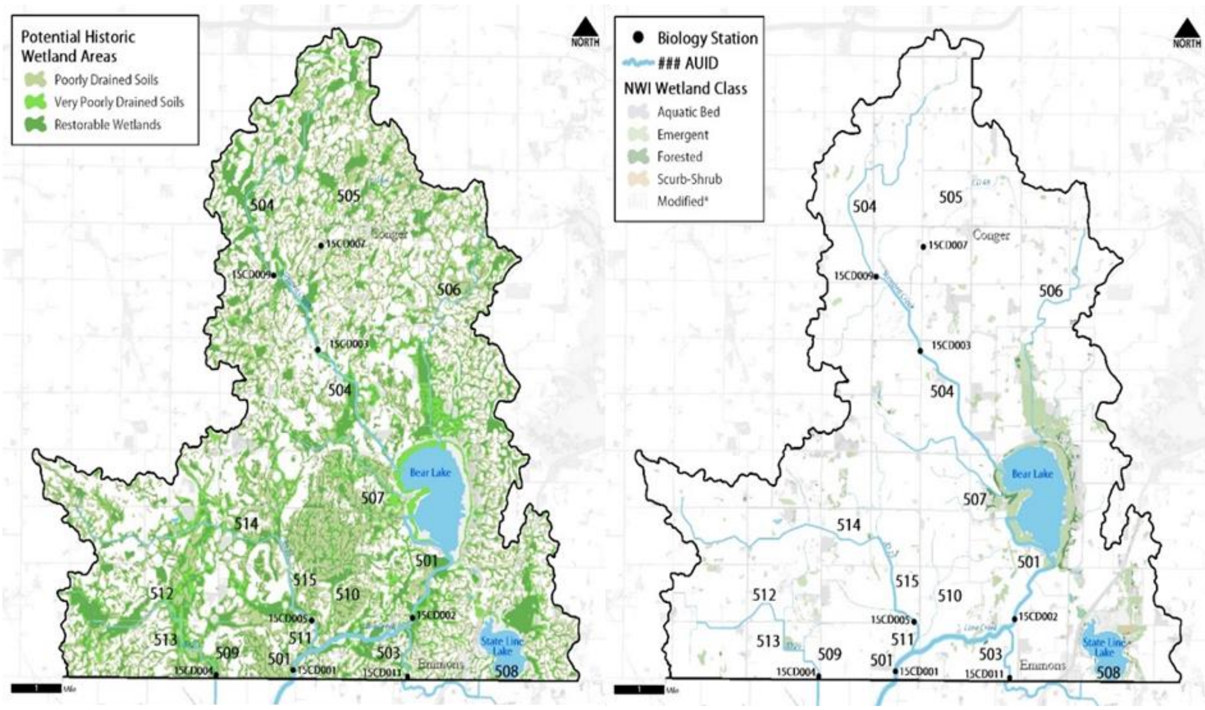


Figure 2. Current wetlands (right) and potential wetland areas (left) in the Winnebago River Watershed (MPCA 2017).

Agriculture makes up 86% of the land use in the Winnebago River Watershed, with about 82% being cultivated crops (Figure 3). According to Minnesota Department of Agriculture (MDA), Freeborn County (where the Winnebago River Watershed is primarily located) is ranked eighth in the state for crop production and number 10 in the state for hog production. The greater watershed (including the Iowa portion) has 1,022 farms and 96% of the land is privately owned (NRCS 2007b). The population of the Minnesota portion of the watershed is 1,143 (DNR 2015b).

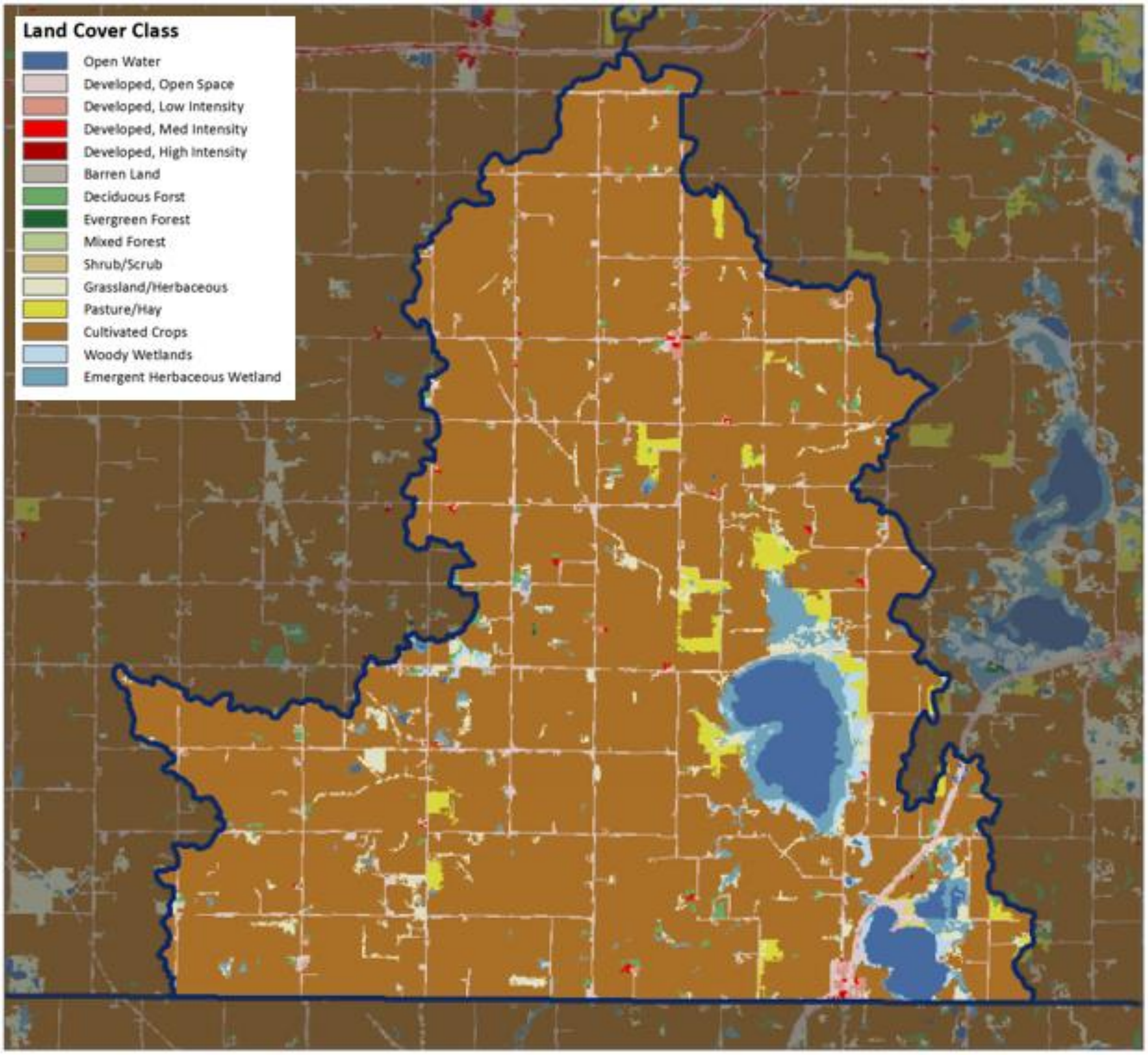


Figure 3. Land cover in the Winnebago Watershed (DNR 2017a).

Two lakes, Bear Lake and State Line Lake, are located in the watershed. Bear Lake is a large and shallow lake, encompassing 1,560 acres and a maximum depth of 6 feet. In 1972, the Minnesota Department of Natural Resources (DNR) designated Bear Lake as a Wildlife Management Lake. State Line Lake, located in the town of Emmons on the Iowa border, is a 445-acre lake with a maximum depth of 5.5 feet. Both of these lakes are primarily managed for waterfowl and wildlife, secondarily as sport fisheries for northern pike and yellow perch. Both lakes suffer from large populations of invasive rough fish, low DO and accompanying winterkill events, and high levels of suspended sediments, algae, and total phosphorus (TP). The DNR has been actively restoring and managing both lakes in an attempt to maintain the ecologically preferred, clear-water, aquatic plant dominated state (Figure 4). The ultimate goal for both lakes is to create healthy wildlife lakes. More information on the existing condition and management of these shallow lakes is provided in Section 2.1.

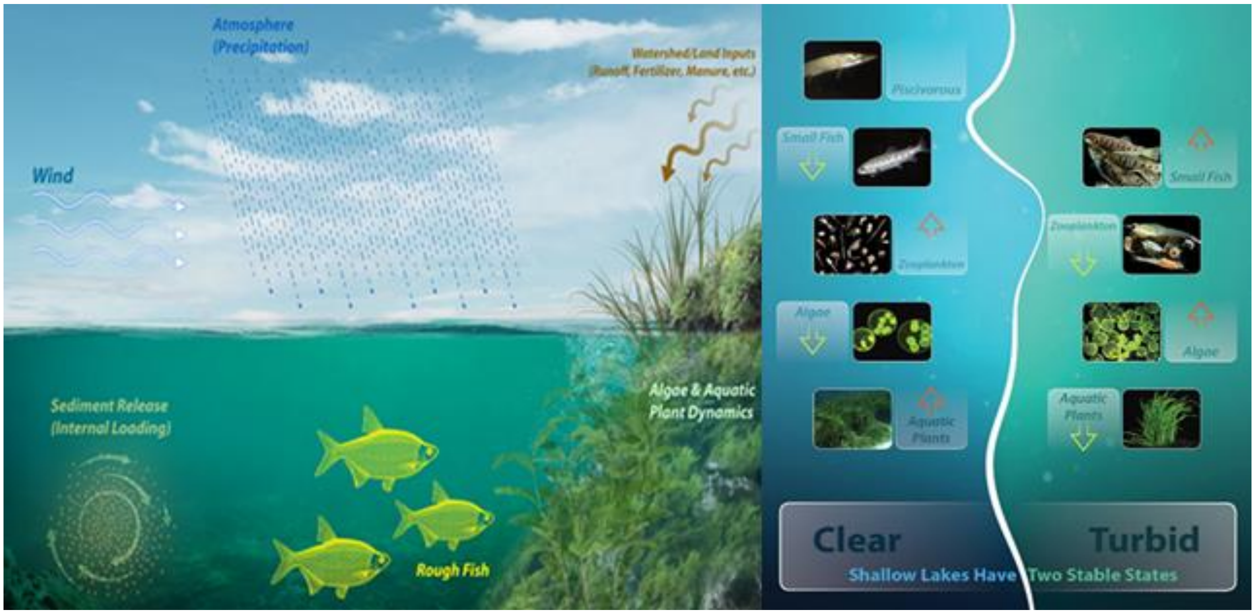


Figure 4. Shallow Lake Factors affecting the status (clear water vs. turbid) of shallow lakes.

Additional Winnebago Watershed Resources

Faribault County Local Water Management Plan: http://www.co.faribault.mn.us/swcd/programs/pages/local-water-management-plan

Freeborn County Comprehensive Water Plan 2016-2021: https://www.co.freeborn.mn.us/DocumentCenter/View/2177/Freeborn-County-Comprehensive-Water-Plan-2016-2021-PDF

Minnesota Department of Natural Resources (DNR) Watershed Context Report: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/context_report_major_50.pdf

Minnesota Department of Natural Resources (DNR) Watershed Health Report Card: : : : : : http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_50.pdf

Minnesota Nutrient Planning Portal: https://mrbdc.mnsu.edu/mnnutrients/watersheds/winnebago-river-watershed

Minnesota Nutrient Reduction Strategy: https://www.pca.state.mn.us/water/nutrient-reduction-strategy

Winnebago River Watershed Stressor Identification Report: https://www.pca.state.mn.us/sites/default/files/wq-ws5-07080203a.pdf

Winnebago River Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-07080203b.pdf

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Winnebago River Watershed: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022944.pdf

2. Watershed conditions

The Winnebago River Watershed contains two shallow lakes that provide critical wildlife habitat. There are no sections of natural stream left in the watershed.

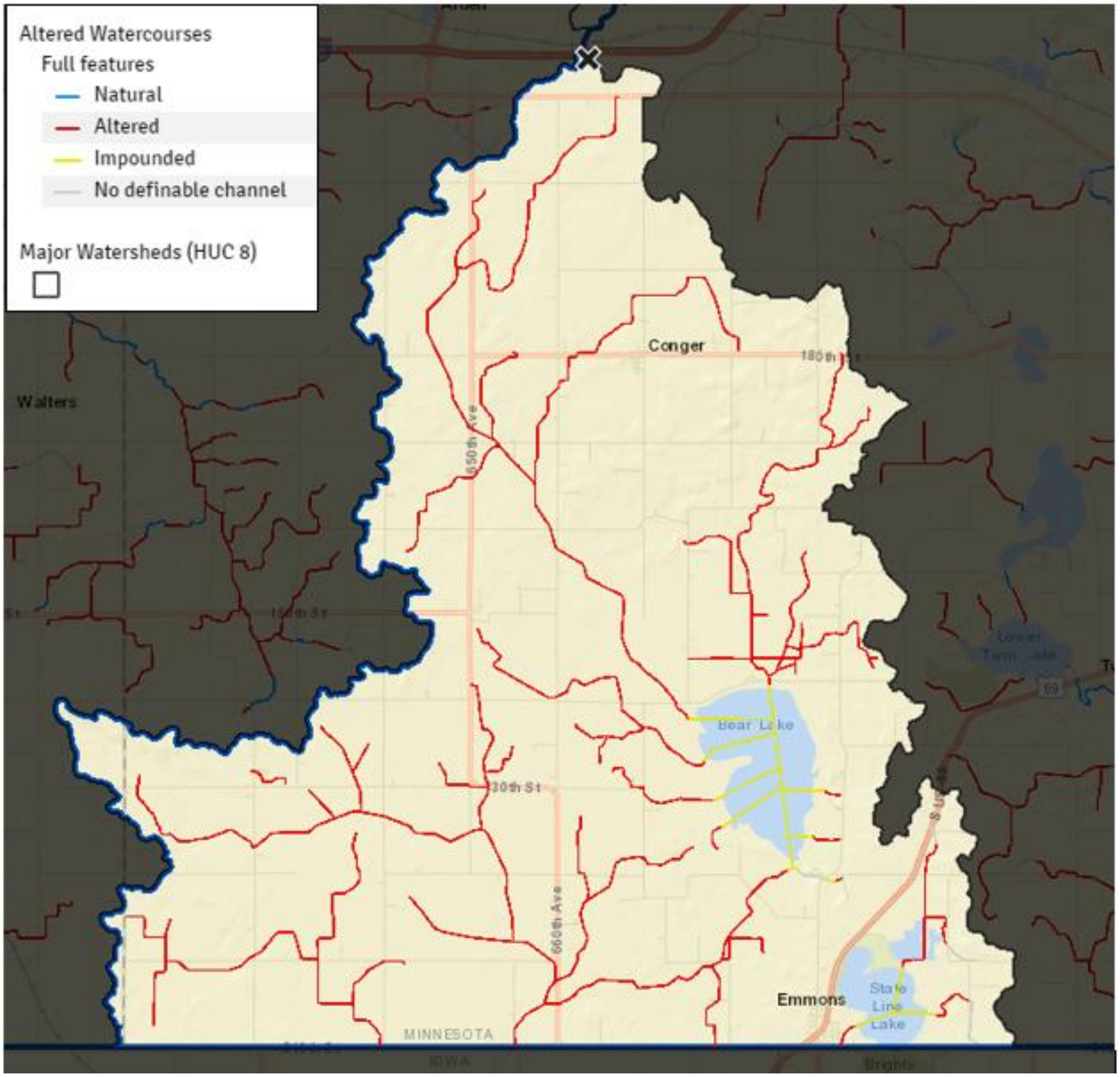


Figure 5. Altered watercourses in the Winnebago River Watershed (left) and estimated tile drainage estimates in the watershed (right).

Water quality in the Winnebago River Watershed is significantly impacted by flow alteration caused by tile drainage, stream channelization (drainage ditches), wetland drainage, and land use changes. Additional discussion on flow alteration is located in Section 2.3.1. Excess nutrients throughout the watershed are contributing to eutrophic conditions in the lakes and stream reaches. The lakes in turn drive eutrophication, poor DO, and high TSS concentrations downstream in Lime Creek. Many of these water quality concerns continue downstream in Iowa.

Data collected as part of the IWM approach suggests degraded water quality conditions exist throughout the watershed (Figure 6). The two lakes, Bear Lake and State Line Lake, in this study were found to be impaired; they are not meeting standards set for aquatic recreation. There was not an IBI process for this lake class to complete an assessment for aquatic life (FIBI) on the lake basins. FIBIs are not conducted on lakes prone to winterkill, such as shallow lakes like Bear and State Line, because environmental conditions dictate species composition and abundance more than in-lake habitat (DNR 2020). A 2009 fish survey conducted by DNR, found that Bear Lake is dominated by tolerant fish species: common carp, black bullhead, fathead minnow and green sunfish. Fish survey data for State Line Lake, conducted in 2017, indicate that the lake is dominated by black bullhead and common carp. Streams in the watershed were characterized by high P concentrations, high *E. coli* concentrations, with high concentrations of Chl-*a* and BOD downstream of the two lakes. Fish and/or macroinvertebrate bio assessments on streams in the Winnebago River Watershed were characterized by low IBI scores for fish and/or macroinvertebrates.

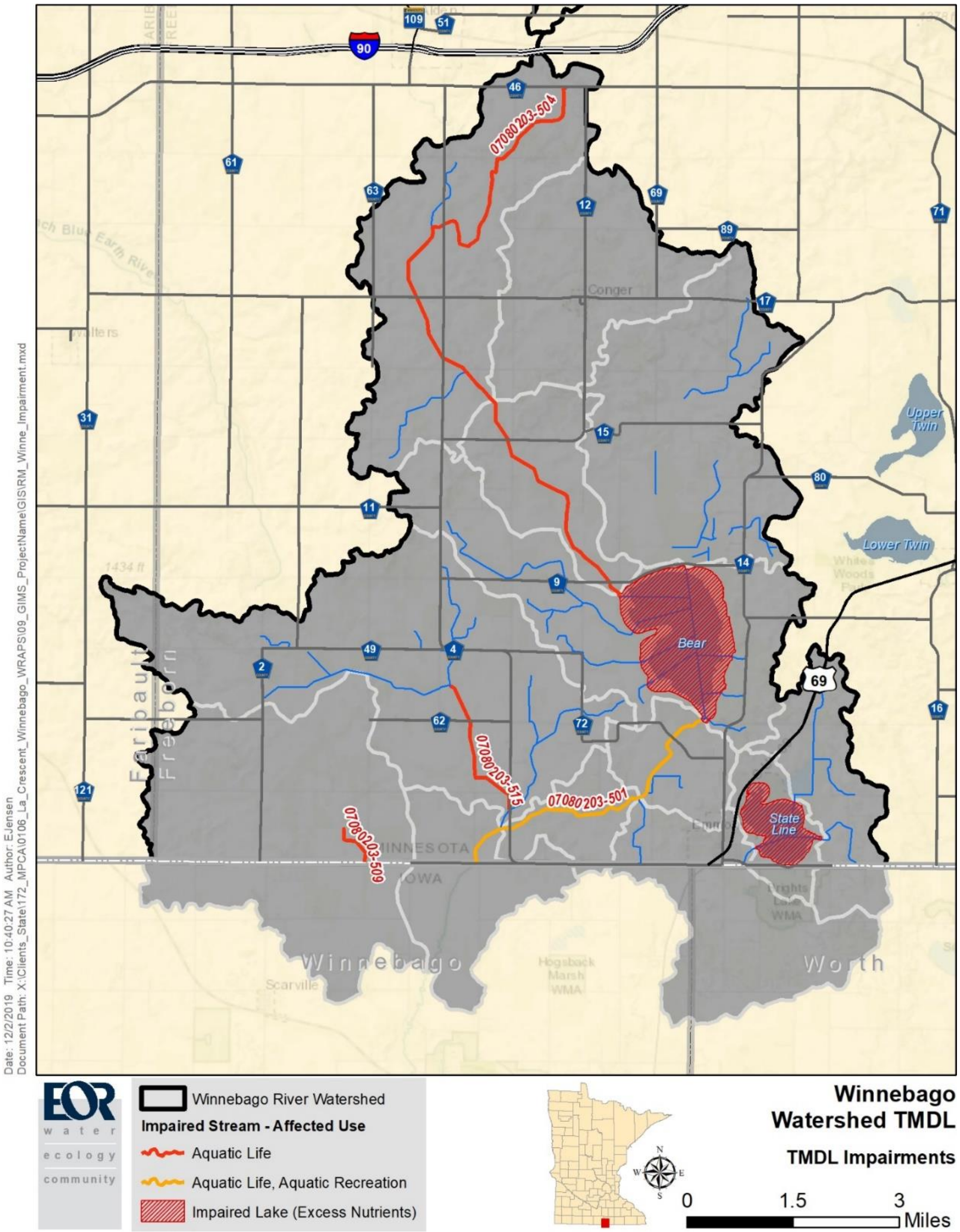


Figure 6. Winnebago River Watershed Impairments.

An examination of remaining wetlands in this ecoregion has found that the majority of remaining wetlands are in either fair (40%) or poor (42%) condition (MPCA 2015). The remaining wetlands are strongly associated with the river and stream drainage network, are partially ditched/drained, and consequently have shorter retention times during high and moderate flow periods.

2.1 Condition status

Beginning in 2015, the MPCA initiated IWM efforts on streams, lakes, and wetlands within the Winnebago River Watershed. This effort included data collection on twelve stream reaches within the watershed (Figure 7), data collection on Bear and State Line Lake, and a hydrogeomorphic (HGM) classification of the watershed's wetlands. See Appendix A for the stream water quality assessment results. Please refer to the Winnebago River and Upper Wapsipinicon River Watersheds Monitoring and Assessment Report (MPCA 2018) for full monitoring and assessment details. The MPCA has also developed the Winnebago Watershed SID Report, this study outlines primary stressors to watershed resources.

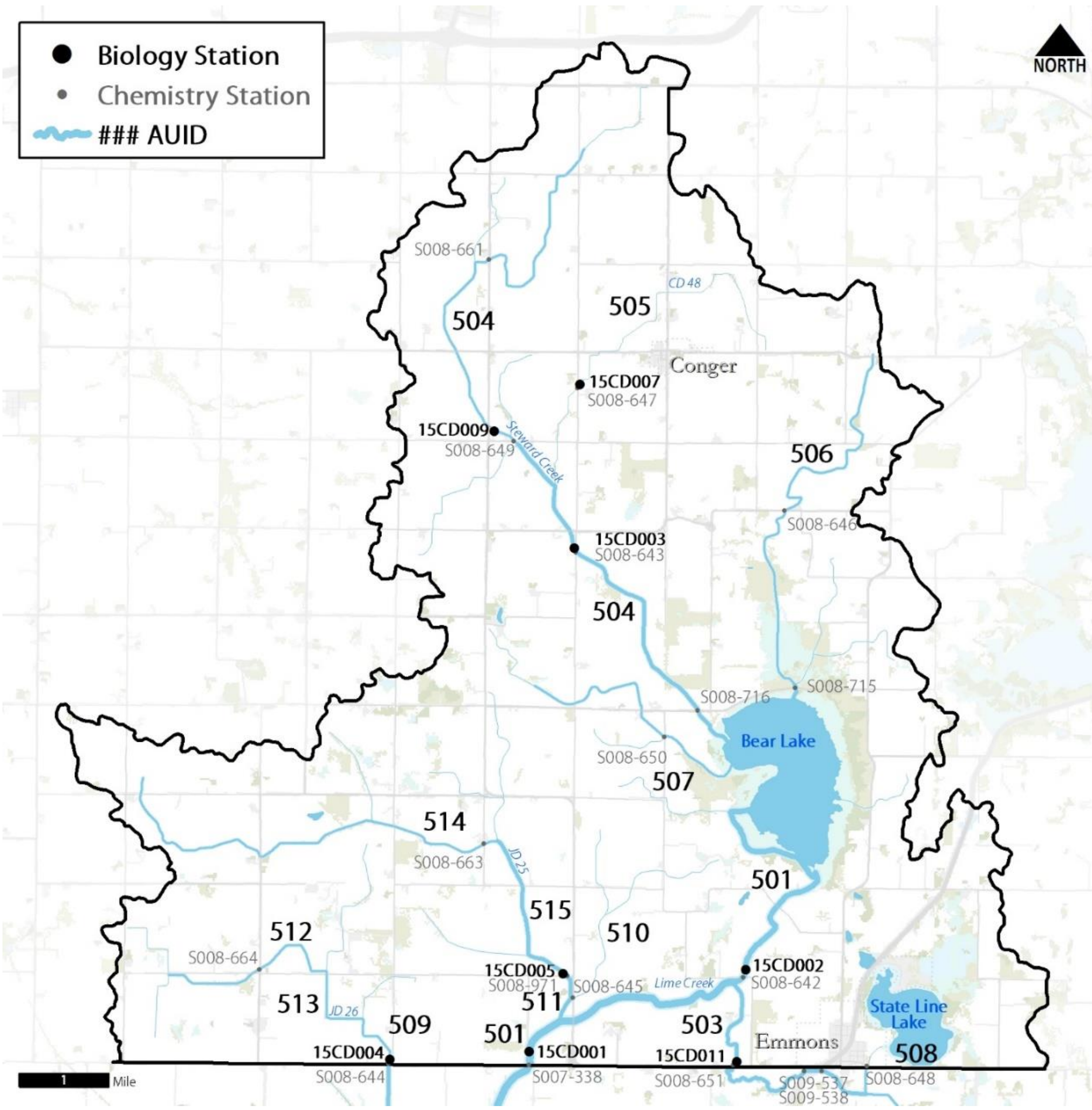


Figure 7. Biology and chemistry monitoring stations for streams in the Winnebago River Watershed.

Mercury and polychlorinated biphenyls (PCBs) were analyzed in fish tissue samples collected from Bear Lake (24-0028) in 1995 by the DNR fisheries staff. State Line Lake was unable to be sampled for fish tissue due to a drawdown, which occurred during the period of time in which Stateline Lake was scheduled to be sampled. The concentrations of mercury in common carp and northern pike were very low - well below the 0.2 mg/kg water quality standard for mercury in fish tissue and, therefore, not impaired. PCBs were tested in composite samples of the largest fish of each species and all were was less than the 0.01 mg/kg reporting limit. This report does not cover toxic pollutants. For more information on mercury impairments, see the statewide mercury TMDL on the MPCA website at: MPCA Statewide Mercury TMDL.

Streams

Four of the twelve stream reaches monitored had enough water quality data to be assessed for aquatic life in the Winnebago River Watershed (Figure 6). All four reaches are on altered channels that are being assessed using modified use thresholds. All four reaches assessed for aquatic life were found to be impaired (see Appendix A. MPCA Stream Water Quality Assessment Results). Despite both fish and invertebrate samples being dominated by tolerant taxa, Judicial Ditch 26 (07080203-509) meets the modified use FIBI and MIBI standards but does not meet DO parameter standards. Lime Creek was the only stream that was assessed for aquatic recreation. Data collected on Lime Creek suggested an Aquatic Recreation impairment due to high *E. coli* concentrations during June through September.

Table 2. Winnebago River Watershed impaired streams.

Reach Name	AUID	Pollutant/ Stressor								
		DO	*E. coli*	TP	TSS	Chl-a	Nitrate	Habitat	Fish Passage	Flow Alteration
Lime Creek	501	●	●	●	●	●		●	?	●
Steward Creek (JD-23)	504	●		●			●	●		●
Unnamed Creek	509	●		●				●		●
Judicial Ditch 25	515	●		●			?	●	?	●

●: Determined to be a direct stressor
?: Inconclusive
Blank: Not considered a stressor

The Winnebago Watershed has two Limited Resource Value (LRV) waters, also called Class 7 waters (Figure 8). These streams have previously demonstrated that the existing and potential aquatic community is severely limited and cannot achieve aquatic life standards. While not being protective of aquatic life, LRV waters are still protected for industrial, agricultural, navigation and other uses. Class 7 waters are also protected for aesthetic qualities (e.g., odor), secondary body contact, and groundwater for use as a potable water supply. To protect these uses, Class 7 waters have standards for bacteria, pH, DO and toxic pollutants. Both LRV waters met standards for DO and pH, no information was collected on toxic pollutants. Of the eight reaches not assessed, six had chemical parameters to compare to aquatic life use standards, however insufficient numbers of samples were available to assess.

The two remaining reaches are limited resource value waters and do not have aquatic life use standards. See Appendix A for detailed stream assessment results from the Winnebago River and Upper Wapsipinicon River Watersheds Monitoring and Assessment Report.

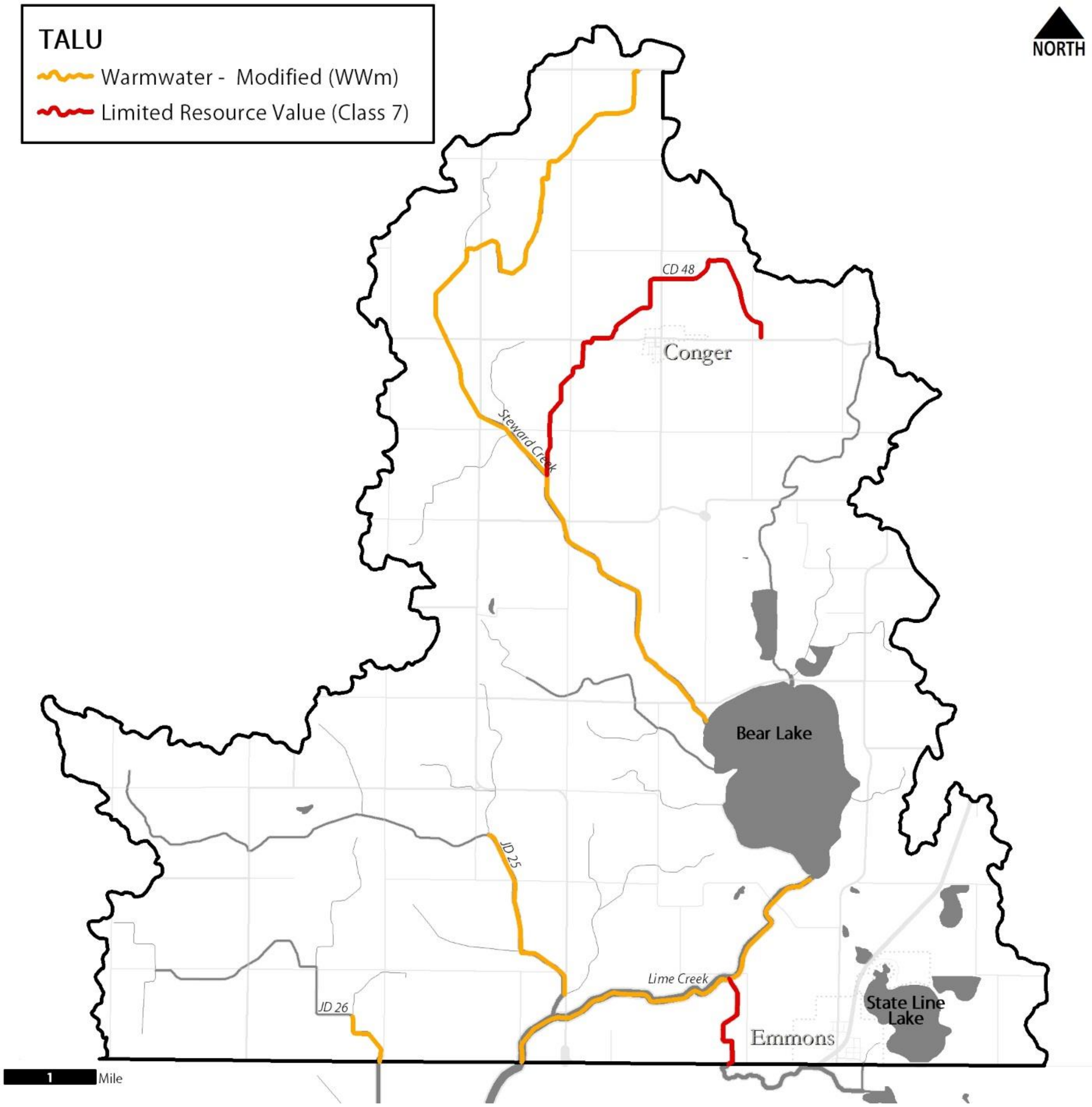


Figure 8. Stream Tiered Aquatic Life Use Designations in the Winnebago River Watershed.

Lakes

Bear and State Line lakes, had data available over the assessment period to compare to water quality standards. TP, Secchi depth, and Chl-*a* far exceeded aquatic recreation standards on both lakes; they are listed as impaired by eutrophication. State Line Lake was noted to have severe algal blooms in the summer months of 2015 and 2016.

Table 3. Lake water aquatic recreation assessments. Source Winnebago River and Upper Wapsipinicon River Watersheds Monitoring and Assessment Report.

Lake Name	DNR ID	Area Acres	Max Depth	Assessment Method	Ecoregion	Secchi Trend	Aquatic Life Indicators:			Aquatic Recreation Indicators:			Aquatic Life use	Aquatic Rec. (Bacteria)
							Fish IBI	Chlorides	Pesticides	Total Phosphorus	Chlorophyll-a	Secchi		
Bear	24-0028-00	1,504	6	Shallow Lake	WCBP	NT	**NA**	**MTS**	--	**EXS**	**EXS**	**EXS**	**IF**	**NS**
State Line	24-0030-00	470	5	Shallow Lake	WCBP	NT	**NA**	**MTS**	--	**EXS**	**EXS**	**EXS**	**IF**	**NS**

MTS = Meets Standard; EX = Exceeds Standard; IF = Insufficient Information; -- = No Data
= New impairment; = full support of designated use; = insufficient information

Shallow Lake Phosphorus and Algae Relationships

The relationship between P concentration and the response variables (algae/Chl-*a* and water clarity/Secchi depth) is often different in shallow lakes, like Bear Lake and State Line Lake, as compared to deeper lakes. In deeper lakes, algae abundance is often controlled by physical and chemical factors such as light availability, temperature, and nutrient concentrations. The biological components of lakes (such as microbes, algae, aquatic plants, zooplankton and other invertebrates, and fish) are distributed throughout the lake, along the shoreline, and on the bottom sediments. In shallow lakes, the biological components are more concentrated into less volume, and consequently exert a stronger influence on the ecological interactions within the lake. There is a more dense biological community at the bottom of shallow lakes than in deeper lakes, because of the fact that oxygen is replenished in the bottom waters and light can often penetrate to the bottom. These biological components can control the relationship between P and the response variables algae and water clarity.

The result of biological components' impact on water clarity is that shallow lakes normally exhibit one of two ecologically alternative stable states (Figure 9): the turbid water, algae-dominated state, and the clear water, aquatic plant-dominated state (Scheffer et al. 1993).

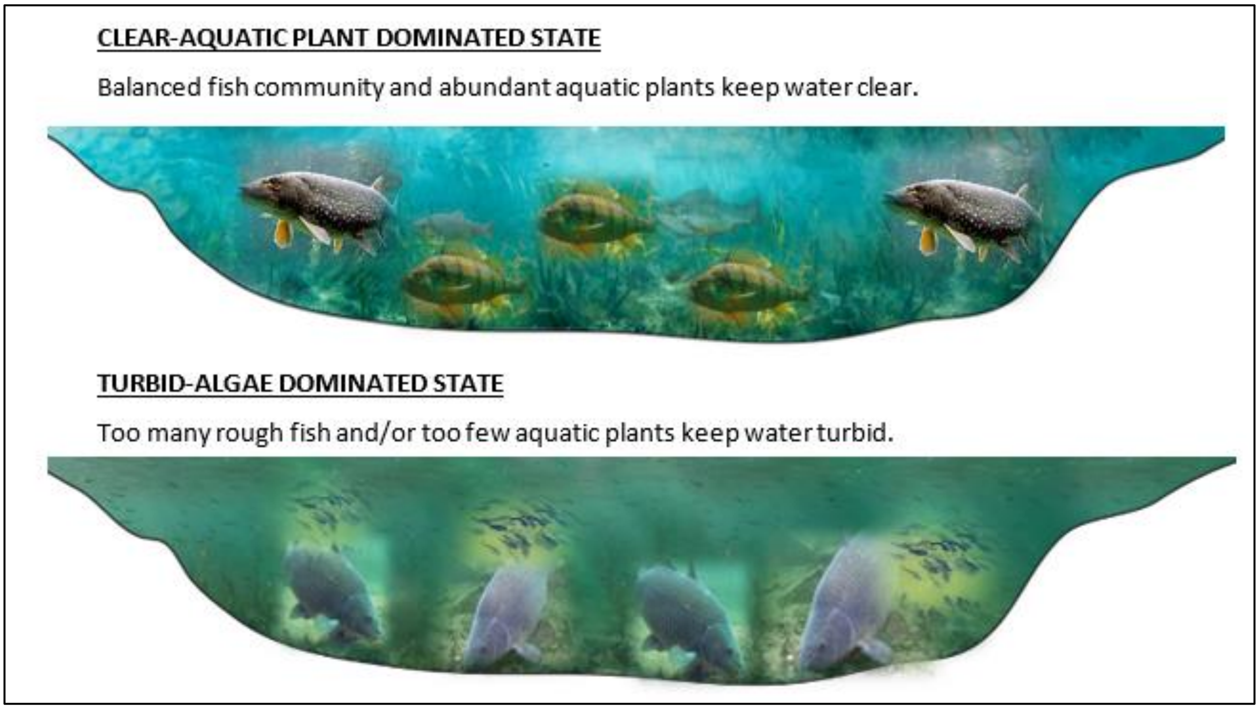


Figure 9. Clear and turbid water states in shallow lakes

According to Minnesota DNR Area Wildlife Manager, the turbid water state is currently the more dominant state in both Bear Lake and State Line Lake. The clear state is the most ecologically preferred, since algae communities are held in check by diverse and healthy zooplankton and fish communities. Fewer nutrients are released from the sediments in this state. This is because roots of aquatic plants stabilize the sediments, lessening the amount of sediment stirred up by wind-driven mixing. Furthermore, a balanced fish community results in less disturbance from bottom feeding such as carp.

Nutrient reduction or addition in a shallow lake does not lead to linear improvement or degradation in water quality (Figure 10). As external nutrient loads are decreased in a lake in the turbid water, algae-dominated state, no improvements in water quality may occur at first. Drastic reductions in nutrient loads or a change in the biological community will cause the lake to abruptly shift from the turbid water, algae-dominated state to the clear water, aquatic plant-dominated state. Conversely, as external nutrient loads are increased in a shallow lake in the clear water, aquatic plant-dominated state, only slight degradations in water quality may occur at first. At some point, further increase in nutrient loads will cause the shallow lake to abruptly shift from the clear water, aquatic plant-dominated state to the turbid water, algae-dominated state. The general pattern in Figure 10 is often referred to as "hysteresis," meaning that when forces are applied to a system, there may be a delay or lag in response. Hysteresis also means that when these forces are removed, a system may not immediately return completely to its original state nor does it follow the same trajectory on the way back.

The biological response of the lake to P inputs will depend on the stable state that the lake is in. For example, if the lake is in the clear state, the aquatic plants may be able to take up P instead of the algae. However, if enough stressors are present in the lake, increased P inputs may lead to a shift to the turbid state with an increase in algal density and decreased transparency. The two main categories of stressors that can shift the lake to the turbid state are:

- Disturbance to the aquatic plant community, for example from wind-driven mixing, bottom feeding fish (such as carp), boat motors, or light availability (influenced by algal density or water depth); and,
- A decrease in the number of zooplankton can result in an increase in algae. A decrease in the number of zooplankton is usually caused by an increase in the number of fish that feed directly on zooplankton due to a decrease in or absence of piscivorous fish (Figure 9).

One implication of the alternative stable states in shallow lakes is that different management approaches are used for shallow lake restoration than those used for restoration of deeper lakes. Shallow lake restoration often focuses on restoring the macrophyte, zooplankton, and fish communities to the lake.

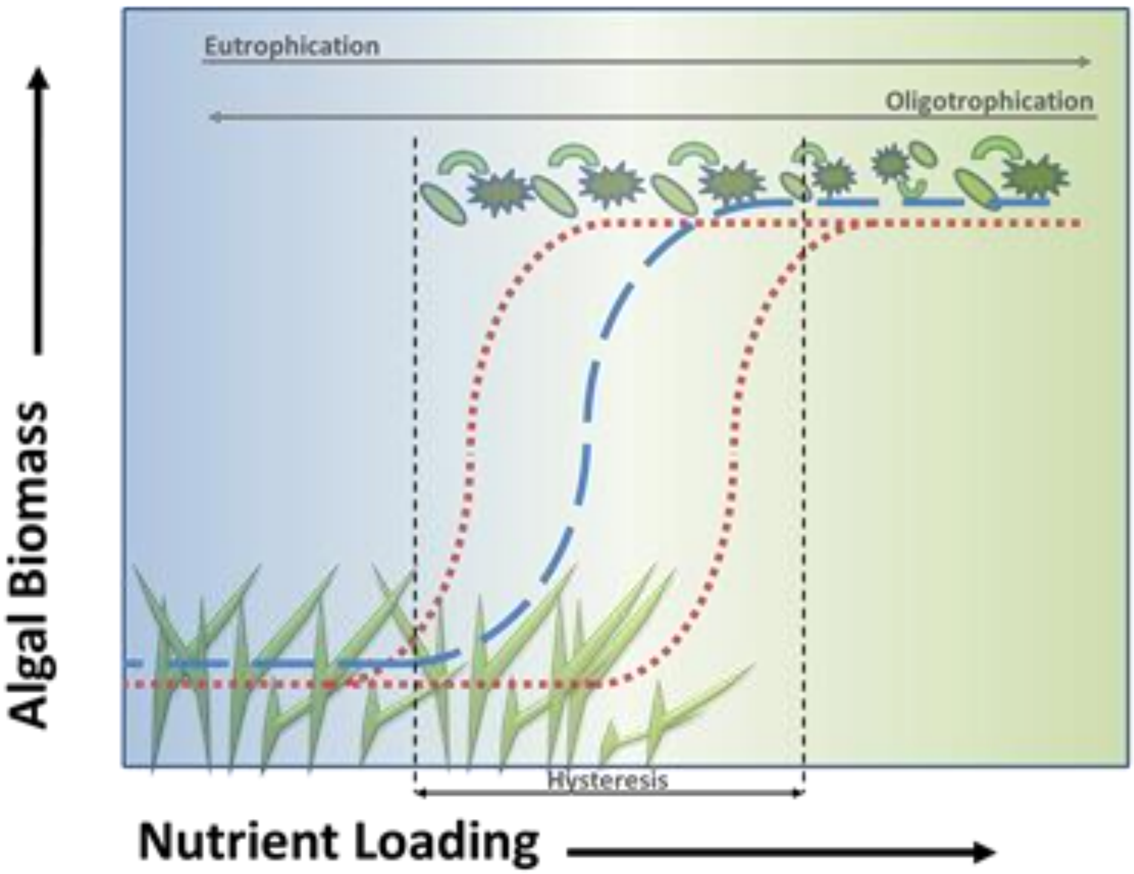


Figure 10. Nutrient loading and algae biomass hysteresis of alternative stable states in shallow lakes (Scheffer *et al.* 1993).

Wetlands

Wetland loss is seen throughout the state; the Winnebago Watershed is no exception. Given that not all wetlands provide the same functions, e.g. human benefits or services, the MPCA used the Hydrogeomorphic (HGM) Classification system to characterize the wetlands of the Winnebago River Watershed. This classification was used so that individual wetland descriptions could be based on the hydrologic regime and expected primary water flow paths (MPCA 2018). Twenty-one unique wetland HGM descriptor combinations were identified within the two watersheds. Thirteen of these 21 unique classes made up less than 2% of the total wetland area and were interpreted to be of minimal importance. The remaining eight HGM classes that comprise at least 2% of the combined wetland area are shown in Table 4. It is likely that in this relatively flat landscape, a large portion of the wetlands historically would have exhibited isolated hydrology, enabling long retention times prior to discharging to the drainage network. Results in Table 4 illustrate that the remaining wetlands are strongly associated with the river and stream drainage network, and likely shorter retention times during high and moderate flow periods. As a result, wetlands in the Winnebago River Watershed have reduced assimilative and storage capacities. Once saturated, they can be expected to freely discharge flow and pollutants downstream. Wetlands with herbaceous emergent vegetation comprise over four times the area (3.5%) compared to the other three wetland classes (0.85%) combined. Wetlands in the Winnebago River Watershed are more common in the southeastern region associated with Bear Lake and the State Line Lake complex (Figure 11).

Table 4. Predominant (> 2.0%) summed area simplified Hydrogeomorphic wetland functional classes present in the Winnebago River Watershed.

HGM Class Code	Wetland HGM landform description	Simplified Wetland Plant Community Classes Present	% of Total Wetland Area	Number of Wetland Polygons	HGM Class Area (ac)
LEBABI	Shallow lake fringing depressional "basin" wetland with bi-directional "ebb and flow"	Shallow Marsh and Hardwood Swamp	17.36	22	620.42
LEFLBI	Shallow lake fringing wetlands in level landscape "flats" with bi-directional "ebb and flow" hydrology	Seasonally Flooded Basin, Hardwood Swamp and Scrub Shrub	10.25	79	366.50
LRFPTH	River floodplain wetlands with "flow through" hydrology	Seasonally Flooded Basin, Hardwood Swamp, Scrub Shrub and Shallow Marsh	11.37	43	406.41
LSFLTH	Wetlands adjacent "fringing" to streams with inflow and outflow "through flow" hydrology	Hardwood Swamp and Seasonally Flooded Basin	9.13	32	326.31
TEBAOU	Inland wetland basins surrounded by upland with outflow hydrology	Hardwood Swamp, Shallow Marsh and Scrub Shrub	14.50	171	518.61
TEFLIS	Inland wetlands in level landscapes "flats" surrounded by upland "isolated" hydrology	Seasonally Flooded Basin and Hardwood Swamp	1.15	26	41.42
TEFLOU	Inland wetlands in level landscapes "flats" with outflow hydrology	Seasonally Flooded Basin, Hardwood Swamp and Scrub	31.34	487	1119.80
TESLOU	Inland wetlands situated on slopes with outflow hydrology	Wet Meadow, Hardwood Swamp, and Scrub Shrub	4.87	132	174.06

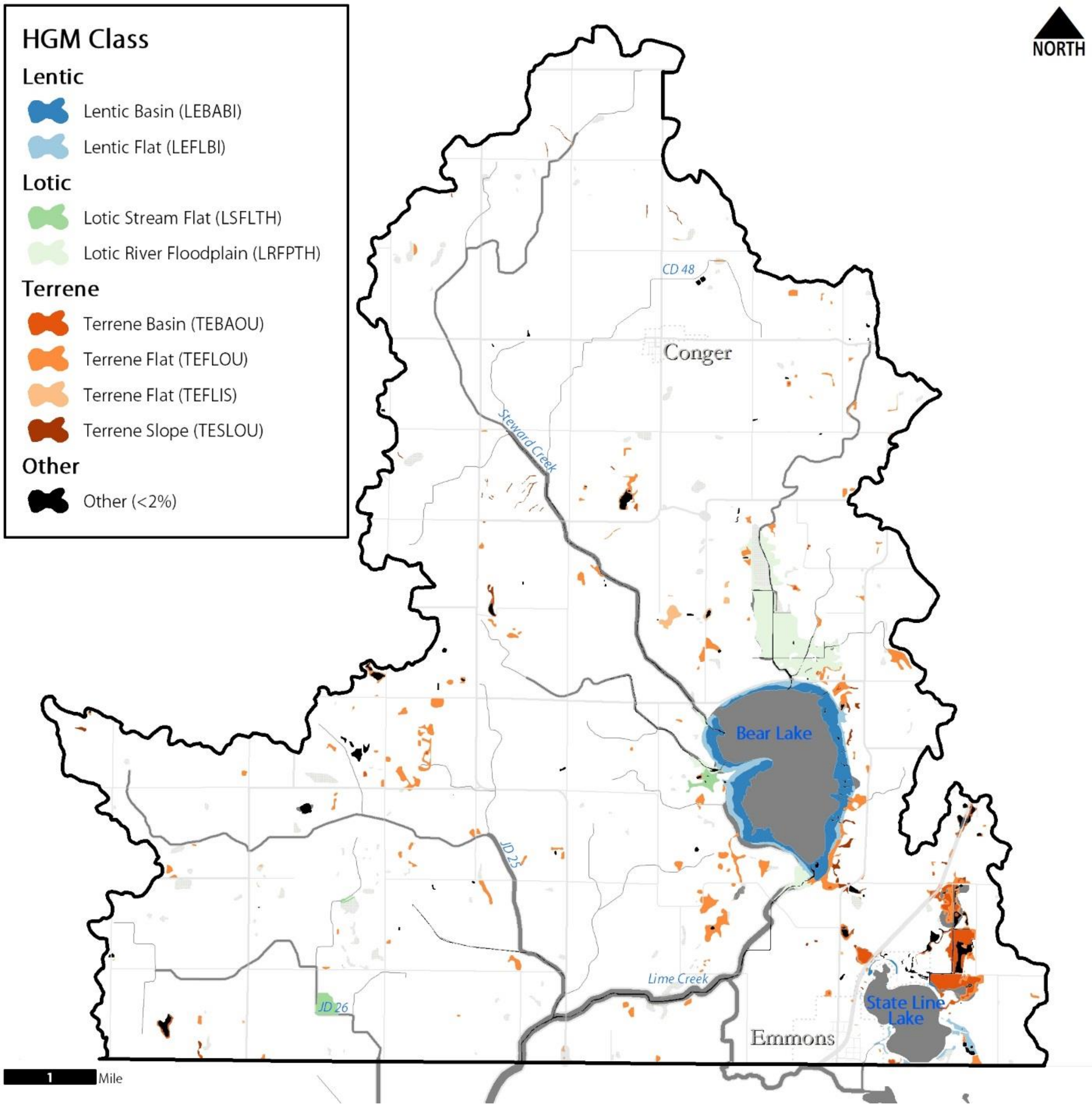


Figure 11. Distribution and types of wetlands according to the updated Minnesota National Wetland Inventory within the Winnebago Watershed.

Groundwater

All citizens in the Winnebago River Watershed rely on groundwater for their source of drinking water. Of the estimated 491 households in this watershed, approximately 20% are estimated to be served by community public water supply systems from the city of Emmons or the city of Conger, while 80% of the households obtain water from private wells.

Nitrate is a contaminant of particular concern in this watershed due to potential contamination from septic systems, commercial nitrogen fertilizer and/or manure. The Minnesota Department of Health (MDH) has developed a method for assessing the vulnerability of water supplies to contaminants from activities at the land surface, based on guidance from a 2011 interagency workgroup that included members of MDH, MDA, and DNR. Figure 12 shows that the majority of the drinking water supply wells in the watershed are located within 100 feet of a known pollutant source, or are located in areas that have been identified as being highly vulnerable to groundwater contamination. Pollution prevention from identified sources is the most effective method for groundwater protection in these areas.

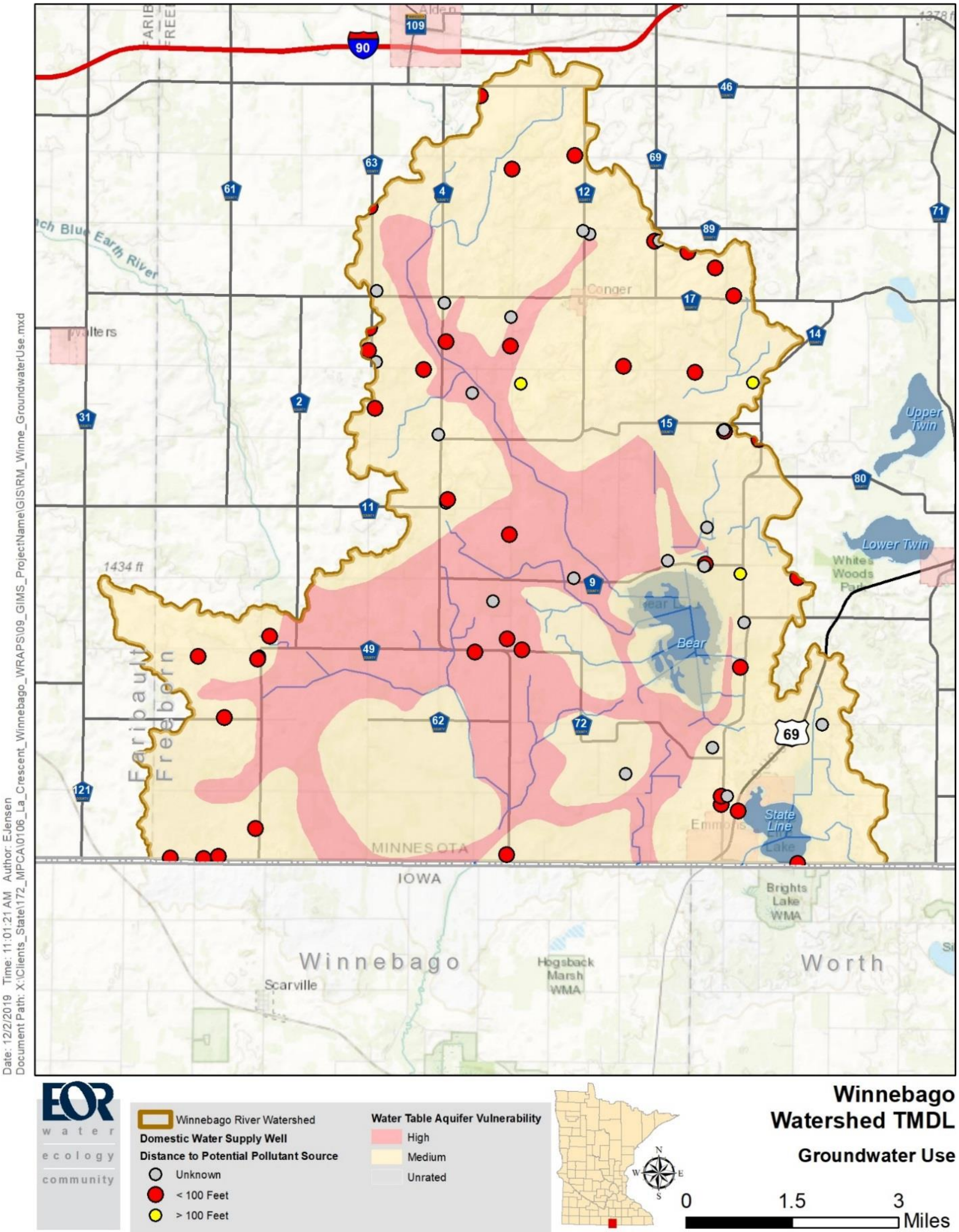


Figure 12. Groundwater Vulnerability.

Groundwater is monitored by several agencies under various programs. There are no MPCA Ambient Groundwater Monitoring wells currently within the watershed. However, from 1992 to 1996, the MPCA conducted baseline water quality sampling and analysis of Minnesota's principal aquifers. The watershed lies entirely within the southeast region, where groundwater quality is considered good when compared to similar aquifers but due to the geology, is potentially susceptible to high concentrations of trace elements like cadmium, lead, and arsenic (MPCA 1999). Freeborn County is the lead local government units (LGU) for groundwater well testing and Freeborn SWCD is the lead LGU for the MDA township testing program.

Mandatory testing across the state by MDH for arsenic, a naturally occurring but potentially harmful contaminant for humans, of all newly constructed wells has found that 10.7% of all wells installed from 2008 to 2016 have arsenic levels above the maximum contaminant level (MCL) for drinking water of 10 ug/L. At the local level, Freeborn County (nearly all of Winnebago Watershed) found 13.3% of new wells were identified with arsenic concentrations exceeding the MCL. The two major public water supply wells in the watershed are located in Conger and Emmons (Figure 13). Both wells are located in areas identified as having a medium level of vulnerability to aquifer contamination. Other groundwater uses in the watershed include irrigation for agricultural fields, sod farms, and golf courses, and livestock watering. Total annual groundwater withdrawal volumes are available for the Winnebago River Watershed since 1988 and are shown in Figure 14.

MDH drafted the Groundwater Restoration and Protection Strategy (GRAPS) report for groundwater within the Winnebago River Watershed in May 2020. GRAPS reports contain maps and data describing groundwater conditions in the watershed. The reports identify local groundwater concerns and outline strategies and programs to address them. Local organizations can use GRAPS reports to develop their water management plans. The GRAPS for the Winnebago River Watershed is available on MDH's GRAPS webpage.

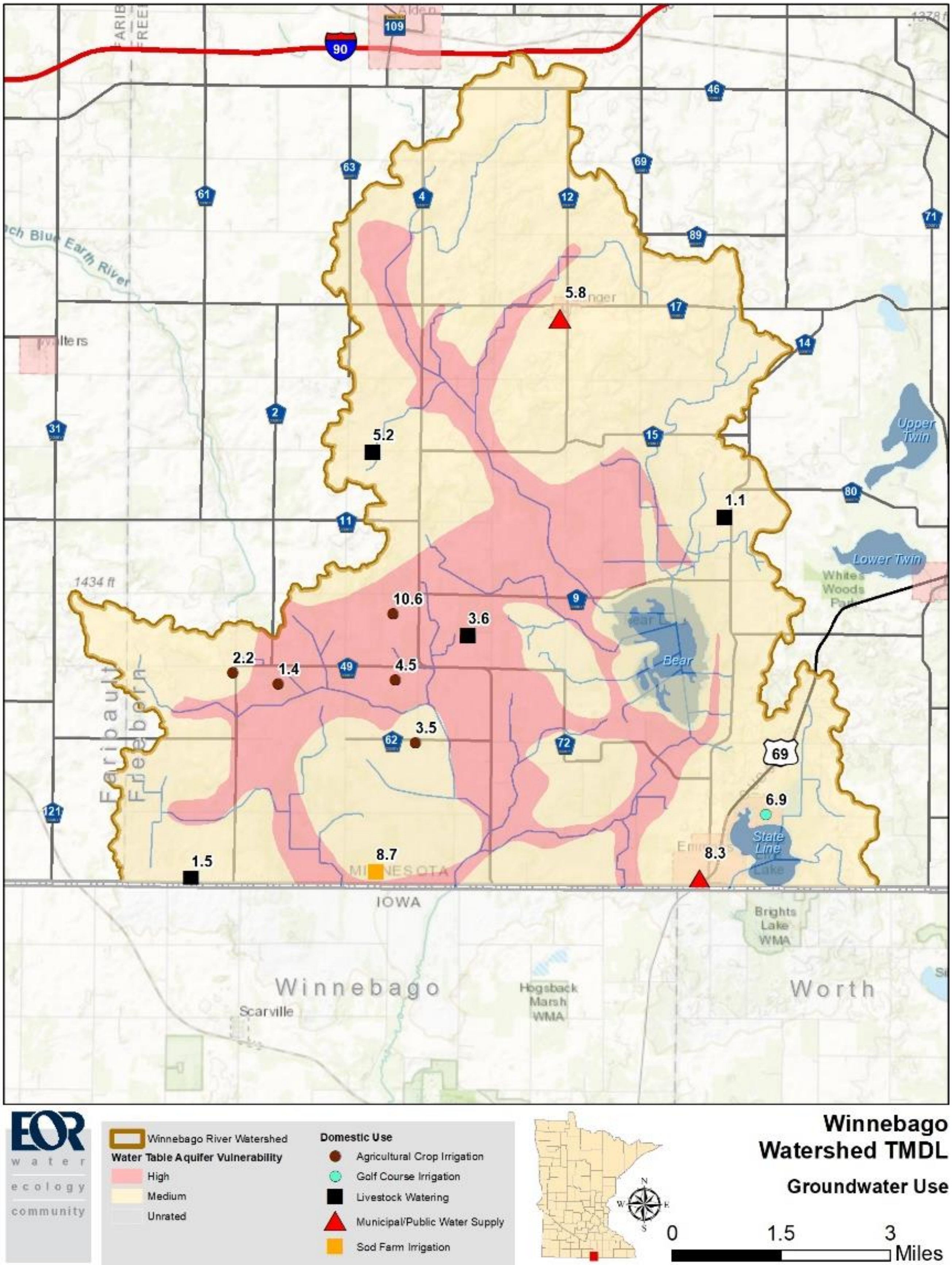


Figure 13. Domestic uses of groundwater. Numbers show average volume of water pumped (million gallons/day) for 2017, the most recent year with available data.

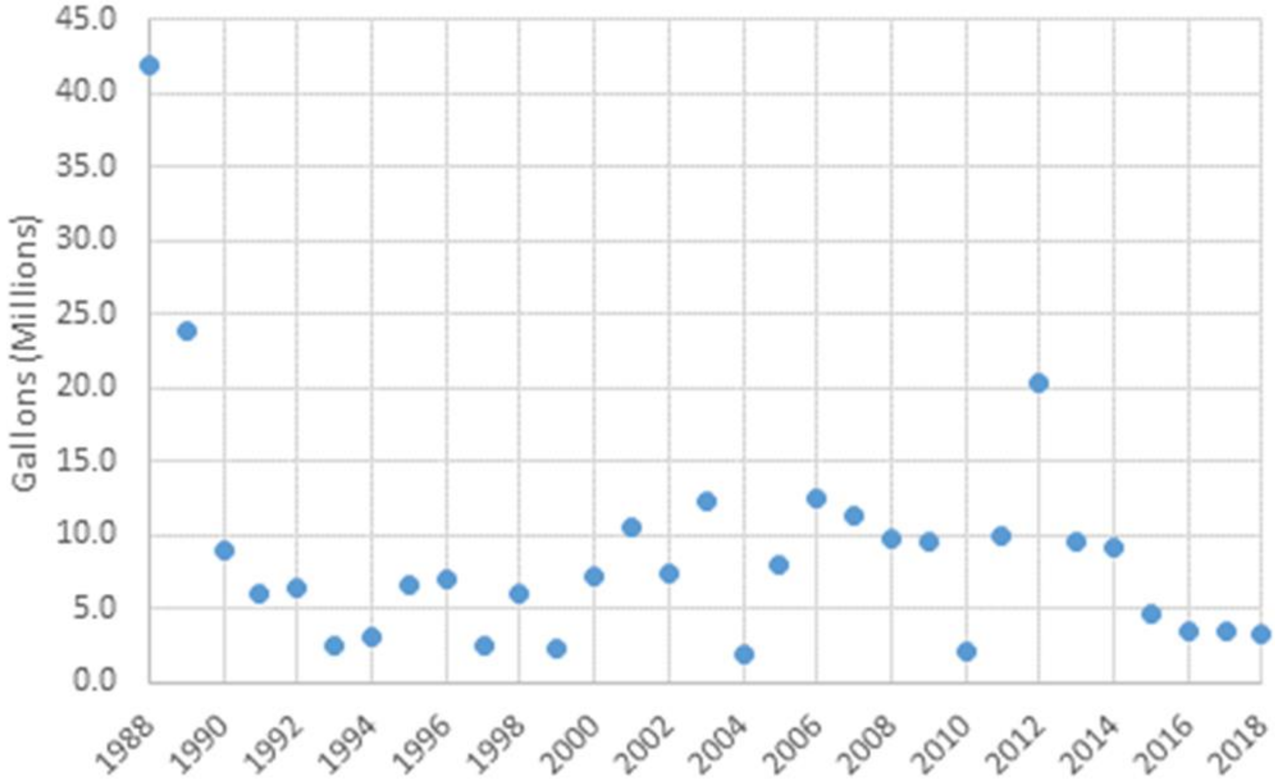


Figure 14. Total annual groundwater withdrawals in the Winnebago River Watershed (1988-2018).

2.2 Water quality trends

Year-to-year weather variations affect water quality observation data; for this reason, interpreting long-term data trends minimizes year-to-year variation and provides insight into changes occurring in a water body over time.

The MPCA completes annual trend analysis on lakes and streams across the state based on long-term transparency measurements. The data collection for this work relies heavily on volunteers across the state, and incorporates any relevant agency and partner data submitted to EQuIS. The water clarity trends are calculated using a Seasonal Kendall statistical test for sites with a minimum of eight years of transparency data, Secchi disk measurements in lakes, and Secchi tube measurements in streams. There is no detectable water clarity trend on State Line Lake or Bear Lake. Water clarity on both lakes varies seasonally and annually due to the shallow lake factors previously discussed. There was no stream analysis completed as there are no citizen stream monitoring locations in the Winnebago River Watershed. Water quality trends can also be analyzed from regularly collected data from stations within MPCA's Watershed Pollutant Load Monitoring Network (WPLMN). However, no WPLMN sites exist within the Winnebago River Watershed.

2.3 Stressors and sources

In order to develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening them must be identified and evaluated.

A biological **stressor** is something that adversely impacts or causes fish and/or macroinvertebrate communities in streams to become unhealthy. Biological SID is conducted for streams with either fish or macroinvertebrate biota impairments, and encompasses the evaluation of both pollutants (such as nitrate-N, P, and/or sediment) and nonpollutant-related (such as altered hydrology, fish passage, and habitat) factors as potential stressors.

Pollutant source assessments are completed where a biological SID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings such as TSS. Pollutants to lakes and streams include point sources (such as wastewater treatment plants [WWTP]) or nonpoint sources (such as runoff from the land).

2.3.1. Stressors of biologically-impaired stream reaches

The MPCA has increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's streams. This approach centers on examination of fish and aquatic macroinvertebrate communities and related habitat conditions at multiple sites throughout a major watershed. From these data, an IBI score can be developed, which provides a measure of overall community health. SID is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act (CWLA). A SID study was conducted to identify the factors (i.e., stressors) that are causing the fish and macroinvertebrate community impairments in the Winnebago River Watershed. For more details on the Winnebago River Watershed stressors and the process used to identify the stressors causing the biological impairments, please consult the 2017 Winnebago River Watershed SID Report.

In the Winnebago River Watershed, three of the four (75%) streams that were assessed were considered to be nonsupportive of designated aquatic life uses due to not meeting FIBI and MIBI thresholds. Two additional AUIDs were not assessed due to their class 7 (LRV) status.

Judicial Ditch 26 (Unnamed Creek) (07080203-509), scored above the modified use (habitat limited) threshold. The chemistry data was also indicating an impairment, as DO was not meeting aquatic life use standards. Tolerant fish taxa made up 88% of the fish collected within this reach, with white sucker and brook stickleback being the most abundant species. This station was sampled twice for invertebrates, once in 2015 and again in 2016, and both samples scored above the modified use threshold. Tolerant invertebrate taxa made up nearly 90% of individuals at both visits. Despite low DO and both fish and invertebrate samples being dominated by tolerant taxa, this reach meets the modified use standard and is not listed as impaired for aquatic life. Table 5 provides the FIBI and MIBI scores for each of the biological monitoring stations in the Winnebago River Watershed.

Table 5. Summary of FIBI and MIBI scores for biological monitoring stations in the Winnebago River Watershed. Scores below impairment threshold are in red. Most of the stations and scores were from sampling in 2015, some 2016. If there were multiple visits from the same year, the mean is presented.

Location		Fish				Macroinvertebrate		
Stream Name	AUID suffix	Station (Year)	FIBI Class (Use)	FIBI impairment threshold	FIBI score (mean)	MIBI Class (Use)	MIBI impairment threshold	MIBI score (mean)
Lime Creek	501	15CD001 (2015)	Southern Modified Use	35	28.5	Southern Modified Use	22	19.6
		15CD001 (2016)			34.6			33.1
		15CD002 (2015)			55.8			0
		15CD002 (2016)			28.7			32.2
Steward Creek (County Ditch 23)	504	15CD009 (2015)			55.7			----
		15CD009 (2016)			43			----
		15CD003 (2015)			36.7			33.5
		15CD003 (2016)			27.4			43.6
Unnamed Creek (Judicial Ditch 26)	509	15CD004 (2015)			43.6			27.5
		15CD004 (2016)			----			39.4
Judicial Ditch 25	515	15CD005 (2015)			0			37.1
		15CD005 (2016)			----			46.9

Lime Creek (-501) biological monitoring stations are noted as having dramatically different FIBI and MIBI scores from 2015 to 2016. At station 15CD002, FIBI scores went from 55.8 (2015) to 28.7 (2016). MIBI scores from both biological stations went from below the threshold in 2015 to above the threshold in 2016. In general, variability in IBI scores is often seen in sites with less than ideal physical characteristics. Biological sampling stations exhibiting pristine physical characteristics typically have consistent IBI scores above thresholds, while sites exhibiting heavily degraded characteristics have consistent IBI scores below thresholds. While there is no single and clear explanation for the fluctuations in IBI scores for Lime Creek, the biology is likely responding to episodes of eutrophication impacts and inadequate habitat.

The major stressors that are contributing to the impairments in the Winnebago River Watershed are excess nitrates, eutrophication (P), DO, habitat loss, TSS, and flow alteration (Table 6). The excessive plant and algae growth in the watershed is also altering DO dynamics, resulting in low DO and elevated DO flux. Flow alteration is a major source of stress and it is reasonable to assume it is contributing directly or indirectly to all stressors in the Winnebago River Watershed.

Table 6. Summary of probable stressors to impaired biological communities in the Winnebago River Watershed.

Stream/Lake	AUID Last 3 digits/ Lake ID	Biological Impairment	Stressor							
			Temperature	Nitrate	Eutrophication	DO	TSS	Habitat	Fish Passage	Flow Alteration
Lime Creek	-501	F-IBI, M-IBI	?		✧	✧	✧	●	?	♦
Steward Creek (CD 23)	-504	M-IBI		●	●	●		●		♦
Judicial Ditch 25	-515	F-IBI		?	●	●		●	?	♦

● Determined to be a direct stressor
♦ A "root cause" stressor, which causes other consequences that become the direct stressors.
✧ Stressor is likely connected to condition of upstream lake
? Inconclusive

Lack of Habitat

In this report, habitat refers to the in-channel and adjacent to stream habitat. Important stream habitat components include: stream size and channel dimensions, channel gradient (slope), channel substrate, habitat complexity, and in-stream and riparian zone vegetation. Degraded habitat reduces aquatic life's ability to feed, shelter, and reproduce, which results in altered behavior, increased mortality, and decreased populations. During the SID study, degraded habitat was identified as a stressor for all three bio-impaired reaches.

Throughout the Winnebago River Watershed, qualitative habitat was measured with the Minnesota Stream Habitat Assessment (MSHA). The MSHA assessment gives a numerical score for floodplain, riparian, instream, and channel morphology quality at biological stream monitoring locations. The total score can be broken up into poor (<45), fair (45 to 66) and good (>66) categories. Generally, "good" habitat scores (>65) are necessary to support healthy, aquatic communities. The MSHA scores in the Winnebago River Watershed range from 20.375 to 48.675 with an average score of 32.26.

Table 7. MSHA results for the Winnebago River Watershed.

Biological Station ID	Reach Name	MSHA Score (0 – 100)	MSHA Rating
15CD001	Lime Creek (Winnebago River)	20.375	Poor
15CD002	Lime Creek (Winnebago River)	21.75	Poor
15CD009	Steward Creek (County Ditch 23)	31.875	Poor
15CD003	Steward Creek (County Ditch 23)	37.875	Poor
15CD011	Trib. to Lime Creek (Winnebago River)	48.675	Fair
15CD005	Judicial Ditch 25	30	Poor
15CD004	Judicial Ditch 26	32	Poor
15CD007	County Ditch 48	35.5	Poor
Average Habitat Results: Lime Creek Aggregated 12 HUC		***32.26***	***Poor***

MSHA ratings = **Good:** MSHA > 66; **Fair:** 45 < MSHA < 66; **Poor**: MSHA<45

Habitat conditions in the Winnebago River Watershed are poor due to lack of habitat and fine substrate. Severe embeddedness, sand, silt, and channelization dominate this watershed and limit the fish and macroinvertebrate communities. Recent geomorphology work completed by DNR on stations 15CD001 and 15CD004 noted that "channelized drainage ditches like those exhibited in the Winnebago River Watershed typically lack natural habitat features (i.e. riffles and pools), have minimal bank erosion, and have fine stream bed particles" (DNR 2017).

Sediment

Total suspended solids (TSS) are materials suspended in the water that can directly affect aquatic life by reducing visibility, clogging gills, and smothering substrate, which limits reproduction. Excessive TSS indirectly affects aquatic life by reducing the penetration of sunlight, limiting plant growth, and increasing water temperatures. These materials are often primarily sediment but also includes algae and other solids. Suspended sediment and streambed sediment are closely related because they have many of the same sources. In this report, the term "sediment" combines these two parameters. Issues related to the algae-portion of TSS are due to P (eutrophication) and are addressed in that section of this report. Sources of sediment are discussed in Section 2.3.2

Elevated nitrate-nitrogen

Nitrate toxicity to freshwater aquatic life is dependent on concentration and exposure time, as well as the overall sensitivity of the organism(s) in question. The intake of nitrite and nitrate by aquatic organisms has been shown to convert oxygen-carrying pigments into forms that are unable to carry oxygen, thus inducing a toxic effect on fish and macroinvertebrates. Certain species of caddisflies, amphipods, and salmonid fishes seem to be the most sensitive to nitrate toxicity. Nitrate-N level less than 2.0 mg/L nitrate-N are appropriate for protecting the most sensitive freshwater species, and NO3-N concentrations under 10.0 mg/L are protective of several sensitive fish and aquatic invertebrate taxa (MPCA 2017). Further discussion of N occurs in the SID report (MPCA 2018) and in Section 2.3.2 of this report.

Flow Alteration/Altered hydrology

Flow alteration is the change of a stream's flow volume and/or flow pattern (low flows, intermittent flows, increased surface runoff, and highly variable flows) typically caused by anthropogenic activities. These activities can include channel alteration (Figure 5), water withdrawals (Figure 14), land cover alteration, wetland drainage (Figure 2), agricultural tile drainage (Figure 16), urban stormwater runoff, and impoundment. Altered hydrology as an identified stressor more specifically refers to changes in the amount and timing of stream flow. Both too much and too little stream flow directly harm aquatic life by creating excessive speeds in the water or reducing the amount of water. Altered hydrology can also indirectly harm aquatic life because it increases the transport or exacerbates the conditions of other pollutants and stressors, including sediment from streambank erosion, nitrogen, and connectivity issues.

A study of southern Minnesota watersheds (Schottler et al. 2013) found human-caused changes, including agricultural drainage and crop changes, as the primary cause of increased flows. This study also estimated that in agriculturally-dominated watersheds, such as the Winnebago, more than 50% of the increase in flow between the mid and late 20th century was caused by changes in agricultural drainage (Figure 15).

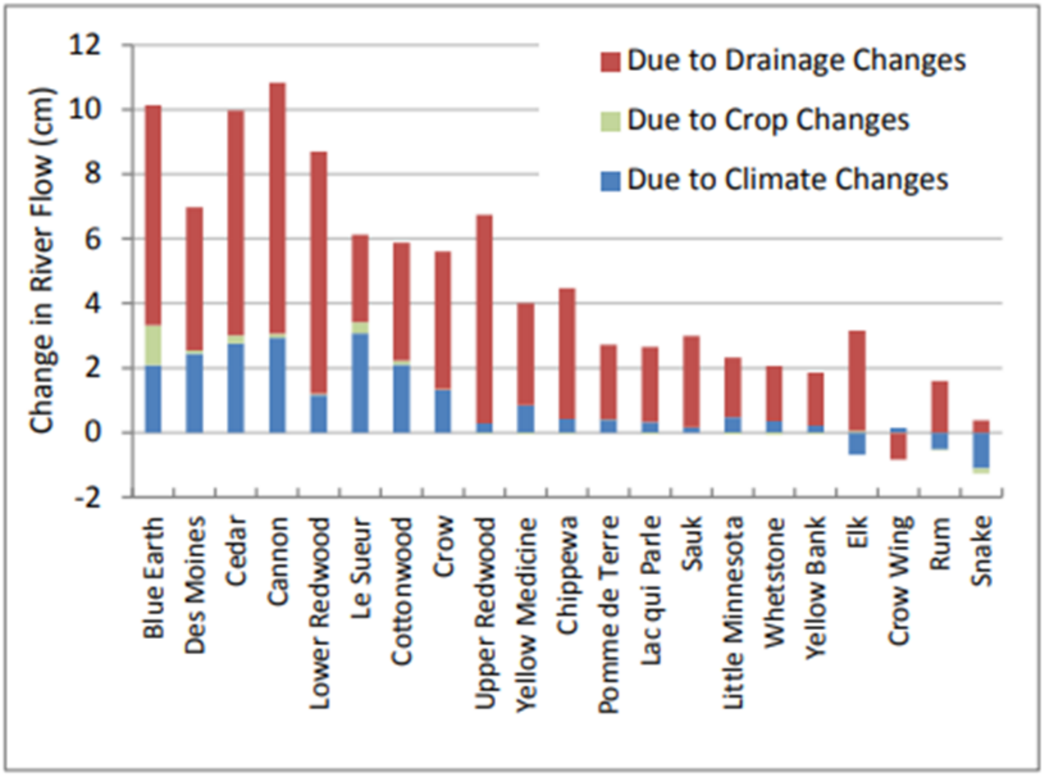


Figure 15. Causes of changes in river flow. Schottler et al 2013.

The amount of agricultural tile drainage in the Winnebago River Watershed was estimated using United States Geological (USGS) National Elevation Dataset, and Soil Survey Geographic Database (SSURGO) soil drainage class (Figure 16). Using these two datasets, the MPCA SID staff estimated that roughly 41% (18,716 acres) of the watershed is tiled (MPCA 2017).

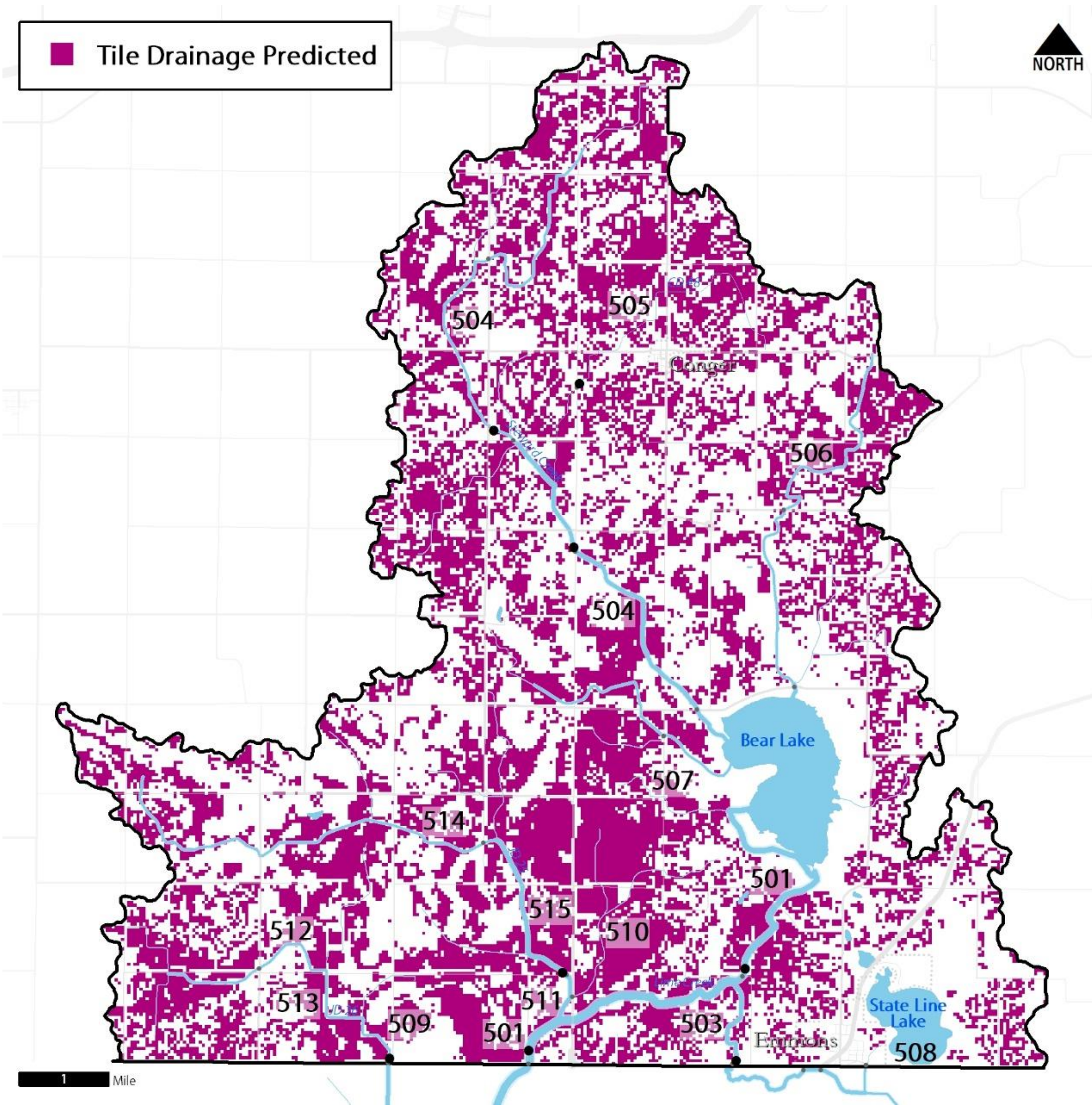


Figure 16. Estimated agriculture tile drained areas of the Winnebago River Watershed.

Eutrophication/Phosphorus

Eutrophication is an excessive amount of nutrients in a water body. Within the Winnebago River Watershed, both lakes and the outflow of Bear Lake (Lime Creek/Winnebago River) are impaired by eutrophication. The primary nutrient responsible for this eutrophication is P. P is an important nutrient for plants and animals and is frequently the limiting nutrient for algae and plants in fresh water. It impacts aquatic life by changing food chain dynamics, impacting fish growth and development, increasing algae, and increasing the DO variation (i.e. high and low DO). High P impacts aquatic recreation in lakes by fueling excessive algae growth, making waters undesirable or even dangerous to swim in due to the potential presence of toxic blue-green algae. Further discussion of P occurs in the SID report (MPCA 2018) and in Section 2.3.2 of this report.

Dissolved oxygen

DO is oxygen gas within water. Low or highly fluctuating concentrations of DO can have detrimental effects on many fish and bug species. Low DO concentrations impact aquatic life by limiting respiration, which contributes to stress and disease and can result in reduced growth or death. Low DO in water bodies is caused by: 1) excessive oxygen use, which is often caused by the decomposition of algae and plants, whose growth is fueled by excess P and/or 2) too little re-oxygenation, which is often caused by minimal turbulence due to low flow or high-water temperatures. Low DO levels can be exacerbated in over-widened channels because these streams move more slowly and have more direct sun-warming. Likewise, channels with degraded riparian vegetation lack cover and are susceptible to excessive warming.

Low DO and elevated DO flux occur frequently in the Winnebago River Watershed. These conditions are reflected in the fish and macroinvertebrate communities, as low DO tolerant individuals dominate most stations. Low DO is a stressor in all biologically impaired AUIDs (-501, -504, and -515).

2.3.2. Pollutant sources

This section summarizes the sources of pollutants (P, nitrate, sediment and bacteria) to water resources in the Winnebago River Watershed. A HSPF computer model was used to evaluate the extent and magnitude of contributions from point, nonpoint, and atmospheric sources for TSS, P and N for each subwatershed (Figure 18) in the Winnebago River Watershed. Computer modeling can extrapolate the known conditions of the watershed to areas with less monitoring data. Computer models, such as HSPF, represent complex natural phenomena with numeric estimates and equations of natural features and processes. HSPF incorporates data including stream pollutant monitoring, land use, weather, soil type, etc. to estimate flow, sediment, and nutrient conditions within the watershed. In this way, the HSPF model is useful, in that it provides a reasonable means of building upon existing data to evaluate how changes in watershed characteristics (e.g., land use) and past climatological data effect pollutant generation and delivery across the watershed in space (nonmonitored portions of the watershed) and time (continuous multi-year time).

More information about the HSPF model is provided in Section 3.2 of this document. Figure 17 provides a comparison of the magnitude of point versus nonpoint sources of P loading in the watershed, using HSPF Reach 273 as an example.

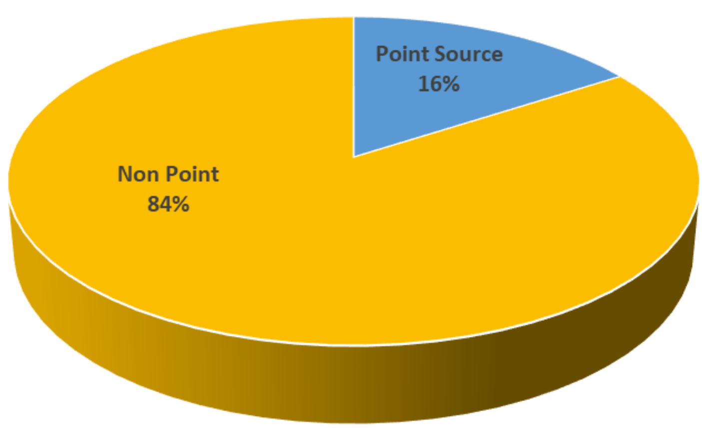


Figure 17. Breakdown of phosphorus sources for HSPF Reach 273 – State Line Lake Outlet.

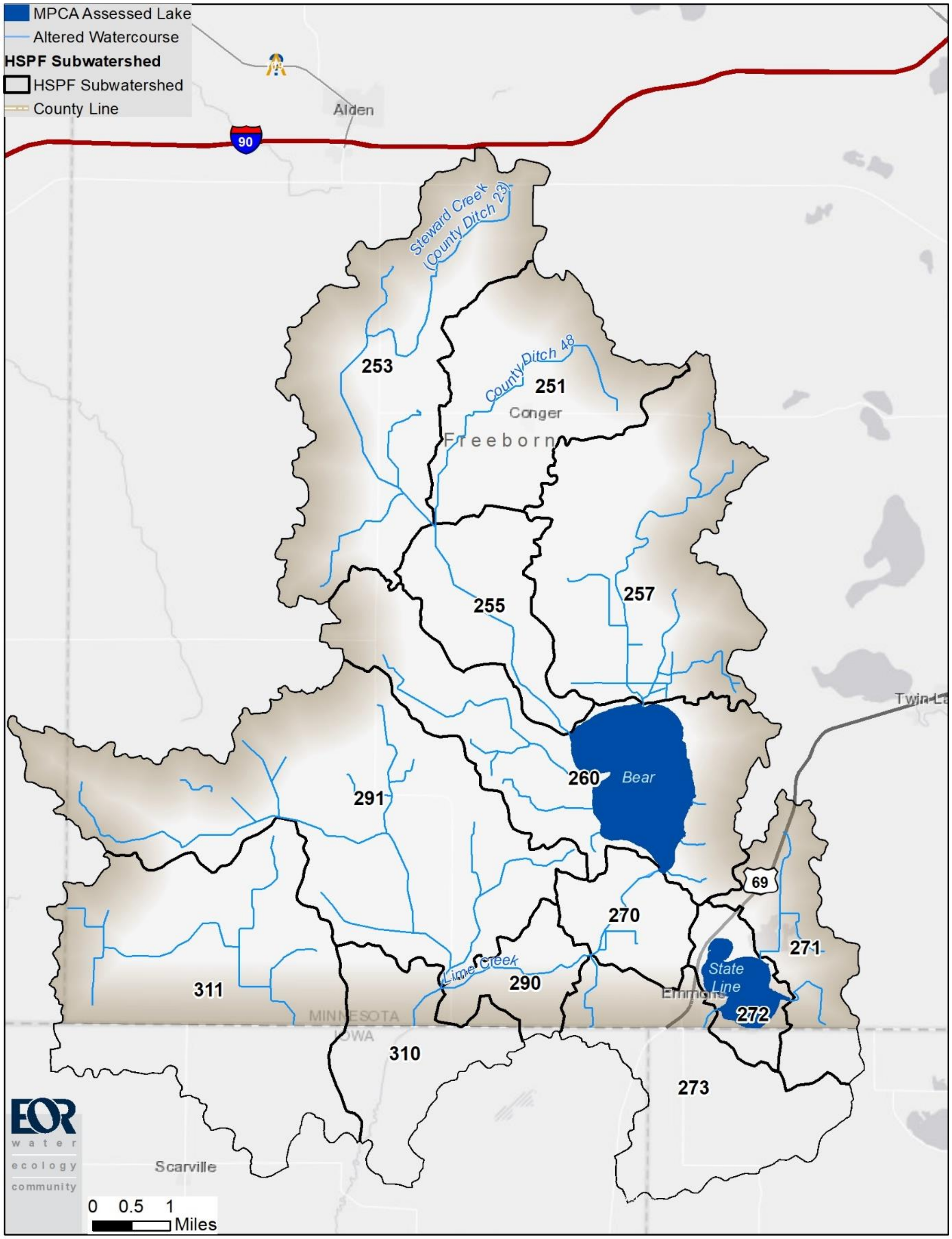


Figure 18. HSPF subwatersheds within the Winnebago River Watershed.

Point Sources

Point sources are defined as facilities that discharge stormwater or wastewater to a lake or stream and have a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit (Permit). The regulated sources of P, sediment, nitrate and *E. coli* within the subwatersheds of the impairments include WWTP effluent, NPDES feedlots, construction stormwater, and industrial stormwater (Table 8). At the writing of this report, there are no Municipal Separate Storm Sewer Systems (MS4s) or NPDES-permitted Industrial facilities in the Winnebago River Watershed.

Additional information on pollutant loading from point sources is provided in the following subsections. Pollutant loading data from wastewater treatment facilities ([WWTFs] 2000 through 2018) are provided in Appendix 6.2.

Table 8. Permitted point sources in the Winnebago River Watershed.

Point Source Name	Permit #	Type	Receiving water body	Water body impairments in same watershed as facility
Conger WWTF	MN0068519	WWTP	Bear Lake	Eutrophication (TP)
Emmons WWTF	MN0023311	WWTP	Lime Creek	Eutrophication (TP) Bacteria (*E. coli*)

NPDES-permitted feedlots not listed as they are a zero discharge facility.

WWTPs

Individual wasteload allocations (WLAs) were provided for the two NPDES-permitted WWTFs that discharge within a P impaired stream subwatershed, including 1) the Conger WWTF in the Steward Creek/CD 23 stream system and 2) the Emmons WWTF in the Lime Creek stream system. The MPCA recently completed a watershed-based review of TP effluent limits for both facilities. Currently, the Conger WWTF has an annual TP limit of 158 pounds per year. The MPCA has determined that a more restrictive TP limit is not presently needed. The Emmons WWTF is a continuous mechanical system with a design flow of 0.124 mgd. At the writing of this report, Emmons WWTF did not have a TP limit. As part of the TMDL process, a TP limit for the Emmons WWTF was established by MPCA for a limit of 2.43 pounds per day (1.1 kg/day). This new TP effluent limit for Emmons WWTF should be attainable as this facility currently discharges only about 0.38 kg/d, on average, during the summer, about a third of their new 1.1 kg/d limit. When the Emmons WWTF permit is renewed in May 2023, the new TP limit will be added as a permit condition.

Construction Stormwater

Construction stormwater is regulated by NPDES permits (MNR100001) for any construction activity disturbing: (a) one acre or more of soil, (b) less than one acre of soil if that activity is part of a "larger common plan of development or sale" that is greater than one acre, or (c) less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. The WLA for stormwater discharges, from sites where there are construction activities, reflects the number of construction sites greater than one acre in size that are expected to be active in the impaired lake or stream subwatershed at any one time. Over the past five years, the average annual fraction of the watershed area under construction activity was calculated to be 0.25% of the watershed.

Animal Feeding Operations

CAFOs are defined by the EPA based on the number and type of animals. The MPCA currently uses the federal definition of a CAFO in its permit requirements of animal feedlots along with the definition of an animal unit (AU). In Minnesota, the following types of livestock facilities are required to operate under a NPDES permit or a state issued SDS Permit: a) all federally defined CAFOs that have had a discharge, some of which are under 1,000 AUs in size; and b) all CAFOs and nonCAFOs that have 1,000 or more AUs.

CAFOs and AFOs with 1,000 or more AUs must be designed to contain all manure contaminated runoff from precipitation events of less than a 25-year, 24-hour storm event. Having and complying with an NPDES permit allows some enforcement protection if a facility discharges due to a 25-year, 24-hour precipitation event and the discharge does not contribute to a water quality impairment. Large CAFOs permitted with an SDS permit or those not covered by a permit must contain all runoff, regardless of the precipitation event. Therefore, many large CAFOs in Minnesota have chosen to have a NPDES permit, even if discharges have not occurred in the past at the facility. A current manure management plan that complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and AFOs with 1,000 or more AUs.

CAFOs are inspected by the MPCA in accordance with the MPCA NPDES Compliance Monitoring Strategy, approved by the EPA. All CAFOs (NPDES permitted, SDS permitted, and not required to be permitted) are inspected by the MPCA on a routine basis with an appropriate mix of field inspections, offsite monitoring, and compliance assistance.

Table 9. Winnebago River Watershed NPDES-permitted CAFOs.

Permit ID	Name	Animal Type	Animal Units
MNG440526	Gary & Mary Chicos Farm	Swine	1179
MNG441029	Kjell Mattson Farm 2	Swine	750
MNG440443	Kjell Mattson Farm	Swine	1890
MNG441056	Perschbacher Hog Farm – Sec 10	Swine	1200
MNG441961	John Perschbacher Hog Farm - Conger	Swine	1500
MNG442059	Precision Pork Producers Inc	Swine	1420.6

Nonpoint Sources

Nonpoint pollution sources, unlike pollution from industrial and municipal sewage treatment plants, comes from many different sources. Nonpoint-source pollution is caused by rainfall or snowmelt moving over and through the ground from a number of diffuse sources. As the runoff moves, it picks up and carries away natural and human-caused pollutants and deposits them into lakes and streams. In the Winnebago River Watershed, the primary pollutants leading to impairments and stressing aquatic life are suspended solids (including algae), P, nitrate and bacteria (*E. coli*).

E. coli

The following text, which provides an overview of nonpoint sources of fecal coliform and *E. coli* bacteria and associated pathogens, is excerpted from *the Revised Regional TMDL Evaluation of Fecal Coliform*

Bacteria Impairments in the Lower Mississippi River Basin in Minnesota (MPCA 2006), and adapted with new information. At the time the 2006 MPCA study was conducted, Minnesota's water quality standard was based on fecal coliform as indicators of fecal pathogens; the standard has since changed and is now based on *E. coli* counts.

The relationship between land use and fecal coliform concentrations found in streams is complex, involving both pollutant transport and rate of survival in different types of aquatic environments. Intensive sampling at numerous sites in southeastern Minnesota shows strong positive correlations among stream flow, precipitation, and fecal coliform bacteria concentrations. In the Vermillion River Watershed, storm-event samples often showed concentrations in the thousands of organisms per 100 mL, far above non-storm event samples. A study of the Straight River Watershed divided sources into continuous (failing subsurface sewage treatment systems (SSTS), unsewered communities, industrial and institutional sources, WWTFs) and weather-driven (feedlot runoff, manured fields, urban stormwater) categories. The study hypothesized that when precipitation and stream flows are high, the influence of continuous sources is overshadowed by weather-driven sources, which generate extremely high fecal coliform concentrations. However, the study indicated that during drought, continuous sources can generate high concentrations of fecal coliform. Besides precipitation and flow, factors such as temperature, livestock management practices, wildlife activity, fecal deposit storage, and channel and bank storage also affect fecal bacterial concentrations in runoff (Baxter-Potter and Gilliland 1988).

Fine sediment particles in the streambed can serve as a substrate harboring fecal coliform bacteria. "Extended survival of fecal bacteria in sediment can obscure the source and extent of fecal contamination in agricultural settings" (Howell et al. 1996). Sadowsky et al. (2010) studied reproduction and survival of *E. coli* in ditch sediments and water in Minnesota's Seven Mile Creek Watershed (Nicollet County, Minnesota); their work concluded that while cattle are likely major contributors to fecal pollution in the sediments of Seven Mile Creek, it is also likely that some *E. coli* strains reproduce in the sediments and thus some sites probably contain a mixture of newly acquired and resident strains. A study by Chandrasekaran et al. (2015) continued research in the Seven Mile Creek Watershed. Results from this study concluded that populations of *E. coli* can exist in ditch sediments as temporal sinks and be a source of fecal bacteria to streams. Because the Winnebago River and Seven Mile Creek watersheds are both located in the same south-central region of Minnesota, the findings from the Seven Mile Creek Watershed studies could also be represented in the Winnebago River Watershed.

Despite the complexity of the relationship between sources and in-stream concentrations of fecal coliform, the following can be considered major source categories in the Winnebago River Watershed.

<u>Non- NPDES permitted feedlots</u>

Runoff from non-NPDES permitted livestock feedlots, pastures, and land application areas has the potential to be a significant source of fecal coliform bacteria and other pollutants when not properly managed. Facilities raising livestock vary in management styles depending on the types of animals housed. Outside, unroofed areas (open lots) are typically used for dairy and beef operations, while total confinement is traditionally used on swine and poultry facilities. Because open lot facilities are exposed to rain events and snowmelt, they have an increased risk of discharging *E. coli*-contaminated runoff.

All animal feedlots are subject to state feedlot rules, which include provisions for registration, manure management, facility inspection, permitting, and discharge standards. Much of this work is accomplished through a delegation of authority from MPCA to LGUs. On-site feedlot inspections are conducted by compliance staff to verify open lot discharge compliance.

Open lot facilities located in shoreland and/or floodplain are considered highest risk areas for bacterial runoff. Two feedlot facilities are located within shoreland areas of the Winnebago River Watershed; both raising primarily beef livestock. Of the feedlots in the watershed, 40 (72%) are documented as having open lots.

As part of the *Minn. R. ch. 7020* revision in the year 2000, the MPCA administered a program called the Open Lot Agreement, offering feedlot operators enforcement exemptions if open lot improvements were made within a specific time frame. Fifteen feedlots in the Winnebago River Watershed have been enrolled in this program (38% of feedlots with open lots).

The land application of manure can also present an increased risk of *E. coli* runoff into surface and ground waters. *Minn. R. ch. 7020* requires application setback distances, winter application restrictions and incorporation requirements for spreading manure in close proximity to sensitive features (Figure 19).

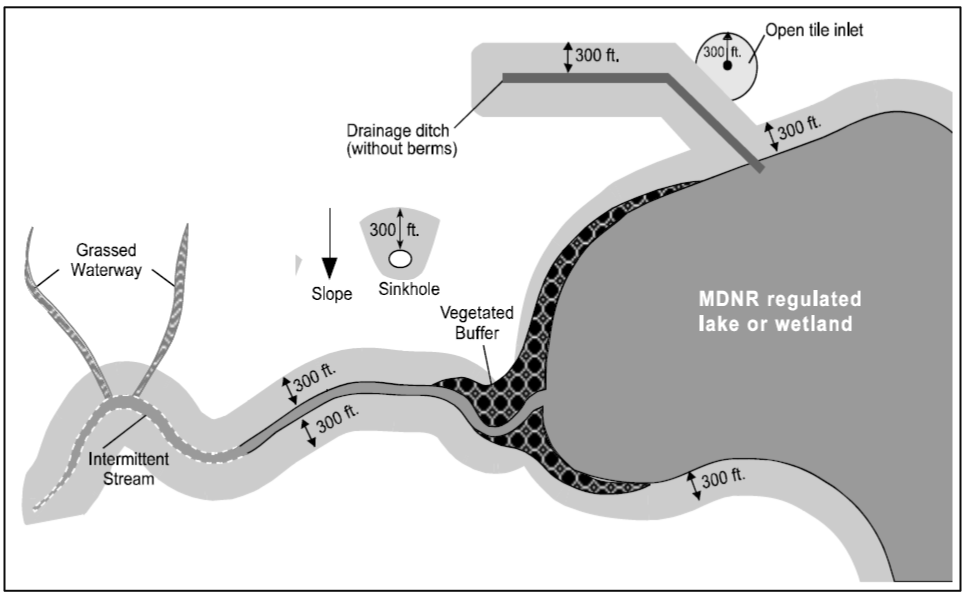


Figure 19. Manure application setback distances around sensitive landscape features. MPCA 2011.

The MDA has recently developed an interactive model to assist livestock producers to evaluate the potential runoff risk for manure applications, based on weather forecasts for temperature and precipitation along with soil moisture content. The model can be customized to specific locations. It is advised that all producers applying manure utilize the model to determine the runoff risk, and use caution when the risk is “medium” and avoid manure application during “high” risk times. For more information and to sign up for runoff risk alerts from the MDA Runoff Risk Advisory Forecast, please see the MDA website.

Nineteen of the fifty-six (34%) active feedlot facilities within the Winnebago River Watershed have been inspected since 2009. This includes one of the feedlot facilities in shoreland. Of those inspected, all facilities were found to be meeting facility discharge requirements. Record inspections for proper manure application rates were also conducted on three feedlots within this time period. All records inspected were report to be compliant. Inspections of the application of animal manure were also conducted within this watershed. Six application inspections were conducted by the County Feedlot Officer between 2012 and 2015. All application inspections were deemed compliant.

Septic Systems

SSTS that are failing can contribute *E. coli* to nearby waters. SSTS can fail for a variety of reasons, including excessive water use, poor design, physical damage, and lack of maintenance. Common limitations that contribute to failure include seasonal high water table, fine-grained soils, bedrock, and fragipan (i.e., altered subsurface soil layer that restricts water flow and root penetration). Septic systems can fail hydraulically through surface breakouts or hydrogeologically from inadequate soil filtration. Most SSTS systems within the Winnebago River Watershed are used for individual homes and residences.

Annual SSTS reports for Freeborn estimate the compliance of SSTS across the county. SSTS compliance has remained fairly consistent for Freeborn County in the last few years. Reported compliance from the past five years indicates that approximately 53% of the SSTS in the County are compliant. Failing SSTS account for approximately 32% of all SSTSs in the County. From 2008 through 2016, an average of 95 SSTS were replaced each year.

Septic systems that discharge untreated sewage to the land surface or directly to streams are considered imminent public health threats (IPHTs). Overall estimated percentages of IPHT are low; approximately 15% of total systems recently reported (Figure 20). IPHT typically include straight pipes, effluent ponding at ground surface, effluent backing up into home, unsafe tank lids, electrical hazards, or any other unsafe condition deemed by certified SSTS inspector. Therefore, it should be noted that not all of the IPHTs discharge pollutants directly to surface waters.

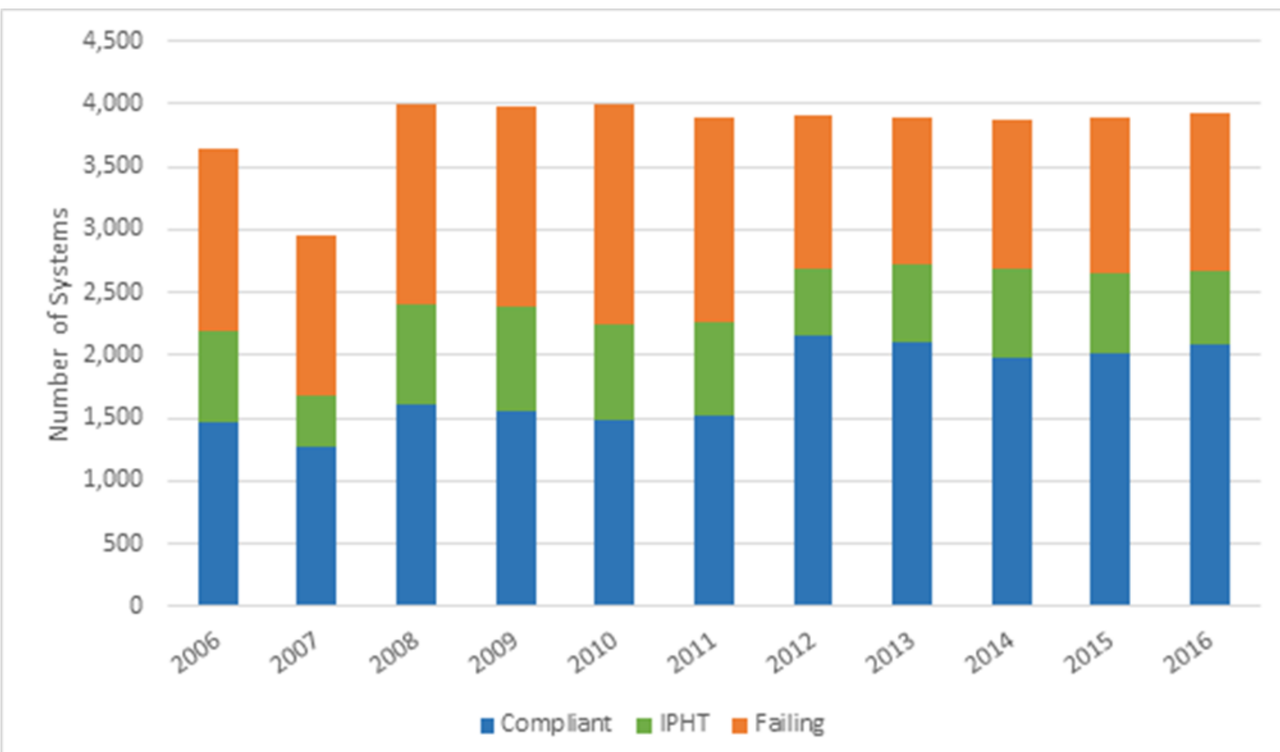


Figure 20. SSTS compliance reported from Freeborn County 2000-2016.

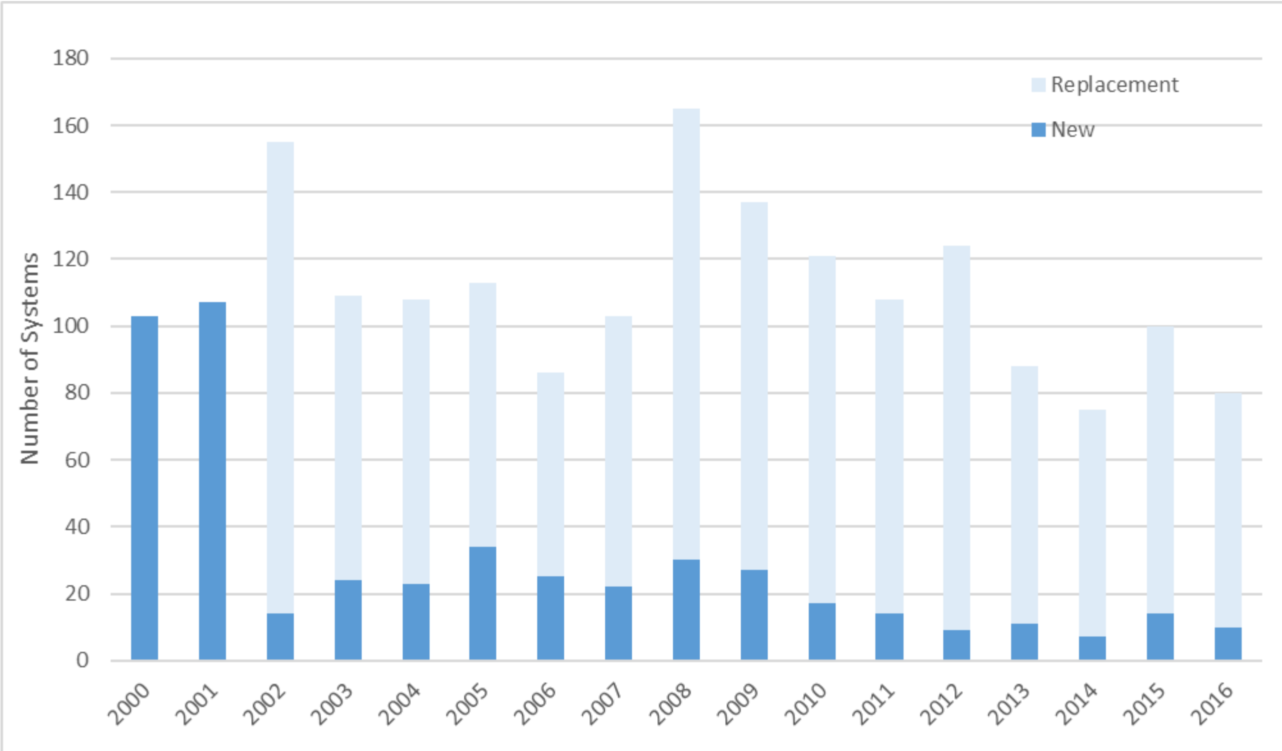


Figure 21. New and replaced SSTS reported for Freeborn County 2000-2016.

<u>Wildlife Fecal Runoff</u>

Sources of fecal contamination can originate from dense/localized populations of wildlife, such as deer or geese. Wildlife staff estimated the pre-fawn deer population in the majority of the Winnebago River Watershed to be about four to five deer per square mile (Norton and Giudice 2017). Deer are not evenly distributed across the landscape (Norton and Giudice 2017). In the Winnebago River Watershed, a good deal of permanent deer habitat is largely associated with watercourses, although the direct deposition of fecal material to water would be minor. Most deposition of urine and feces will be scattered in permanent natural habitats where runoff rates are low and the ability of the environment to assimilate the deposition is greatest.

Phosphorus

P is a nutrient that fuels algae and plant growth. While not directly harmful to aquatic life, excess P can lead to excessive algae growth and eutrophication. A major pathway of P to surface waters is through sedimentation. Molecular bonds adhere P to sediment and allow movement of P in runoff during precipitation events or snowmelt. P is also commonly applied to cropland as a supplemental fertilizer in the form of animal manure or commercial fertilizer. P from cropland can enter surface waters through two general pathways: surface runoff during precipitation/snowmelt and a lesser extent, subsurface (drain tile) discharge.

Different forms of P can indicate the origins of a P source. Natural background P sources include surface runoff and atmospheric deposition of windblown particulate matter from the natural landscape, and background stream-channel erosion. Internal loading of P in upstream lakes is an additional P source that can be both anthropogenic and natural in origin, and is primarily caused by P releasing from lake sediments or aquatic plants. Human-made influences typically include state and federal permitted discharges from wastewater, industrial and commercial entities, urban development, impervious surfaces (roads, roofs, and driveways), stormwater from artificial drainage on urban and agricultural lands, row cropping, pastured lands, individual sanitary-treatment systems, feedlots, and channelized streams/ditches.

Minnesota's NRS was completed in 2014. The NRS outlines goals and milestones for P reductions and strategies that will be used to meet the reductions. To address downstream impacts, the NRS set a goal of reducing P loading by 45% by 2040. Since the baseline period, a 33% reduction has been realized mainly through point source reductions. A 12% reduction of P is still needed. Based on SPARROW modeling from the NRS, the Winnebago River Watershed needs a P reduction of 1.5 metric tons (MT) per year to reach the remaining 12% n goal.

Nonpoint source pollution from cropland land use is the most dominant pollutant source in the watershed (Table 10). A detailed breakdown of P loading from the subwatershed of HSPF Reach 273 is provided in Figure 22, as an example of the dominant pollutant sources in the watershed. The 2019 Winnebago River Watershed TMDL Study used the HSPF model to identify the relative contribution of point and nonpoint P and *E. coli* sources to the watershed's impaired streams and lakes.

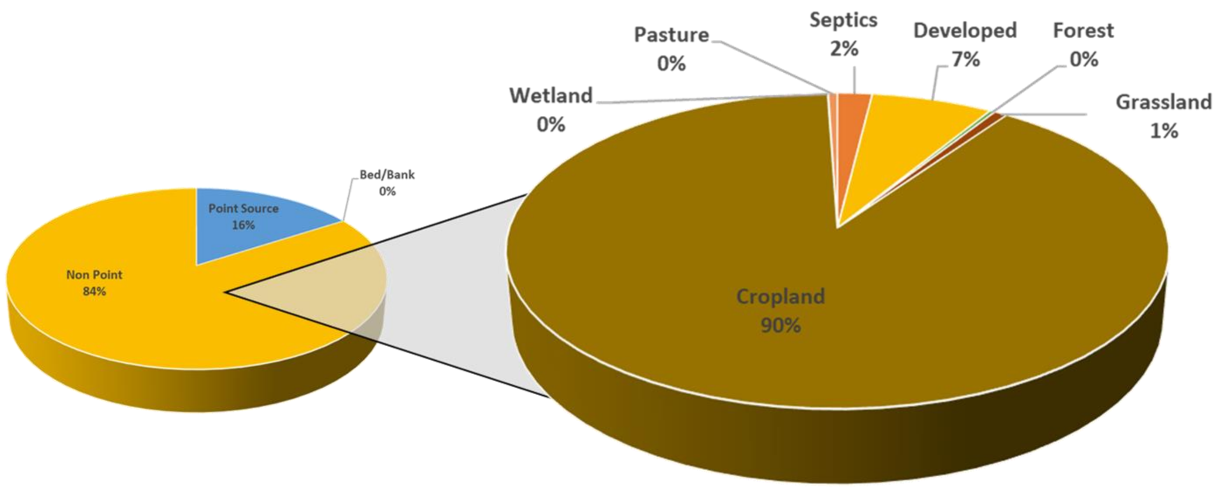


Figure 22. Phosphorus contributions from point versus nonpoint sources – HSPF Reach 273.

Table 10. Winnebago River HSPF model percent contribution to total phosphorus load leaving the HSPF subwatershed by HSPF Reach Number.

HSPF Reach #	Upland Nonpoint	Feedlot	Septics	Point Source	Atm. Dep.*	Internal*
A251	97.8%	0.1%	1.5%	0.5%	0.0%	0.0%
A253	98.1%	0.5%	1.4%	0.0%	0.0%	0.0%
A255	98.0%	0.6%	1.5%	0.0%	0.0%	0.0%
A257	97.6%	0.8%	1.6%	0.0%	0.0%	0.0%
A260	96.3%	0.5%	2.1%	0.0%	0.0%	1.1%
A270	98.4%	0.0%	1.6%	0.0%	0.0%	0.0%
A271	98.0%	0.1%	1.9%	0.0%	0.0%	0.0%
A272	93.0%	0.0%	3.1%	0.0%	0.0%	3.8%
A273	82.5%	0.0%	1.6%	15.9% **	0.0%	0.0%
A290	97.4%	0.8%	1.8%	0.0%	0.0%	0.0%
A291	97.9%	0.2%	1.9%	0.0%	0.0%	0.0%
A310	97.5%	0.0%	2.5%	0.0%	0.0%	0.0%

*** Independent estimates of atmospheric deposition and internal loading in Bear (A260) and State Line (A272) Lakes were made using BATHTUB because HSPF tends to underestimate this phosphorus source (see Section 4.2.1 of the TMDL)**
**** Emmons WWTP (see Section 4.2.3.5 of the TMDL)**

Internal Loading in Lakes

Internal loading in lakes refers to the P within a lake's bottom sediments or aquatic plants that is released back into the water column. Internal loading can occur via:

- *Chemical release from bottom sediments:* Caused by anoxic (lack of oxygen) conditions in the overlying water column layers or high pH (greater than nine). If a lake's hypolimnion (bottom area) remains anoxic for a portion of the growing season, the P released due to anoxia will be distributed throughout the water column during fall mixing. In shallow lakes, the periods of anoxia can last for short periods of time and occur frequently.
- *Physical disturbance of bottom sediments*: Caused by bottom-feeding fish behaviors (such as carp and bullhead), motorized boat activity, and wind-driven mixing/wave action. This is more common in shallow lakes than in deeper lakes.

In shallow lakes, like those in the Winnebago River Watershed, the biological components of lakes (such as microbes, algae, aquatic plants, zooplankton and other invertebrates, and fish) are distributed throughout the lake, along the shoreline, and on the bottom sediments. These biological components are more concentrated into less volume and consequently exert a stronger influence on the ecological interactions within the lake. There is a more dense biological community at the bottom of shallow lakes than in deeper lakes, because of the fact that oxygen is replenished in the bottom waters and light can often penetrate to the bottom. These biological components can control the relationship between P and the response variables (algae and water clarity). Due to the extremely shallow nature of Bear and State Line Lakes, internal loading is most likely due to physical disturbance from benthic feeding fish (common carp) and lack of aquatic plant growth.

Atmospheric deposition

Atmospheric deposition represents the P that is bound to particulates in the atmosphere and is deposited directly onto surface waters. In the Cedar River Basin atmospheric deposition accounts for 0.145 pounds per acre per year in dry years and up to 0.177 pounds per acre per year in wet years.

Sediment

Sediment is an important factor for addressing turbidity, degraded aquatic habitat and eutrophication. While the quantity of sediment is not enough to cause a TSS impairment in the Winnebago River Watershed, sediment is impacting aquatic habitat and introducing P (resulting in eutrophication). While generally the majority of the TSS impairments are related to sediments such as silts and clays, in certain conditions algae growth and decay could also contribute to TSS impairments. This condition is more pronounced in low flow conditions, downstream from impoundments such as Bear Lake. The TSS impairment on Lime Creek (AUID: 07080203-501) is linked to Bear Lake eutrophic conditions since the creek is the outflow of the lake. Sediment reductions will be needed to address aquatic habitat conditions and eutrophication in the other impaired stream reaches.

HSPF modeling results indicate that upland nonpoint sources contribute 85-91% of subwatershed total sediment loads (Table 11). A geomorphology study conducted by DNR (2017) citied that even though the modified streams in the watershed were channelized, stream bank erosion was minimal. Sediment introduced via subsurface cropland tile drainage discharges (through surface tile intakes) represents another vector of sediment delivery to downstream resources. Sediment loading from WWTFs (2000 through 2018) is provided in Appendix 6.2. A detailed breakdown of sediment loading from the subwatershed of HSPF Reach 273 is provided in Figure 23.

Table 11. Winnebago River HSPF model percent contribution to total suspended solid load leaving the HSPF subwatershed by HSPF Reach Number.

HSPF Reach #	Upland NonPoint	Feedlot	Septics	Cropland Tile Drainage	Point Source	Atm. Dep.	Internal
A251	91.0%	0.2%	0.0%	8.5%	0.0%	0.0%	0.3%
A253	90.2%	0.5%	0.0%	8.6%	0.0%	0.0%	0.7%
A255	90.4%	0.6%	0.0%	8.5%	0.0%	0.0%	0.6%
A257	90.4%	0.9%	0.0%	8.5%	0.0%	0.0%	0.2%
A260	29.4%	0.2%	0.0%	2.8%	0.0%	0.0%	67.7%*
A270	86.9%	0.0%	0.0%	8.2%	0.0%	0.0%	4.8%
A271	91.1%	0.1%	0.0%	8.6%	0.0%	0.0%	0.1%
A272	14.2%	0.0%	0.0%	1.3%	0.0%	0.0%	84.5%*
A273	90.2%	0.0%	0.0%	8.4%	0.9%	0.0%	0.4%
A290	85.2%	1.0%	0.0%	9.3%	0.0%	0.0%	4.5%
A291	89.4%	0.3%	0.0%	10.0%	0.0%	0.0%	0.3%
A310	90.2%	0.0%	0.0%	9.8%	0.0%	0.0%	0.0%

*** Algae derived suspended solids from impaired, shallow lakes (Bear and State Line) with algae levels that greatly exceed state standards)**

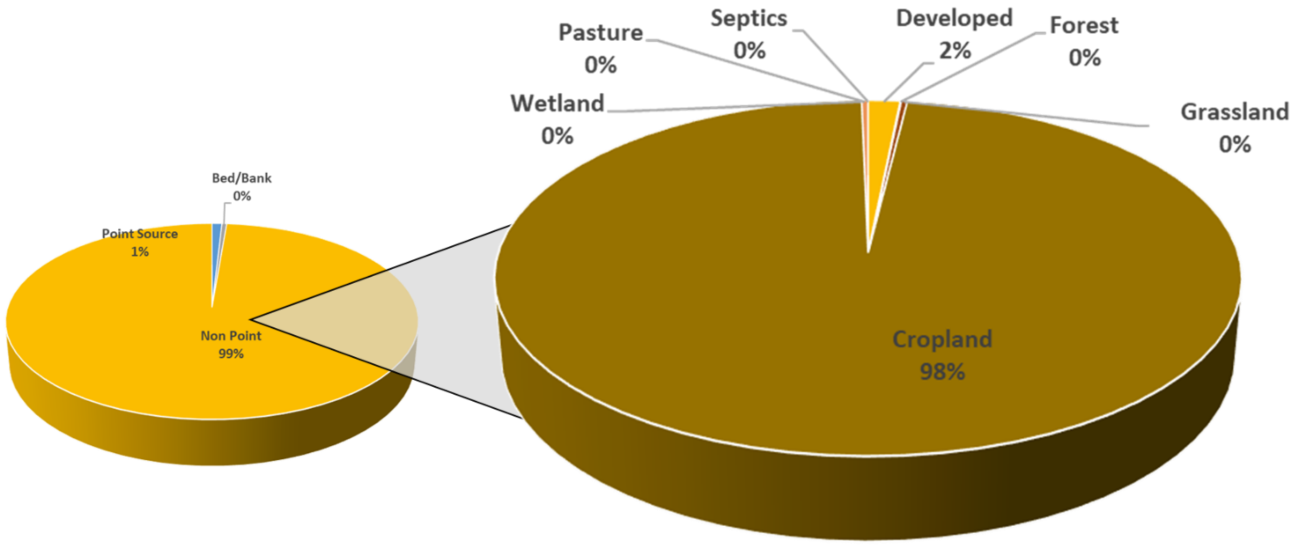


Figure 23. Sediment contributions from point versus nonpoint sources – HSPF Reach 273.

Areas of the watershed where wind-erodible soils and whole soil erodibility (K Factor) are most likely are presented in Figures 24 and 25. Strategies to minimize sediment from these highly erodible areas are described in Section 3.3.

The wind erodibility index is a numerical value representing the susceptibility of soil to wind erosion. The higher the number, the more prone the soil is to wind erosion.

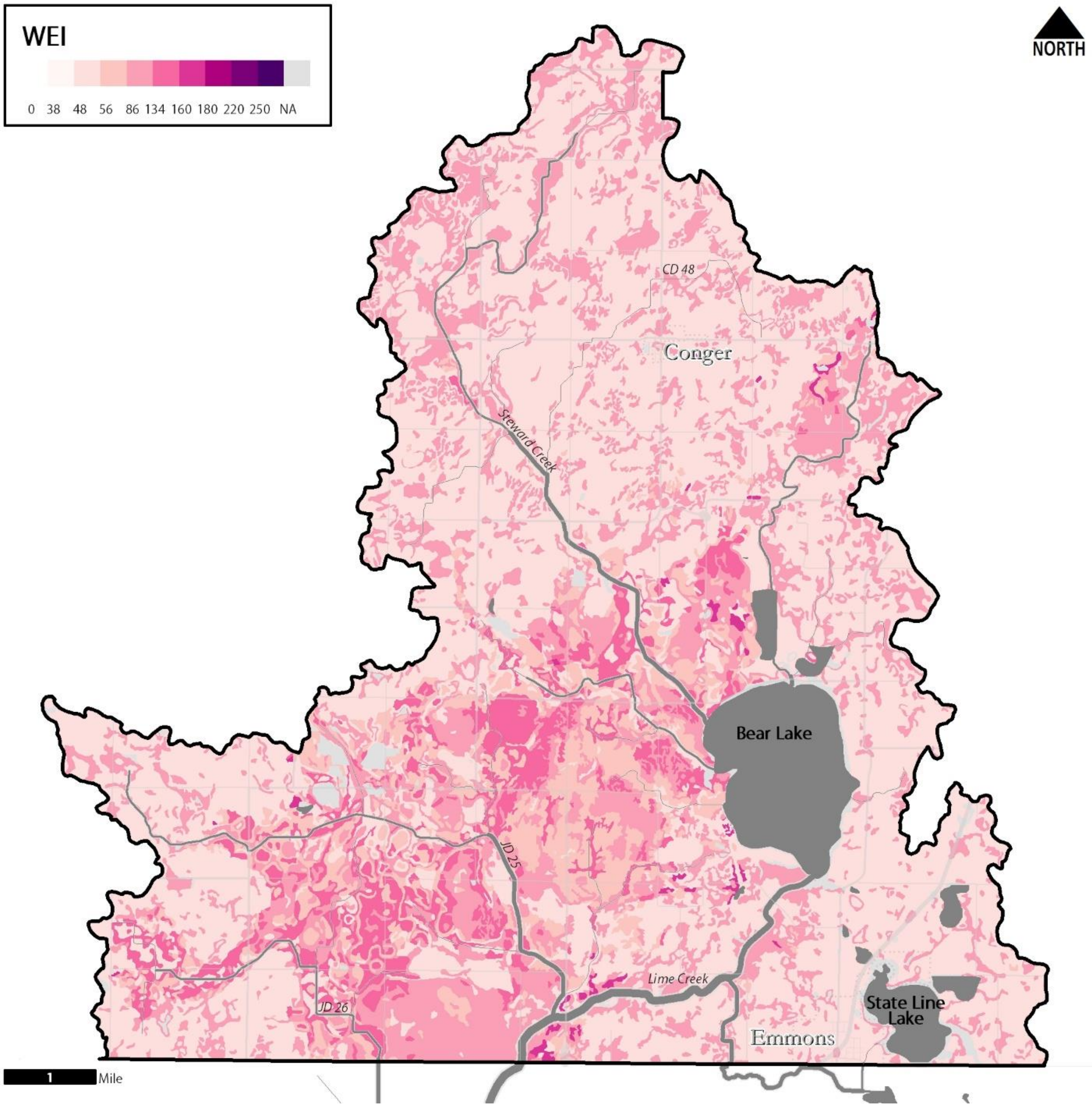


Figure 24. Wind Erosion Index in the Winnebago River Watershed.

A whole soil K Factor assigns erosion potential. Values of .05 to .25 mean low erosion potential, .25 to .4 are moderate and above .4 is high erosion potential.

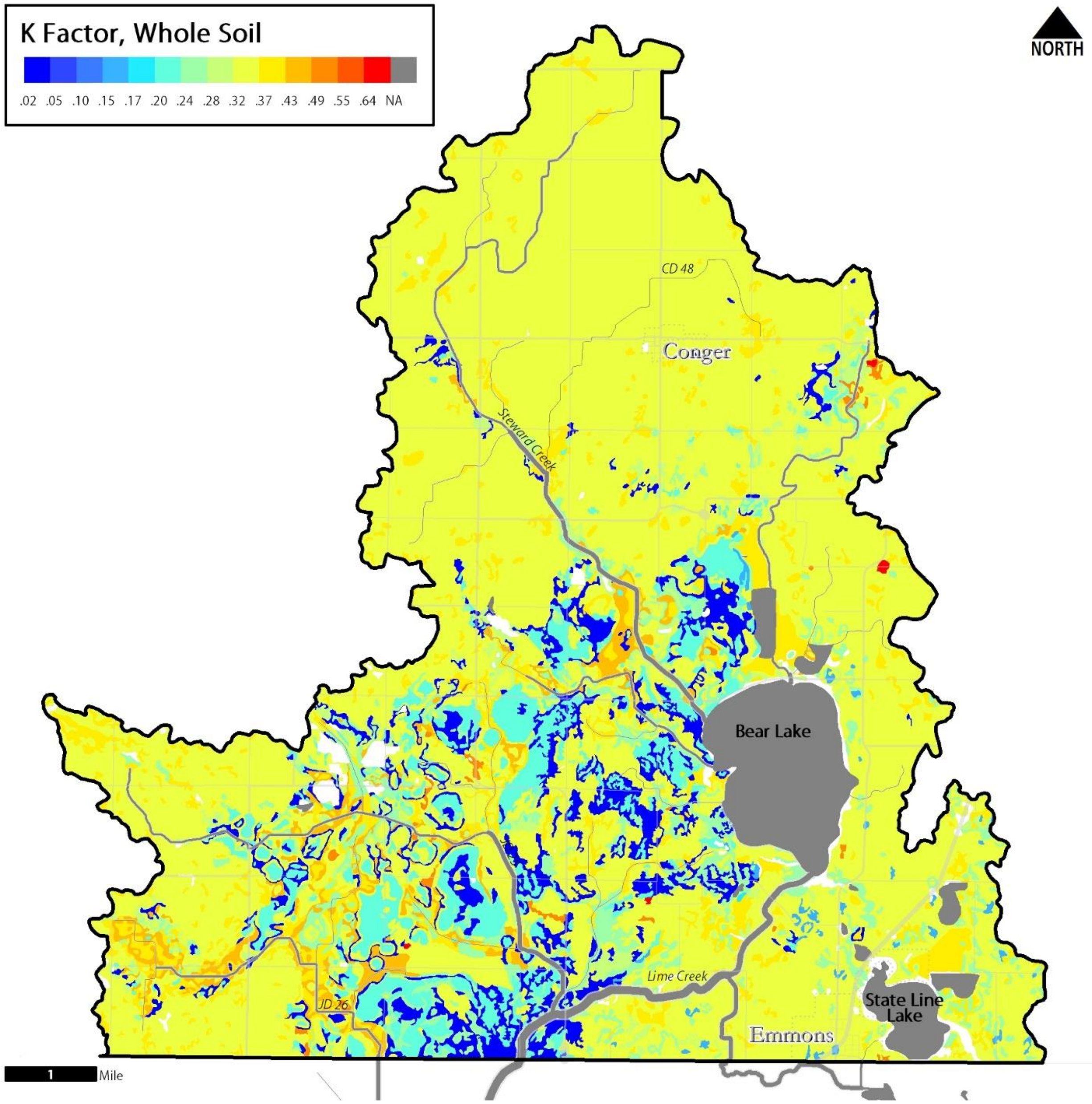


Figure 25. Whole soil K Factor for the Winnebago River Watershed.

Nitrogen/Nitrate

N exists in the environment and water in numerous forms, including ammonia, nitrite, and nitrate. Organic N exists naturally in the environment as soil organic matter and/or decaying plant residue. The N cycle is the process in which N changes from one form to another; allowing particular forms of N to move easier within the environment (Figure 26). Nitrate is the form of N of most concern in water. Nitrates pose risks to humans in drinking water, such as the risk of methemoglobinemia (i.e., "blue baby syndrome") in infants and susceptible adults, are toxic to aquatic life in large quantity, and have contributed to low oxygen, or hypoxic conditions, in coastal areas such as the Gulf of Mexico. Transformations among the different forms of N occur constantly in the water cycle. Because of this constant cycle, N it is often considered in totality as "total nitrogen" (TN).

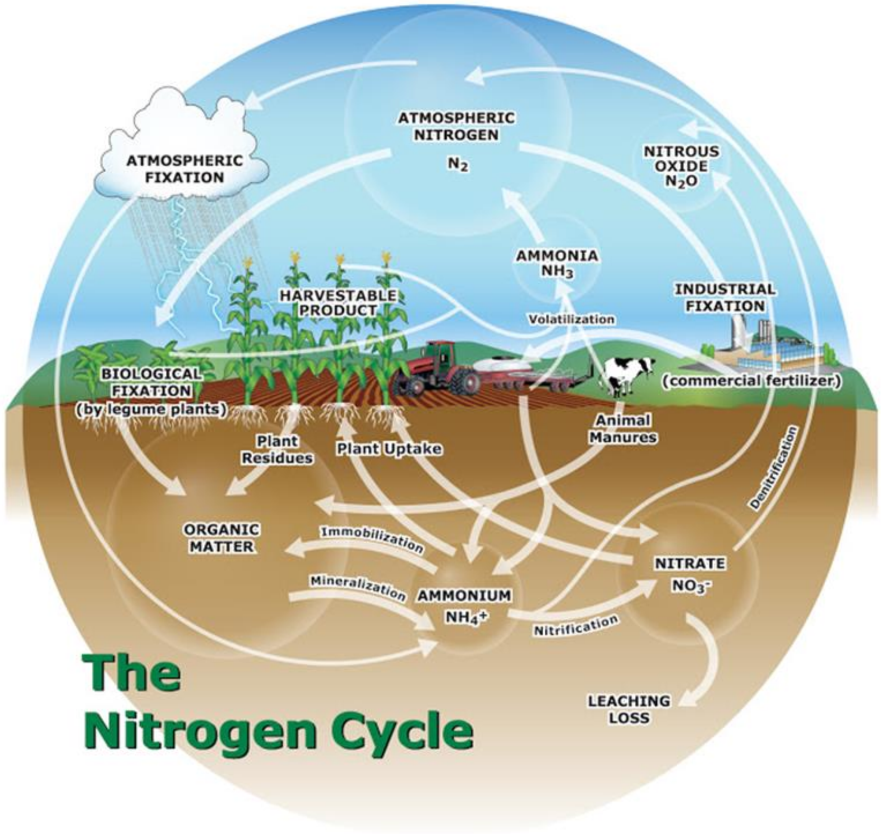


Figure 26. The nitrogen cycle; Cates 2019.

The State of Minnesota has diligently studied N and its impact to the environment. Minnesota's NRS, as called for in the 2008 Gulf of Mexico Hypoxia Action Plan, was completed in 2014. Minnesota contributes the sixth highest N load among all states to the Gulf, and is 1 of 12 member states serving on the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. The scientific foundation of information for the N component of the NRS is represented in the 2013 report, "Nitrogen in Minnesota Surface Waters" (The Nitrogen Study). This document will be useful as the MPCA and other state and federal organizations further their N -related work, and also as local governments consider how high N levels might be reduced in their watersheds.

The N study and the NRS state that cropland N losses through agricultural tile drainage and agricultural groundwater (leaching loss from cropland to local groundwater) make up the majority of N sources in Minnesota (Figure 27). These conclusions are critical when considering appropriate tools and strategies for managing N.

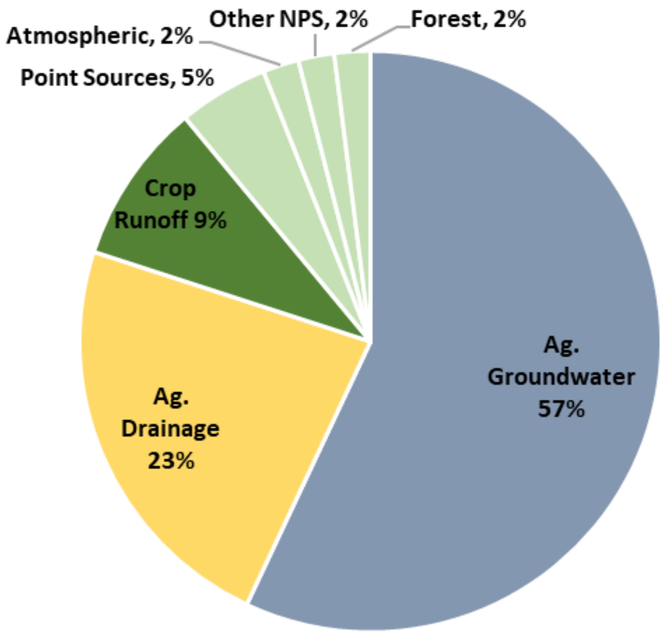


Figure 27. Estimated nitrogen sources to surface waters from the Minnesota contributing areas of the Lower Mississippi River Basin (avg. precipitation year); MPCA 2013.

Minnesota's statewide N reduction goals are 20% by 2025 and 45% by 2040. Modeling conducted for the NRS estimated that the Winnebago River Watershed has a current N load of 817.5 MT/yr. and a reduction goal of 163.5 MT/yr. The state of Iowa also has a nitrate reduction goal set forth by the 2006 Cedar River Nitrate TMDL. A reduction of 35% in nitrate is the end objective.

N from cropland groundwater, drainage and runoff comes from a variety of sources (Figure 28). Assessing N sources statewide, the MPCA (2013) determined that commercial fertilizer represents the largest source of N that is added to soil. Manure, legumes, and atmospheric deposition are also significant sources, and when added together provide similar N amounts as the fertilizer additions. Soil organic matter mineralization is not an N source in itself, but rather a process that mobilizes large quantities of N from the soil bank. While mineralization is an ongoing natural phenomenon, the increase in tile drainage has resulted in an increase transport of this N to surface waters. Septic systems, lawn fertilizers and municipal biosolids add comparatively small amounts of N to soils statewide (less than 1% of added N).

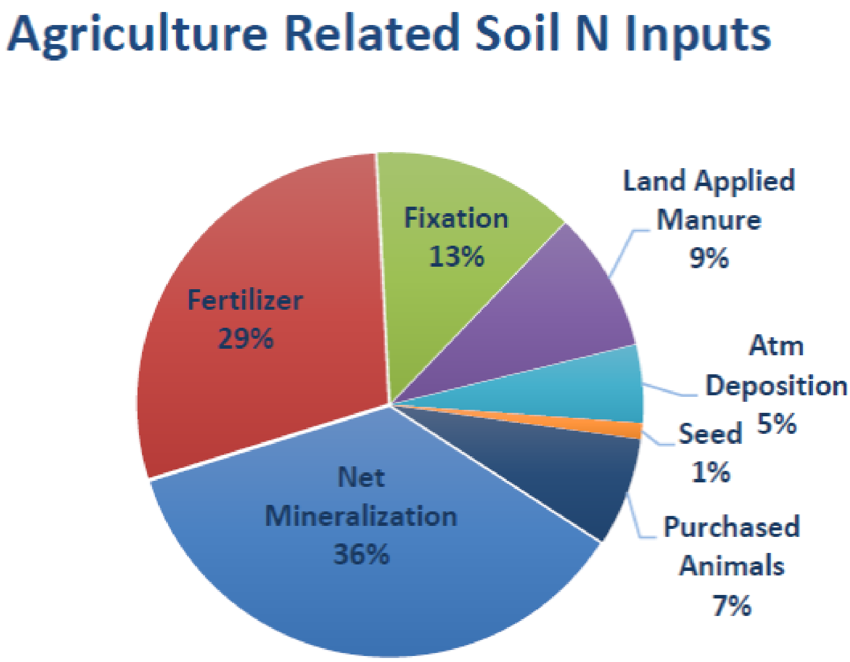


Figure 28. Nitrogen inputs to agricultural soils (state-wide); MPCA 2019.

The MDA surveyed farmers across Minnesota about commercial N applications on corn and manure use practices (MDA 2017a). Responses included information about rates, applications, incorporations, types of manure and other management decisions based on manure use on corn acres. In Freeborn County, 47 participants operating about 15,000 acres responded to the survey. Average commercial N fertilizer application rate for corn following soybeans was 155 lbs/acre; 167 lbs/acres for corn following corn.

Agricultural tile provides a pathway for the N to reach streams. In the greater Cedar River Basin (which the Winnebago River Watershed is a part of), 51% of the nitrate reaches surface waters through cropland tile drainage.

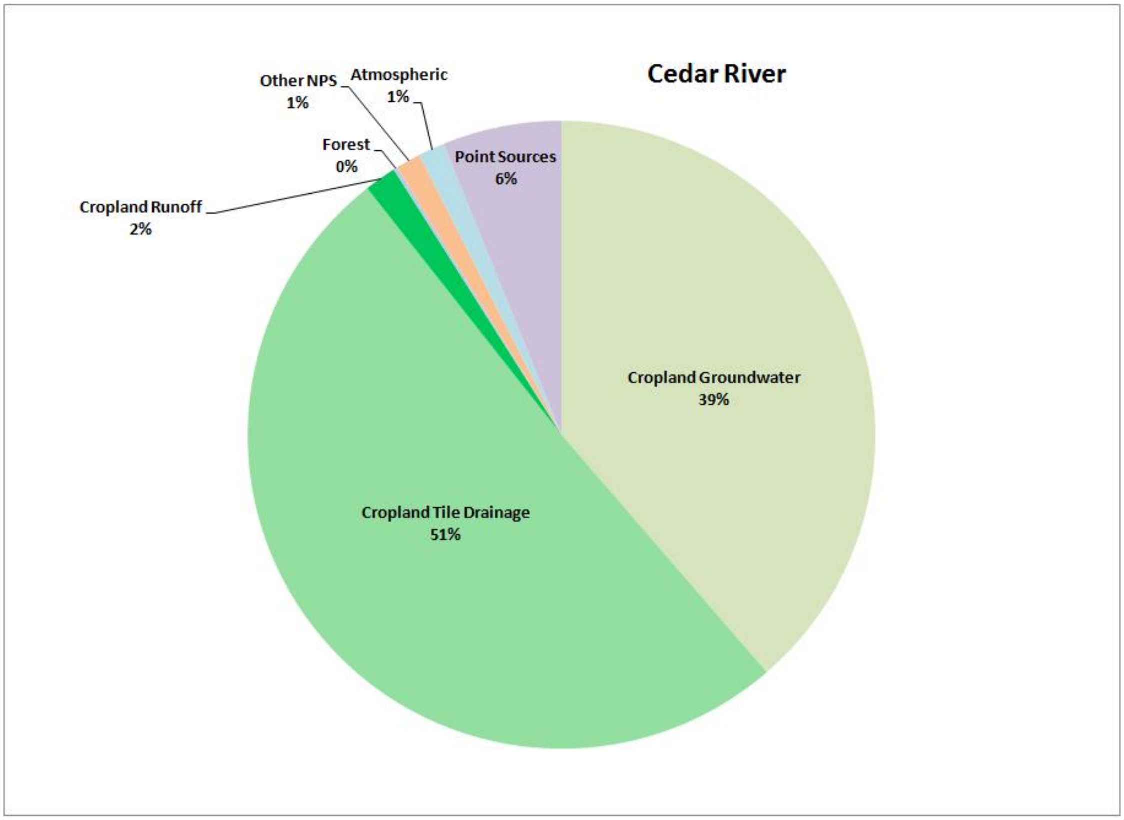


Figure 29. Nitrogen sources in the Cedar River Basin; MPCA 2013.

The State of Minnesota regulates animal manure by using land application nitrogen rate recommendations and location restrictions though Feedlot Rules (Minn. R. ch. 7020). Rate recommendations for manure follow the University of Minnesota's (UMN) recommendations for N. The Winnebago River Watershed does not contain vulnerable groundwater areas or DWSMAs, therefore the MDA's Groundwater Protection Rule, approved in 2019, requirements for commercial N fertilizer do not apply.

Similar to sediment and P, almost all of the TN in the Winnebago Watershed is from nonpoint sources, specifically cropland and pasture (Table 12). A detailed breakdown of N loading from the subwatershed of HSPF Reach 273 is provided in Figure 30.

Table 12. Winnebago River HSPF model percent contribution to total nitrogen load leaving the HSPF subwatershed by HSPF Reach Number.

HSPF Reach #	Upland NonPoint	Feedlot	Septics	Point Source	Atm. Dep.	Internal
A251	98.6%	0.1%	0.9%	0.1%	0.2%	0.0%
A253	98.5%	0.4%	0.9%	0.0%	0.3%	0.0%
A255	98.4%	0.5%	0.9%	0.0%	0.1%	0.0%
A257	98.2%	0.7%	1.0%	0.0%	0.1%	0.0%
A260	79.3%	0.4%	1.1%	0.0%	16.1%	3.1%*
A270	98.9%	0.0%	0.9%	0.0%	0.1%	0.0%
A271	98.6%	0.1%	1.2%	0.0%	0.1%	0.0%
A272	64.4%	0.0%	1.3%	0.0%	25.5%	8.8%*
A273	98.0%	0.0%	1.2%	0.7%	0.1%	0.0%
A290	98.0%	0.6%	1.2%	0.0%	0.2%	0.0%
A291	98.5%	0.2%	1.2%	0.0%	0.1%	0.0%
310	98.3%	0.0%	1.6%	0.0%	0.2%	0.0%

*** HSPF Reach 260 and 272 are Bear Lake and State Line Lake.**

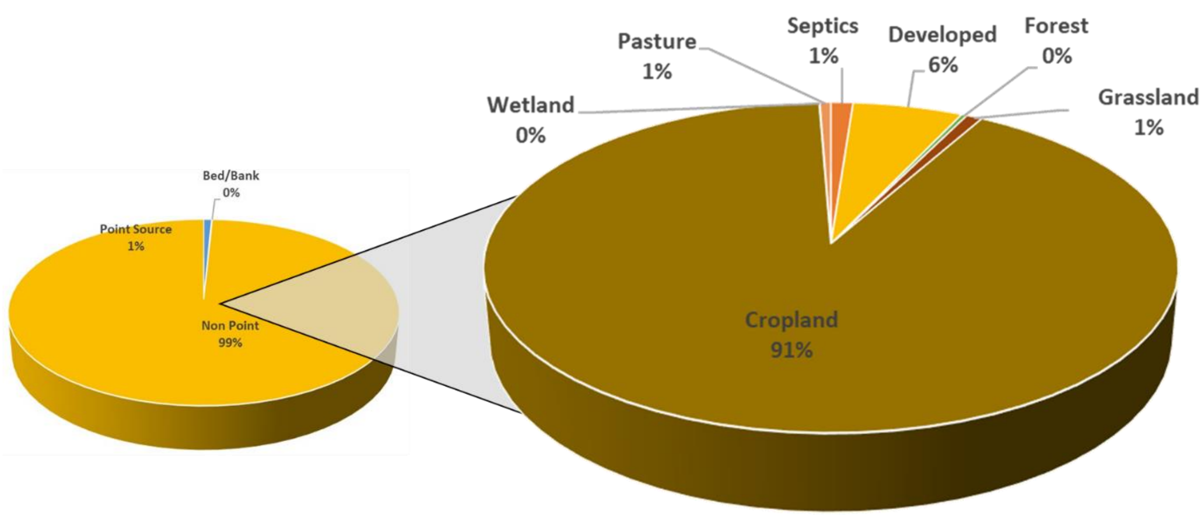


Figure 30. Nitrogen contributions from point versus nonpoint sources – HSPF Reach 273.

Nitrogen Field and plot-scale work by the UMN has sampled subsurface tile water to determine nitrate-nitrogen loading rates for various cropping systems. Over the four years spent monitoring, a continuous corn rotation showed the highest N-loading rate while perennial cover (CRP) showed the lowest; approximately 50 times lower when compared to continuous corn (Figure 31).

Effect of CROPPING SYSTEM on drainage volume, NO_3-N concentration, and N loss in subsurface tile drainage during a 4-yr period (1990-93) in MN.

Cropping System	Total discharge	Nitrate-N Conc.	Nitrate-N Loss
	Inches	ppm	lb/A
Continuous corn	30.4	28	194
Corn – soybean	35.5	23	182
Soybean – corn	35.4	22	180
Alfalfa	16.4	1.6	6
CRP	25.2	0.7	4

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Figure 31. Effect of cropping system on nitrogen loss (UMN).

2.4 TMDL summary

A TMDL is a calculation of how much pollutant a lake or stream can receive before it does not allow recreational uses or support aquatic life. These studies are required by the Clean Water Act for all impaired lakes and streams. The Winnebago River Watershed TMDL study includes three TP TMDLs and one *E. coli* TMDL directly addressing the following impairments included in Minnesota's 2018, 303(d) list:

- aquatic recreation use impairments due to eutrophication (TP) in Bear Lake and State Line Lake,
- aquatic recreation use impairment due to *E. coli* and aquatic life use impairment due to eutrophication (TP) in Lime Creek.

The impairments in the WRW are found in a stream and lake chain system: Steward Creek flows into Bear Lake, and Bear Lake and State Line Lake flow to Lime Creek. As such, improvements in upstream impaired streams and lakes will improve downstream impaired stream and lake water quality. For example, the Bear Lake TP TMDL will improve the TSS impairment in Lime Creek. This approach is appropriate because Lime Creek is the outflow of Bear Lake and TSS is primarily total suspended volatile solids (TSVS); algae produced in Bear Lake.

Additionally, some stream impairments will be addressed through downstream TMDLs. This approach is used because load allocation reductions outlined in the downstream TMDL includes stream tributaries or lake stream inflows. For example, because the DO impaired Judicial Ditch 25 is a tributary to Lime Creek, the impairment is addressed through the Lime Creek TP TMDL.

All impaired streams in the Winnebago River Watershed have one or more parameters contributing to an impairment that are not addressed by the TMDL. This is because there was either not sufficient enough information to link an impairment to a pollutant, pollutant, or the impairment was determined to be caused by a non-pollutant. A list of all impairments in the Winnebago River Watershed are provided in Table 13, along with whether or not a TMDL was developed. Impairments without developed TMDLs are addressed through restoration strategies identified in Section 3.3 of this WRAPS report.

See the Winnebago River Watershed TMDL Report for the existing pollutant loading, wasteload and load allocations, and the load reductions needed to meet water quality goals. The TMDL also provides pollutant source summaries for each impaired stream and lake.

Table 13. Winnebago River Watershed impaired waters with developed TMDLs.

Water Body Name	Reach Description	Stream AUID / Lake ID	Use Class	Year Added to List	Affected Use	Proposed Category	Impaired Waters Listing	Pollutant or Stressor	TMDL Developed (EOR 2020)
Bear Lake	3.5 Miles West of Twin Lakes	24-0028-00	2B, 3C	2018	Aquatic Recreation	4A	Nutrient/ Eutrophication Biological Indicators	Phosphorus	Yes: phosphorus
State Line Lake	At Emmons	24-0030-00	2B, 3C	2018	Aquatic Recreation	4A	Nutrient/ Eutrophication Biological Indicators	Phosphorus	Yes: phosphorus
Lime Creek	Bear Lake to MN/IA Border	501	2Bg, 3C	2018	Aquatic Life	4A	Aquatic macroinvertebrate bioassessments Fish bioassessment	TSS Eutrophication DO Habitat Flow alteration	Yes: addressed via Bear Lake TMDL[a] Yes: addressed via phosphorus TMDL No: addressed via phosphorus TMDL No: nonpollutant stressor No: nonpollutant stressor
							Dissolved oxygen	DO	Yes: addressed via phosphorus TMDL
							Nutrient/ Eutrophication Biological Indicators	Phosphorus	Yes: phosphorus
					Aquatic Recreation	4A	*E. coli*	*E. coli*	Yes: *E. coli*
Steward Creek (CD 23)	Headwaters to Bear Lake	504	2Bg, 3C	2018	Aquatic Life	5*	Aquatic macroinvertebrate bioassessments	Nitrate Eutrophication DO Habitat Flow alteration	No: No standard for 2Bg Yes: addressed via Bear Lake TMDL Yes: Not conclusively linked to phosphorus load but Bear Lake TP TMDL will address DO issue as it relates to eutrophication No: nonpollutant stressor No: nonpollutant stressor
						4A	Dissolved oxygen	DO	Yes: Not conclusively linked to phosphorus load but Bear Lake TP

Water Body Name	Reach Description	Stream AUID / Lake ID	Use Class	Year Added to List	Affected Use	Proposed Category	Impaired Waters Listing	Pollutant or Stressor	TMDL Developed (EOR 2020)
									TMDL will likely address DO issues as it relates to eutrophication.
Judicial Ditch 25	Unnamed Ditch to Unnamed Creek	515	2Bg, 3C	2018	Aquatic Life	4A	Fish bioassessment	Eutrophication DO Habitat Flow alteration	Yes: will be addressed via Lime Creek TMDL No: Not conclusively linked to phosphorus load. No: nonpollutant stressor No: nonpollutant stressor
						4A	Dissolved oxygen	DO	Yes: Insufficient information for eutrophication assessment but Lime Creek TP TMDL will likely address DO issues as it relates to eutrophication.
Unnamed Creek	Judicial Ditch 26 to MN/IA Border	509	2Bg, 3C	2018	Aquatic Life	5	Dissolved oxygen	DO	No: Not conclusively linked to phosphorus load. Insufficient information for eutrophication assessment.

a. Addressing Bear Lake eutrophication will improve Lime Creek TSS (via TVS reductions).

* Unable to propose category 4A because pollutant exceedance (nitrate) is contributing to impairment.

3. Prioritizing and implementing restoration and protection

The CWLA requires that WRAPS reports summarize tools and information useful in targeting actions to improve water quality, and identify point sources and nonpoint sources of pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions. In addition, WRAPS may include a table of strategies that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources.

This section of the report provides the results of such tools for prioritization and strategy development. Because many of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users, and residents of the watershed, it is imperative to create social capital (trust, networks and positive relationships) with those who will be needed to voluntarily implement BMPs. Thus, effective ongoing civic engagement is fully a part of the overall plan for moving forward.

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

3.1 Targeting of geographic areas

The following section describes the specific tools that were used by the Winnebago River Watershed stakeholders to identify, locate and prioritize watershed restoration and protection strategies. Follow-up field reconnaissance will be the next part of the process to validate identified areas.

Critical Area Identification

HSPF

HSPF was used to predict the relative magnitude of TSS, TP, and TN pollution generated in each subwatershed of the Winnebago River Watershed. The HSPF model was also used to evaluate the extent of contributions from point, nonpoint, and atmospheric sources. Sediment, P, and N yields predicted from the HSPF model in the Winnebago River Watershed are mapped in Figure 32 through Figure 34.

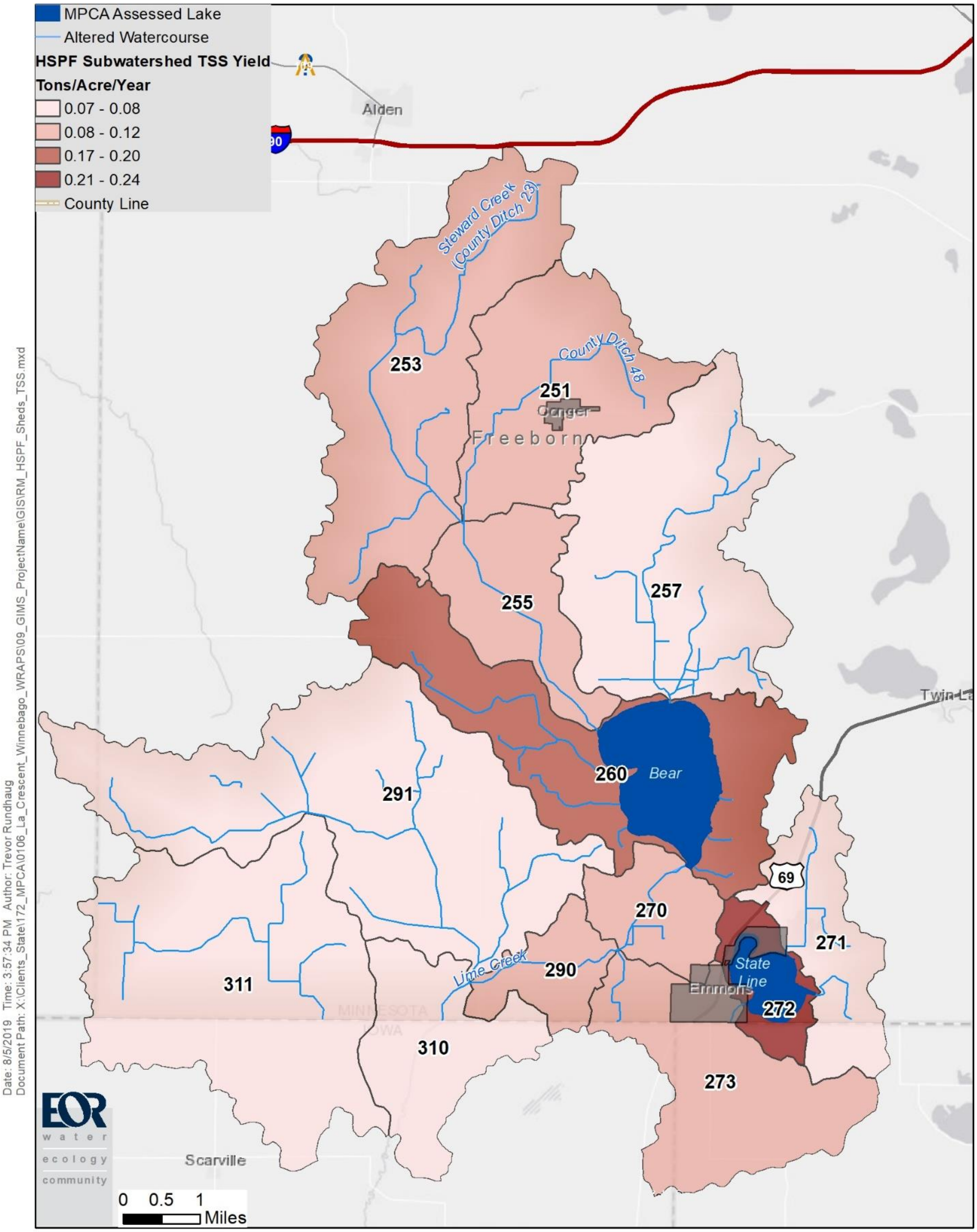


Figure 32. HSPF Total Suspended Solids Yield (tons/acre/year).

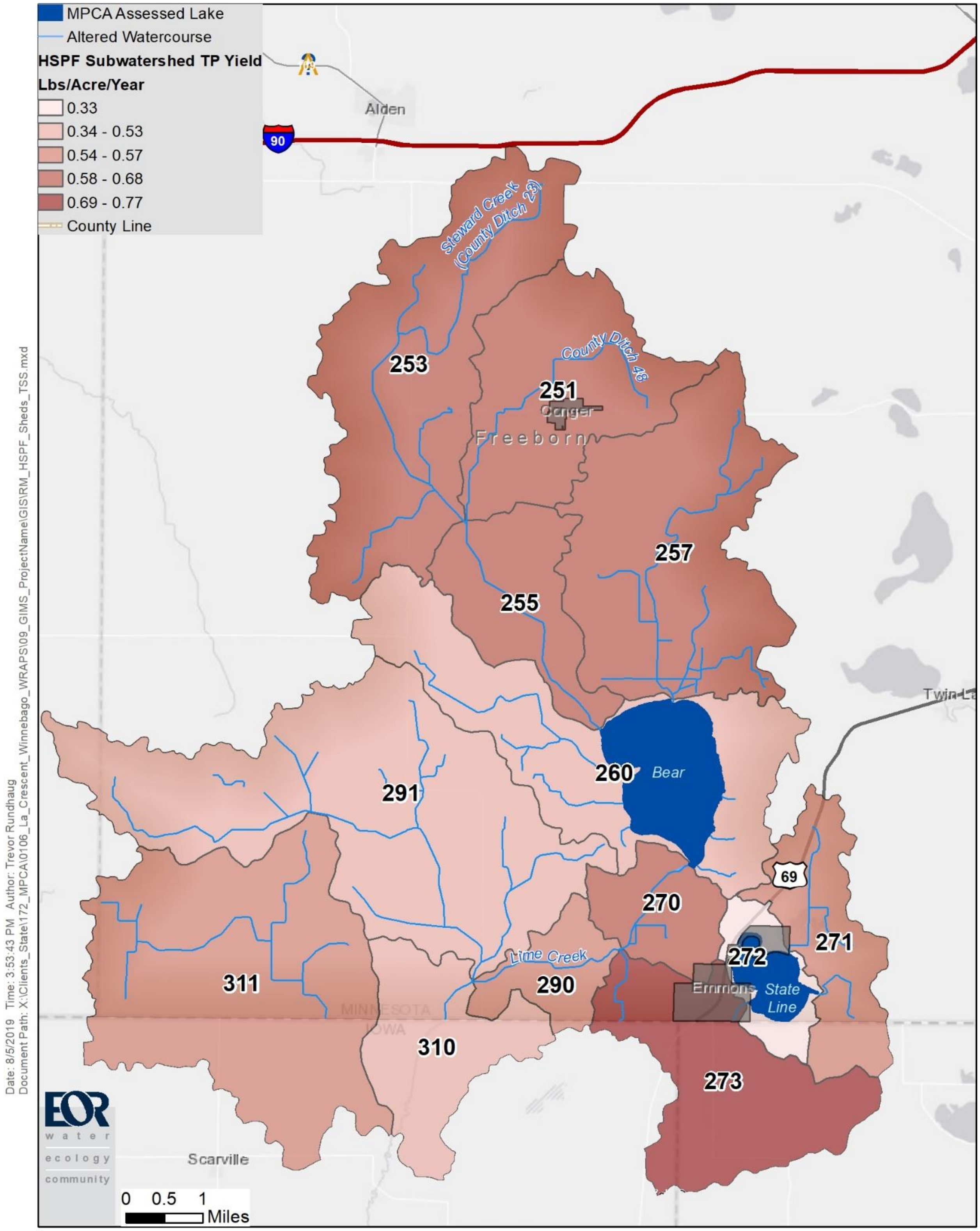


Figure 33. HSPF Total Phosphorus Yield (lbs/acre/year).

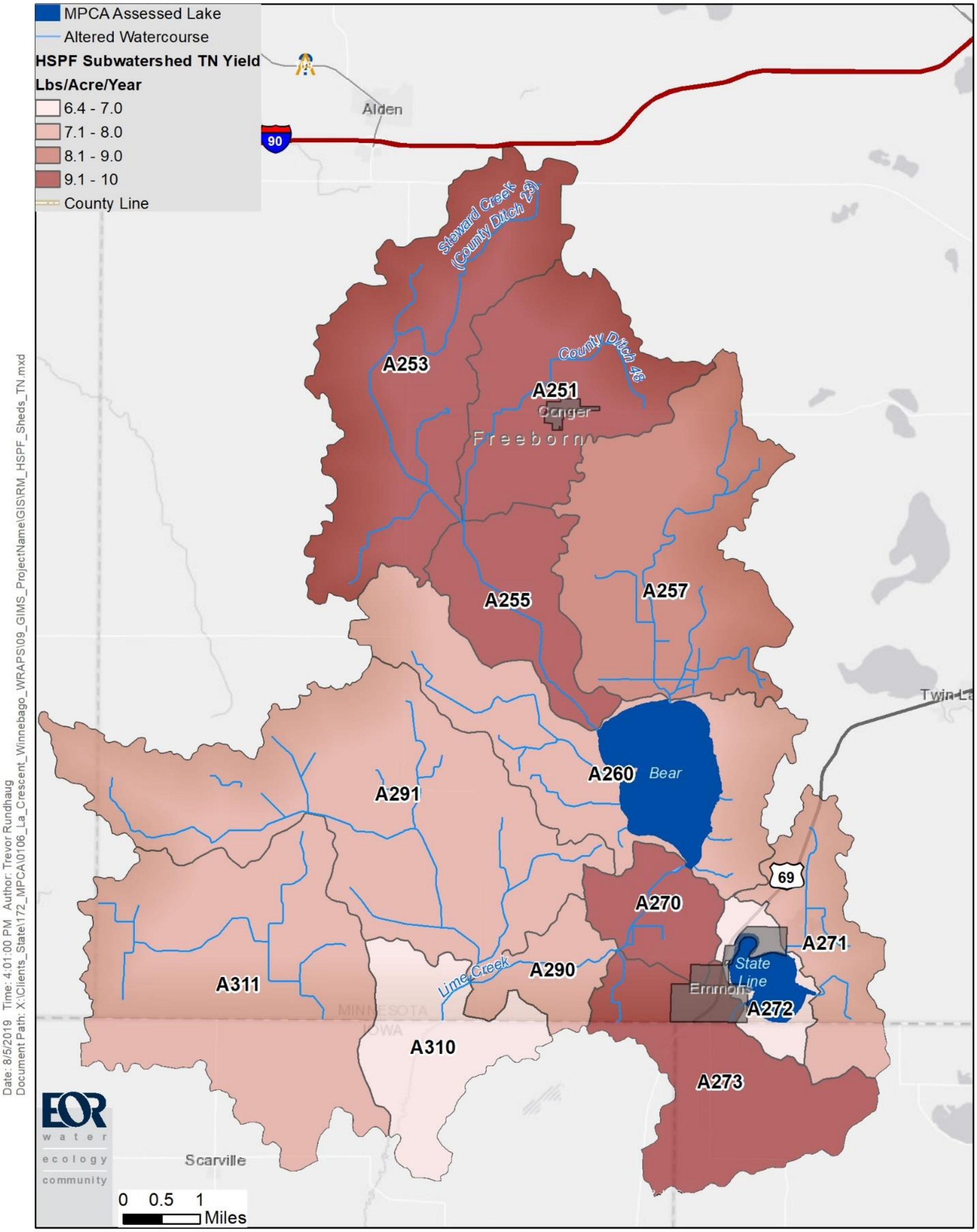


Figure 34. HSPF Total Nitrate and Nitrite Yield (lbs/acre/year).

Existing BMP Inventory

Existing BMPs can help to better target geographic areas for implementation in the Winnebago River Watershed. For example, areas with a higher percentage of existing BMPs may be targeted for BMP inspection, and areas with fewer BMPs may be targeted for BMP installation. Freeborn County and SWCD staff identified 187 proposed, newly implemented or existing BMPs within the Winnebago River Watershed. BMPs were identified as being located in either the Bear Lake, Stateline Lake or Lime Creek subwatersheds. Continued discussion of these BMPs is in Section 3.3.

The MPCA has developed a system to track the actions taken within the state to achieve healthier watersheds (See the MPCA "Healthier Watersheds" webpage, https://www.pca.state.mn.us/water/best-management-practices-implemented-watershed). Actions taken to reduce polluted runoff from agricultural and rural lands from 2004 to 2018 are provided in Figure 35 on a subwatershed scale. These numbers represent only the BMPs that have been funded through federal and state programs and reported to the MPCA.

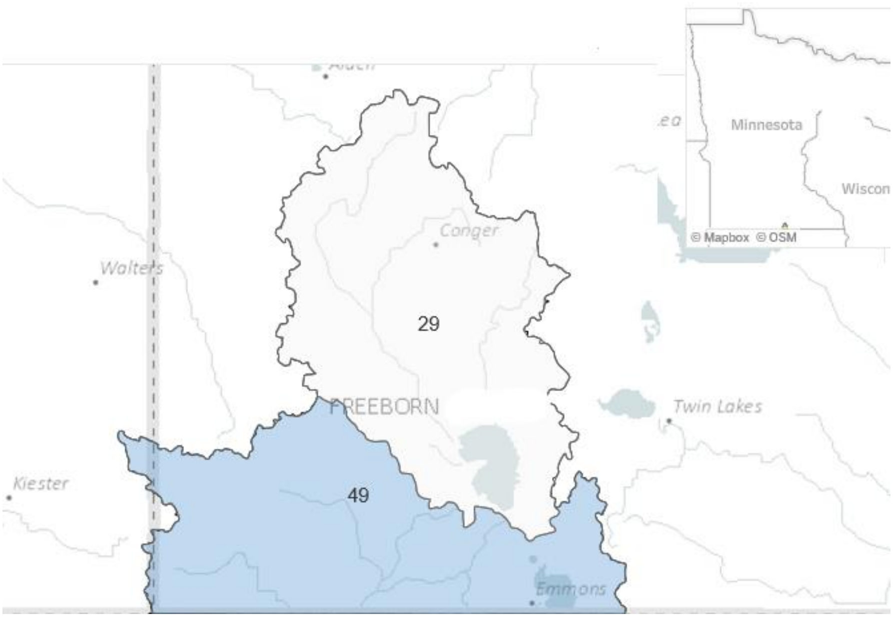
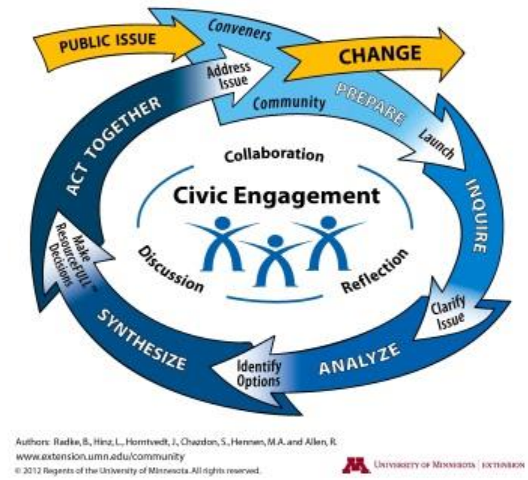


Figure 35. BMPs reported on MPCA's Healthier Watersheds.

Partner-led HSPF Scenarios

The MPCA has provided funding for additional HSPF scenario work to benefit local watershed planning efforts. In addition to HSPF, the Scenario Application Manager (SAM) was applied to convert the highly technical results of HSPF into applied analysis for planning and implementing targeted actions to restore or protect water quality in a specific geographic area. SAM provides results at a watershed scale but efforts have been made to develop methods to integrate higher resolution terrain analysis to develop more localized implementation strategies. For this project, a specified set of scenarios were simulated in HSPF-SAM for the Shell Rock and Winnebago River watersheds. The scenario results will identify the most cost-effective subwatersheds and higher resolution areas based on the terrain component for the scenario BMPs to be implemented. The terrain analyses redistributes subbasin-wide SAM loading rates at a higher resolution for localized targeting of more critical and cost-effective source areas. A final report of the project results will be publically available on the MPCA watershed webpages for the Winnebago River Watershed once complete (by October 2020).

3.2 Civic engagement



A key prerequisite for successful strategy development and on-the-ground implementation is meaningful civic engagement. This is distinguished from the broader term 'public participation' in that civic engagement encompasses a higher, more interactive level of involvement. The MPCA has coordinated with the UMN Extension Service for years on developing and implementing civic engagement approaches and efforts for the watershed approach. Specifically, the UMN Extension's definition of civic engagement is "Making 'resourceFULL' decisions and taking collective action on public issues through processes that involve public discussion, reflection, and collaboration." Extension defines a resourceFULL decision as one based on diverse sources of information and supported with buy-in, resources (including human), and competence. Further information on civic engagement is available at: http://www.extension.umn.edu/community/civic-engagement/.

Civic engagement has been conducted in the Winnebago Watershed as part of many existing initiatives including: pre-WRAPS contract between Freeborn SWCD and MPCA, Shell Rock/Winnebago Comprehensive Watershed Management Plan (CWMP) development, and County-wide water quality programs. Table 14 outlines the opportunities used to engage the public and targeted stakeholders in the watershed.

Table 14. Winnebago River Watershed TMDL Civic Engagement Opportunities.

Date	Location	Meeting Focus
6/28/18	Conger Community Center	Winnebago Watershed update to local residents.
3/10/15 – 6/30/16	Freeborn County	Phase I landowner interviews (20)
4/22/2013	Freeborn County Courthouse	Bear Lake Watershed: Winnebago Watershed update
2017-2019	Freeborn County	Phase II Landowner interviews (8)
3/19/2019	Conger Community Center	Winnebago Watershed update to local residents
12/5/2019	Agricultural field west of Bear Lake	Controlled Drainage Field Public Demonstration

Public outreach, accomplishments and future plans

The following are organizations are involved in the watershed and work with the public through various programs to improve and protect water quality.

Freeborn Area Soil Health Team: The mission of the Freeborn Area Soil Health Team is to facilitate local collaboration that encourages, educates, and demonstrates how to improve area soil health and water quality while improving productivity, profitability and sustainability of natural resources. Recent civic engagement events include soil health tours where local farmers can see and discuss examples of reduced tillage and cover crop practices. For more information on the work of the Freeborn Area Soil Health Team, see their Facebook page.

Shell Rock/Winnebago Comprehensive Watershed Management Plan (CWMP) development and implementation:

The Shell Rock/Winnebago CWMP is under development. To date, various committees have been established including the Policy Committee (elected officials from City of Albert Lea, Freeborn Co, Freeborn SWCD, Shell Rock River Watershed District [SRRWD]), Advisory Committee and Steering Committee. In addition to the committee formation, a public outreach event was held to identify and prioritize resource concerns and applicable actions to address those concerns. More information on civic engagement activities during the CWMP process is available on the SRRWD webpage.

Freeborn County:

Freeborn County Environmental Services is the lead for the SSTS program, private well testing, feedlots, WCA (wetland conservation act), shoreland zoning, buffer enforcement and household hazardous waste/recycling. Future civic engagement plans for the Winnebago Watershed include well testing (Mansfield Township) and SSTS inventory (2022). Freeborn County is also the drainage authority responsible for maintaining public ditches.

State Line Lake Restoration Incorporated:

This active citizen-based nonprofit group works towards water quality and habitat improvement of Stateline Lake through upland riparian projects, land acquisition, and providing support to DNR for lake management strategies. Members include local residents and the town of Emmons mayor.

Freeborn County SWCD:

The following outreach activities were accomplished between 2015 and 2019 as part of the Winnebago Watershed Strategy Development Project by Freeborn County and Freeborn SWCD:

- Collected crop residue data from 116 points in 2015 and 2016, and collected cropping and crop residue data during the 2017 through 2019 growing seasons.
- Completed a Drainage Water Management Plan for County Ditch 23 and County Ditch 5.
- Identified 20 suitable sites for potential BMPs (wetland restoration, two stage ditch, controlled drainage, in ditch sediment basins, and N bioreactors).
- Conducted 28 landowner/producer interviews that resulted in identification of 24 BMPs landowners were interested in implementing.
- Identified 187 proposed, newly implemented or existing BMPs.
- Hosted an educational watershed booth at the Freeborn County fair (2017 through 2019).
- Hosted one technical committee meeting and three public outreach meetings.
- Planned a field-scaled conservation drainage management demonstration site in 2019.

Other outreach and engagement efforts accomplished through regular work include:

- Controlled drainage project completed in 2019 (first one in Co.);
- Volunteer Well Monitoring Network: Mansfield Township currently targeted for monitoring
- CREP and CRP acre enrollment;

- Tree sales;
- No-till drill rental;
- Volunteer conservation guidance (BMPs: waterways);
- Volunteer rain gage readers (state climatology);
- Assist with administering Minnesota Agricultural Water Quality Certification Program (MAWQCP).

3.3 Restoration and protection strategies

Waterbody-specific goals are set for the individual impairments in the watershed, and are reflected in the strategy tables. Final water quality goals for P impaired lakes and *E. coli* impaired streams are identified in the Winnebago River Watershed TMDL (EOR 2020). Final water quality goals for biota impairments were determined using the applicable fish biocriteria (MIBI and/or FIBI score) necessary to obtain the aquatic life use goals for each water body. Goals for biota impairments are supported by the SID reports.

This section includes watershed-wide restoration strategies, as well as customized strategies to specific waterbodies in the Winnebago River Watershed. Example BMP scenarios that meet interim and final reduction goals, including the estimated scale of adoption, were developed with local stakeholders. Estimated scales of adoption of N and P -related BMPs were determined using the UMN Agricultural BMP Scenario Tools (N and P BMP Tools). The N and P BMP Tools were developed by the UMN to assist resource managers in better understanding the feasibility and cost of various BMPs in reducing nutrients from Minnesota cropland.

Watershed Wide Restoration Strategies

Table 15. Watershed wide restoration strategies for the Winnebago River Watershed.

Strategy	Practice Type	Applicable standards (NRCS standard or Ag BMP reference)
Reduce nutrients & sediment from field surface runoff	Alternative tile intake - perforated riser pipe, blind, rock, sand filter	606, 170M, 171m, 172M, 173M
	Cover Crops with Corn & Soybeans	340
	Conservation Crop Rotation - add more perennials	328
	Grassed waterway	412
	Maintain/enhance existing stormwater ponds	N/A
	Nitrogen bioreactor	747
	No-till or conservation tillage	329,329a
	Nutrient Management (fertilizer, soil, manure)	590
	Vegetative filter strips	386
	Water And Sediment Control Basins (WASCOBS)	638
Protect/stabilize stream banks	Two-staged Ditch	582
Reduce *E. coli* loading	Manure management	N/A
	Reduce and/or treat runoff from non-NPDES feedlots	635/874
	Address failing septic systems	126m

Strategy	Practice Type	Applicable standards (NRCS standard or Ag BMP reference)
Increase watershed water storage capacity	Wetland restoration/creation	657, 658
	Increase living cover (soil health)	N/A
Restore shallow lakes	Support DNR management strategies	N/A

Priority Water Body Specific BMP Load Reduction Analysis

Staff from the Freeborn County SWCD worked collaboratively with Freeborn County to compile spatial information showing the physical location of all existing (recently implemented) and proposed BMPs for the entire Winnebago River Watershed. Next, Emmons & Olivier Resources worked together with the Freeborn County SWCD, MPCA, and project partners to develop a strategy to estimate the load reduction that would be achieved as a result of the implementation of proposed and existing BMPs for Bear Lake, State Line Lake, and Lime Creek. Load reduction estimates were based on a combination of sources, including the HSPF Scenario Application Manager (SAM) tool, the University of Minnesota's Nitrogen and Phosphorus BMP spreadsheet, the Iowa Nutrient Reduction Strategy, and LGU knowledge. Nutrient reductions were calculated for the following two BMP scenarios:

Scenario A: Incorporation of cover crops on 50% of suitable row crop acreage in the watershed (modeled in HSPF-SAM).

Scenario B: Implementation and maintenance of 100% of 187 existing and proposed BMPs identified by Freeborn County SWCD staff (see Table 24 in the Appendix for BMP reduction estimates and sources).

Modeled TP load reductions from both scenarios were then compared to the Winnebago River Watershed TMDL required TP load reductions for the three excess nutrient (TP) impaired resources in the Winnebago River Watershed (Bear Lake, State Line Lake, and Lime Creek). Modeled TP reductions were also compared to the 12% TP load reduction goal outlined for the Cedar River Basin in the Minnesota Nutrient Strategy.

Modeled TN load reductions were compared to the 35% TN load reduction goal in accordance with downstream the Cedar River (Iowa) Nitrogen TMDL and the 20% reduction from the Minnesota Nutrient Strategy.

Scenario B Discussion Points:

- BMPs modeled were based on a comprehensive list of existing and proposed BMPs provided by Freeborn County SWCD in 2019, seven years beyond the HSPF calibration period (1995 through 2012). A portion of the BMPs may have been present during the HSPF model calibration period.
- Structural BMPs (e.g., WASCOBS) were not explicitly modeled in the HSPF model. Land use BMPs (e.g., wetland restorations) may have been partially accounted for in the HSPF model, which assigns lower nutrient loading rates for wetland land uses.

Scenario A: Results

Results from the implementation of cover crops on 50% of all suitable row crop acres are shown in Table 16. TP and TN load reduction estimates from the HSPF–SAM model were higher than load reduction estimates from the P and N BMP spreadsheets because the HSPF-SAM model tracks the cumulative load reduction to downstream resources, whereas the P and N BMP spreadsheets more simply track load reductions occurring on a per acre basis. The implementation of cover crops on 50% of all cropland acreage within the watershed represents an achievable goal that would meet the TMDL required external TP load reductions for State Line Lake and Lime Creek. Model results suggest that additional BMPs will be required to meet TMDL required TP load reductions for Bear Lake and NRS goals for both P and N. TN load reductions from the cover crop scenario were significantly less than required TN reductions outlined in both the Iowa's Cedar River TMDL and the NRS.

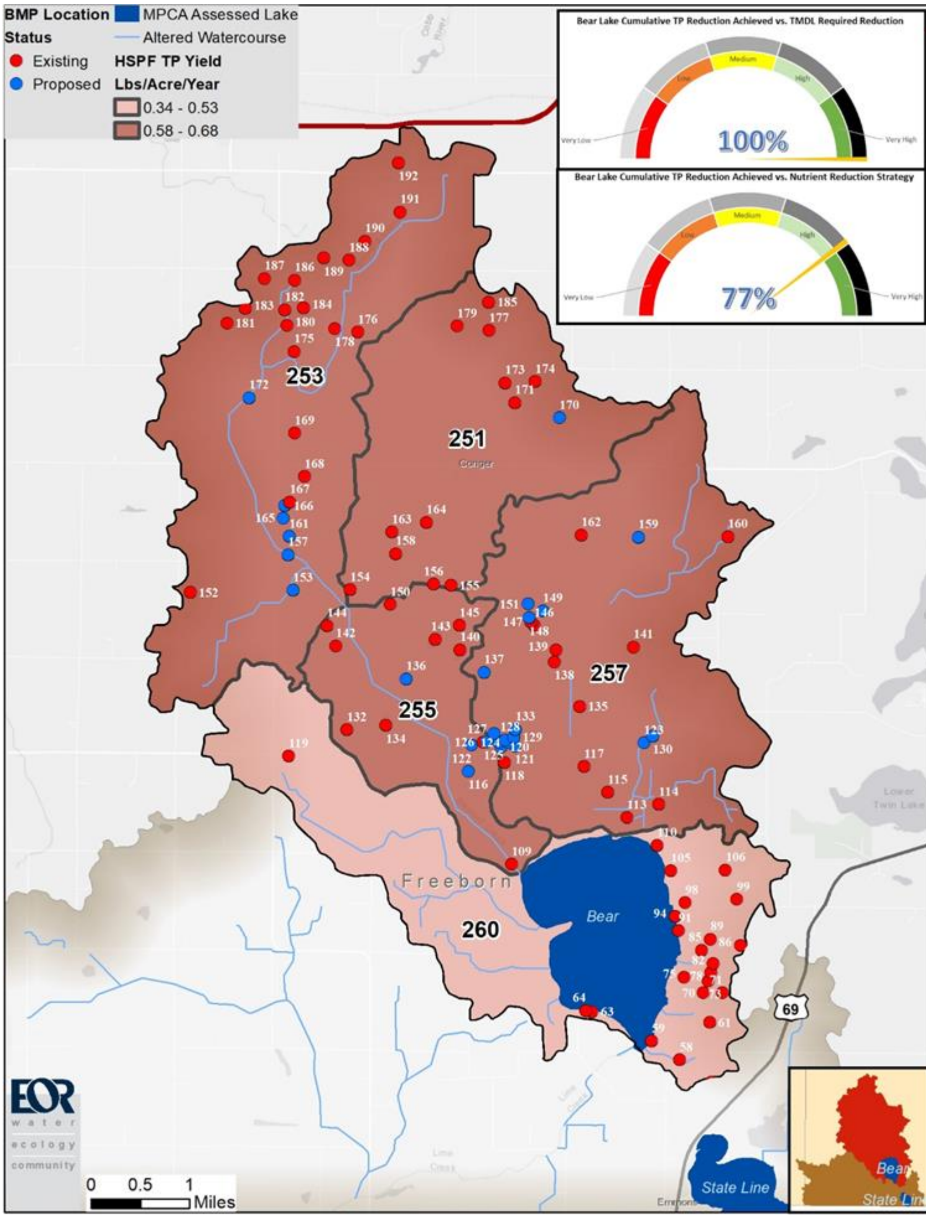
Table 16. Cover Crop Load Reductions.

HSPF Reach ID	HSPF-SAM Cover Crop Suitable Acres	HSPF-SAM Cover Crops Treated Acres	Winnebago River TMDL Watershed Load Target Reduction	Nutrient Reduction Strategy - TP Load Target Reduction	Cedar River (Iowa) TN TMDL 37% Target Reduction*	Nutrient Reduction Strategy - 20% TN Load Target Reduction
Bear Lake: TMDL Reduction Goal = 1,365 lbs of TP/year and 134,991 lbs of TN/year Nutrient Reduction Strategy Goal = 1,844 lbs of TP/year and 72,968 lbs TN/year						
251	3,553	1,776	**- Scenario A:** 1,198 / 1,365 lbs/yr = **88%** **- Scenario B:** 708 / 1,365 lbs TP/yr = **52%**	**- Scenario A:** 1,198 / 1,844 lbs/yr = **65%** **- Scenario B:** 708 / 1,844 lbs/yr = **38%**	**- Scenario A:** 18,164 / 134,991 lbs/yr = **14%** **- Scenario B:** 18,853 / 134,991 lbs/yr = **14%**	**- Scenario A:** 18,164 / 72,968 lbs/yr = **25%** **- Scenario B:** 18,853 / 72,968 lbs/yr = **26%**
253	6,001	3,000				
255	1,904	952				
257	4,924	2,462				
260	3,621	1,810				
Stateline Lake TMDL Reduction Goal = 62 lbs of TP/year and 14,715 lbs TN/year Nutrient Reduction Strategy Goal = 201 lbs of TP/year and 7,955 lbs TN/year						
271	1,530	765	**- Scenario A:** 110 / 62 lbs/yr = **>100%** **- Scenario B:** 68 / 62 lbs/yr = **>100%**	**- Scenario A:** 110 / 201 lbs/yr = **47%** **- Scenario B:** 68 / 201 lbs/yr = **34%**	**- Scenario A:** 3,076 / 14,715 lbs/yr = **21%** **- Scenario B:** 1,787 / 14,715 lbs/yr = **12%**	**- Scenario A:** 3,076 / 7,955 lbs/yr = **39%** **- Scenario B:** 1,787 / 7,955 lbs/yr = **22%**
272	401	200				
Lime Creek TMDL Reduction = 28 lbs of TP/year and 86,455 lbs TN/year Nutrient Reduction Strategy = 1,266 lbs of TP/year and 46,732 lbs TN/year						
270	1,239	619	**- Scenario A:** 1,066 / 28 lbs/yr = >**100%** **- Scenario B:** 553 / 28 lbs/yr = >**100%**	**- Scenario A:** 1,066 / 1,266 lbs/yr = **84%** **- Scenario B:** 553 / 1,266 lbs/yr = **44%**	**- Scenario A:** 30,244 / 86,455 = **35%** **- Scenario B:** 14,450 / 86,455 = **17%**	**- Scenario A:** 30,244 / 46,732 lbs/yr = **65%** **- Scenario B:** 14,450 / 46,732 lbs/yr = **31%**
273	3,137	1,569				
290	1,022	511				
291	7,948	3,974				
310	2,270	1,135				

* Cedar River total Nitrate load reduction required from Minnesota portion of the Shell Rock River = 1, 075 tons/year; equivalent to 35% of existing load from Minnesota portion of Shell Rock River Watershed which includes the Winnebago River.

Scenario B: Results

Results from the implementation of the 102 existing and proposed BMPs identified in the Bear Lake Subwatershed are shown in Figure 36. Model results suggest that the continued maintenance and implementation of these 102 existing and proposed BMPs will achieve the required watershed TP load reductions for Bear Lake as determined in the Bear Lake Nutrient TMDL. However, these BMPs will only achieve 77% of the TP load reduction required by the Minnesota NRS. Furthermore, it should also be noted that these BMPs do not address internal nutrient loading dynamics and associated internal nutrient load reductions.



HSPF Reach ID	Implemented/ Proposed BMP (Number)
251	Critical Area Planting (1)
	Grassed Waterway (6)
	WASCOB (2)
	Filter Strip (1)
	Wetland Restoration (1)
253	Critical Area Planting (1)
	Basin Berm (1)
	Filter Strip (1)
	Grassed Waterway (17)
	WASCOB (2)
	Two-Staged Ditch (2)
	Wetland Restoration (4)
255	Filter Strip (1)
	Grassed Waterway (4)
	Alternative (Rock) Inlet (1)
	Critical Area Planting - 15 YR CRP (1)
	Constructed Pond (1)
	Controlled Drainage (1)
	Pollinator habitat (1)
	Wetland Restoration (3)
257	Controlled Drainage (3)
	Grassed Waterway (6)
	Alternative (Rock) Inlet (5)
	Constructed Pond (3)
	WASCOB (2)
	Terrace/basin (2)
	Wetland Restoration (6)
260	Nitrogen Bioreactor (2)
	Terrace (1)
	Constructed Pond (1)
	Erosion Site (Small WASCOBS) (9)
	Grassed Waterway (5)
	Wetland Restoration (1)
	WASCOB (1)

Figure 36. Modeled phosphorus reductions associated with all existing and proposed BMPs in the Bear Lake Watershed.

A large, ditched wetland complex is located at the north end of Bear Lake (Figure 37). Currently, this area was modeled as an existing BMP. Typically, the effect of a ditch functions to drain adjacent wetlands by lowering the water surface profile through the wetland and into the ditch. In this typical situation the observed water levels decrease closer to the ditch. However, if the ditch itself is hydrologically isolated from the wetland, then we might see the opposite. Nevertheless, it is likely that the highly ditched nature of this wetland complex is reducing the wetland's natural ability to retain nutrients and store water. A re-meandering or abandonment of the existing ditch system within this wetland complex represents a significant potential wetland restoration opportunity that could help to achieve additional TP load reductions to Bear Lake.

Figure 37. The ditched wetland north of Bear Lake represents a potential wetland restoration opportunity.

Results from the implementation of the 19 existing and proposed BMPs identified in the State Line Lake Subwatershed are shown in Figure 38. Model results suggest that the continued maintenance and implementation of these 19 existing and proposed BMPs will achieve both the required State Line Lake TMDL TP load reductions and the reduction required by the Minnesota NRS. It should be noted that State Line Lake has a very small watershed. Furthermore, the calibrated HSPF model suggested that existing TP loading rates within the State Line Lake Subwatershed were the lowest in the Winnebago River Watershed. Therefore, the required watershed TP load reduction requirement is very small. As previously stated, these BMPs do not address internal nutrient loading dynamics and the required internal nutrient load reductions needed for State Line Lake to meet its overall TP reduction goals.

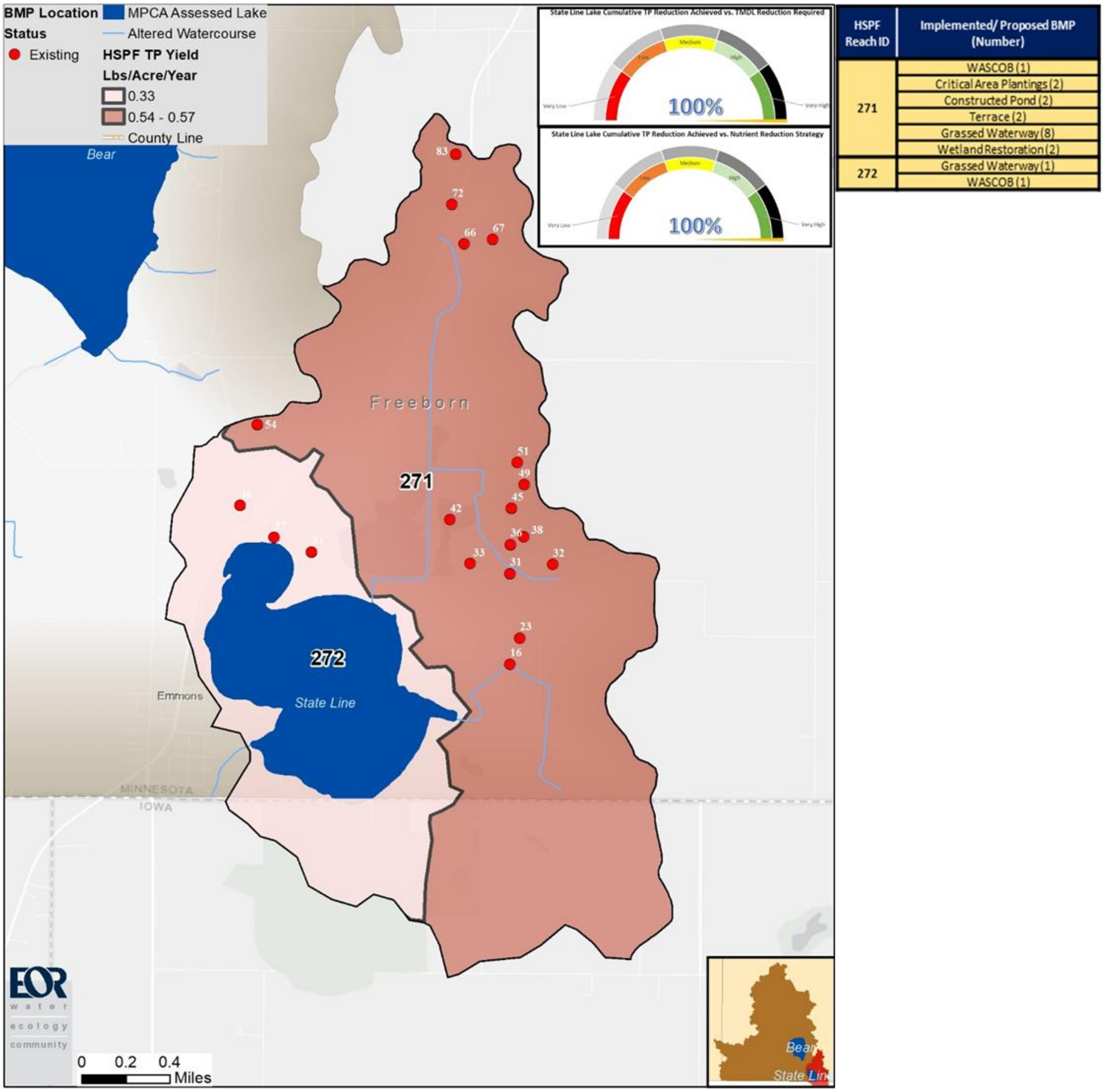


Figure 38. Modeled phosphorus reductions associated with all existing and proposed BMPs in the State Line Lake Watershed.

Results from the implementation of the 66 existing and proposed BMPs identified in the Lime Creek Subwatershed are shown in Figure 39. Model results suggest that the continued maintenance and implementation of these 66 existing BMPs will achieve the required watershed TP load reductions for Lime Creek as determined in the Lime Creek Nutrient TMDL. However, these BMPs will only achieve 36% of the TP reduction outlined in the Minnesota NRS. The combined TP load reduction from the implementation of cover crops on 50% of suitable cropland, in addition to the implementation and maintenance of all existing and proposed BMPs in the Lime Creek Subwatershed, will meet the reductions required by Minnesota NRS.

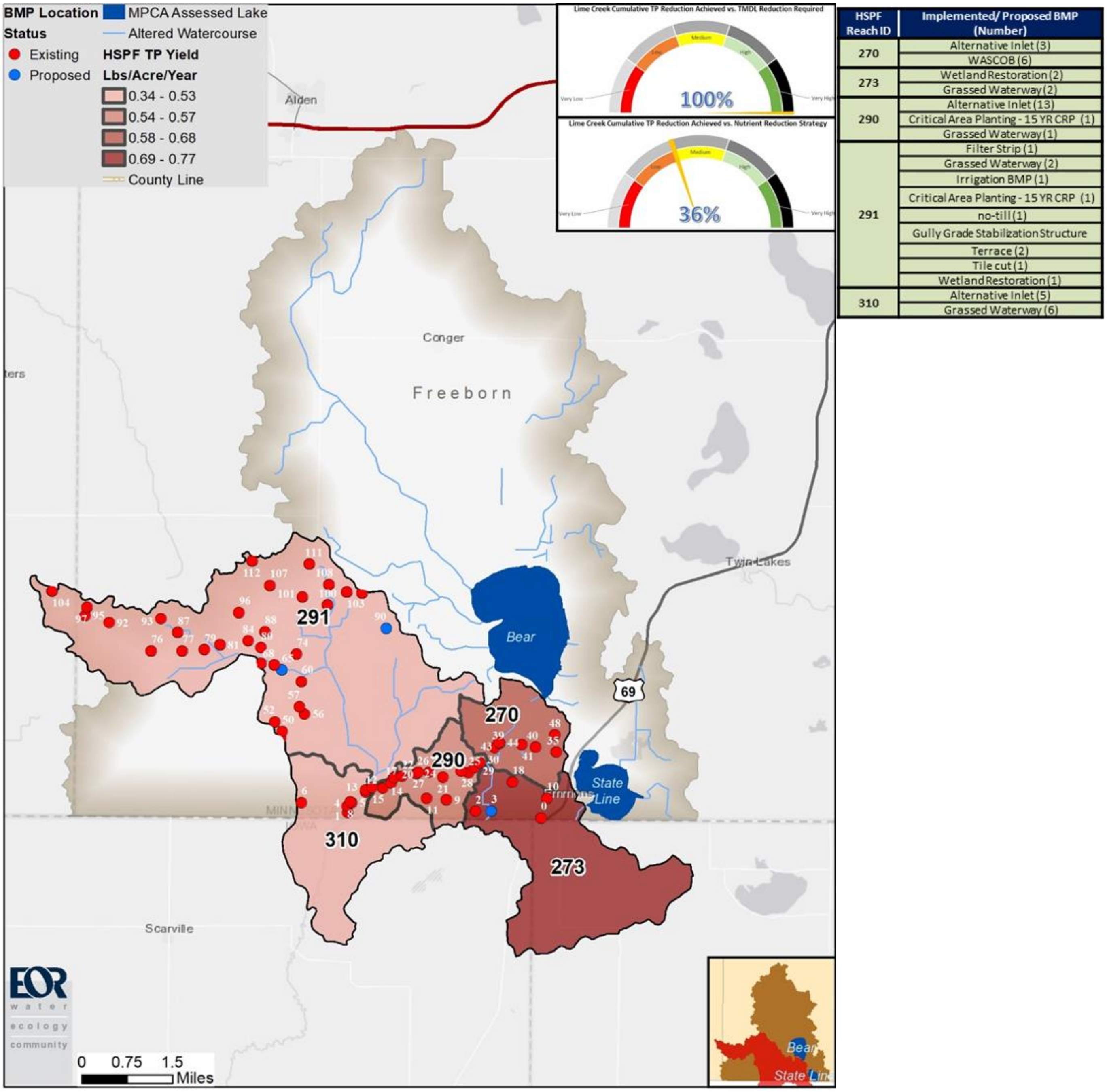
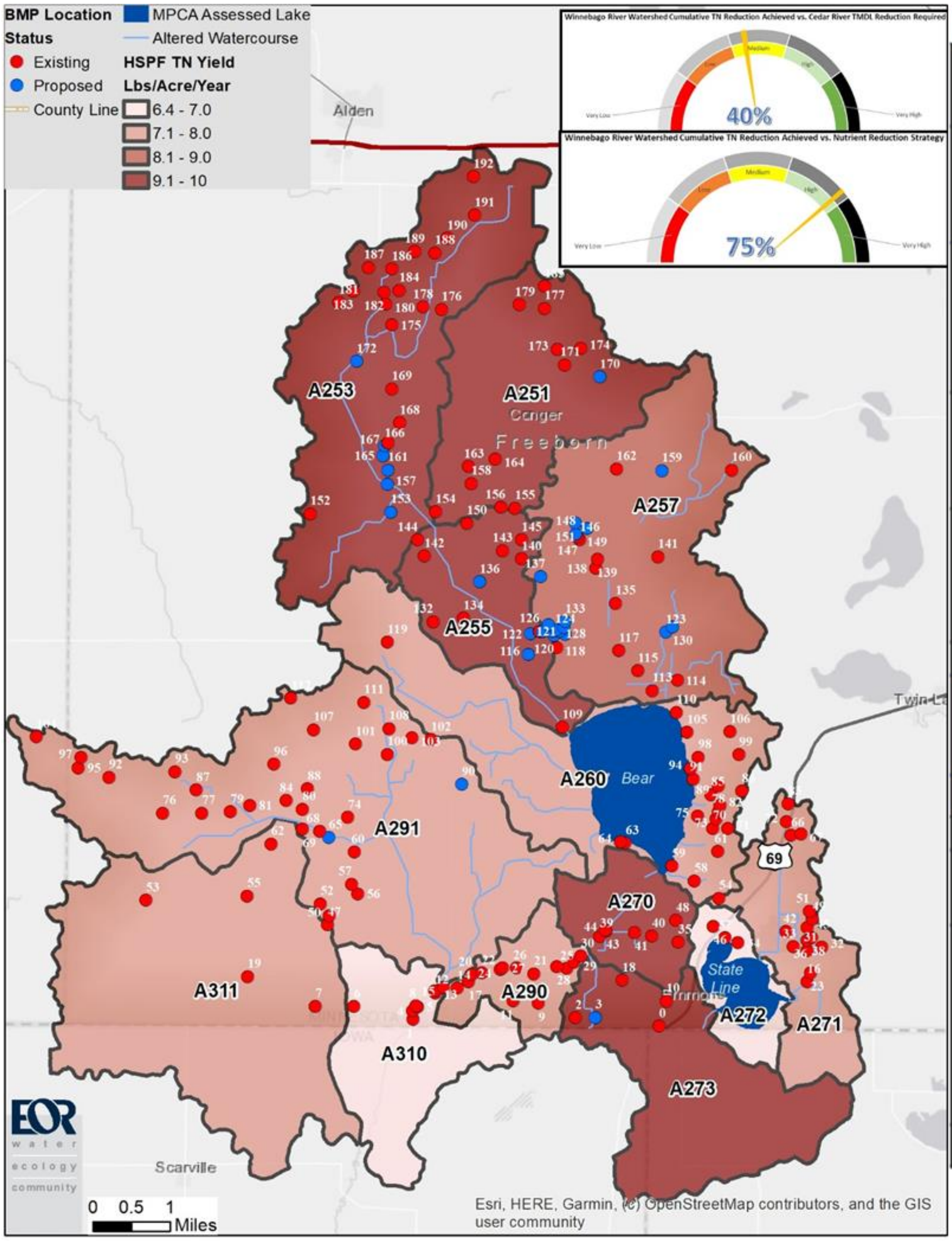


Figure 39. Modeled phosphorus reductions associated with all existing and proposed BMPs in the Lime Creek Watershed.

Results from the implementation of 187 existing and proposed BMPs identified in the Winnebago River Watershed, in comparison with required TN load reductions outlined in the Minnesota NRS and the downstream Cedar River Nitrate TMDL, are shown in Figure 40. TN load reductions from this scenario were significantly less than required TN reductions outlined in both the Cedar River TMDL and the NRS. A combination of scenario A (cover crops), scenario B (structural practices), and the conversion of vulnerable cropland to perennial vegetation will be required to meet N reduction goals.



HSPF Reach ID	Implemented/ Proposed BMP (Number)
251	Critical Area Planting (1)
	Grassed Waterway (6)
	WASCOB (2)
	Filter Strip (1)
	Wetland Restoration (1)
253	Critical Area Planting (1)
	Basin Berm (1)
	Filter Strip (1)
	Grassed Waterway (17)
	WASCOB (2)
	Two Staged Ditch (2)
	Wetland Restoration (4)
255	Filter Strip (1)
	Grassed Waterway (4)
	Alternative (Rock) Inlet (1)
	Critical Area Planting - 15 YR CRP (1)
	Constructed Pond (1)
	Controlled Drainage (1)
	Pollinator habitat (1)
	Wetland Restoration (3)
257	Controlled Drainage (3)
	Grassed Waterway (6)
	Alternative (Rock) Inlet (5)
	Constructed Pond (3)
	WASCOB (2)
	Terrace/basin (2)
	Wetland Restoration (6)
260	Nitrogen Bioreactor (2)
	Terrace (1)
	Constructed Pond (1)
	Erosion Site (Small WASCOBS) (9)
	Grassed Waterway (5)
	Wetland Restoration (1)
	WASCOB (1)
270	Alternative Inlet (3)
	WASCOB (6)
271	WASCOB (1)
	Critical Area Plantings (2)
	Constructed Pond (2)
	Terrace (2)
	Grassed Waterway (8)
	Wetland Restoration (2)
272	Grassed Waterway (1)
	WASCOB (1)
273	Wetland Restoration (2)
	Grassed Waterway (2)
290	Alternative Inlet (13)
	Critical Area Planting - 15 YR CRP (1)
	Grassed Waterway (1)
291	Filter Strip (1)
	Grassed Waterway (2)
	Irrigation BMP (1)
	Critical Area Planting - 15 YR CRP (1)
	no till (1)
	Gully Grade Stabilization Structure
	Terrace (2)
	Tile cut (1)
	Wetland Restoration (1)
310	Alternative Inlet (5)
	Grassed Waterway (6)

Figure 40. Modeled nitrogen reductions associated with all known and existing BMPs in the Winnebago River Watershed.

Prioritization

The tools described above (HSPF, HSPF-SAM, BMP load reduction scenario evaluation, and professional judgment) were used to the extent possible to prioritize areas within the Winnebago River Watershed. The Shell Rock River/Winnebago Watershed CWMP document will add detail to the strategies described in the WRAPs, by further vetting the sources of pollutants at the field scale, identifying additional, priority locations for BMPs, and enumerating the anticipated load reduction benefits and anticipated outcomes for resources of the Winnebago River Watershed. The relationship between the CWMP process and the WRAPS/TMDL process is that work performed within the WRAPS is used as a springboard to strengthen future prioritization efforts in the Winnebago River Watershed.

In-Lake Management

The relationship between P concentration with algae levels and water clarity is often different in shallow lakes like Bear Lake and State Line Lake as compared to deeper lakes. Because of this, whole lake drawdowns are a standard management approach.

A whole lake draw down is the process of drawing lake water levels down through an outlet structure to the lowest elevation possible. This management tool is a common strategy used for shallow lakes (less than 15 ft) in Minnesota. Drawdowns mimic natural droughts and aim to expose bottom sediments causing:

- Consolidation of lake sediments when subjected to drying, which reduces resuspension of lake sediment from wave action (once water level is restored) resulting in a clearer water column;
- Oxidation of organic matter in lake sediments, which reduces P release in the water column;
- Fish kill, which allows zooplankton populations to rebound and reduce algae levels in the water column resulting in a clearer water column and more aquatic plant growth;
- Exposure of lake sediments to air, which results in germination of some aquatic plant seeds (like bulrush) that need to be dried or exposed on mud flats in order to germinate.

Bear Lake Management Strategies

The overall in-lake management strategy for Bear Lake is water level management to emulate the natural variability of water conditions observed in Bear Lake, to encourage aquatic plant growth in littoral areas. The DNR 2012 Bear Lake Management Plan identifies three water level management strategies:

- Removing and adding stop logs to the variable crest dam.
- Partial drawdown of up to 18 inches.
- Periodic major or full drawdown.

Specific actions from the DNR 2012 Lake Management Plan for each water level management strategy are included below:

The first strategy is to annually remove stop logs from the dam in early spring to establish a summer control elevation up to eight inches below the normal runout elevation. This strategy is intended to mitigate some impacts from siltation and hydrological changes associated with drainage, channelization, cropping patterns and climate change. Lower water levels in spring and early summer allows adequate sunlight to penetrate and stimulate annual growth of sago pondweed, wild celery, and other submersed plants, and reduces the potential for drowning or uprooting emergent plants. Stop logs are returned to the normal runout elevation in mid-summer when runoff events are less likely and less likely to damage aquatic plants.

A second strategy is to use partial drawdowns of up to 18 inches. These drawdowns are intended to replicate lake conditions due to moderate droughts, and are used occasionally to manage fish and sustain submersed plants and also to sustain improvements achieved from a full drawdown for a longer duration of time. The DNR will lower water levels occasionally in winter (December to April) to 1.4 feet below runout elevation to control carp populations. Reduced water levels in winter should help induce hypoxia by limiting the volume of unfrozen water in the lake. Extended periods of hypoxia will reduce populations of undesirable fish in the lake. Reduced rough fish populations may release zooplankton and aquatic plants from intense depredation and grazing pressure, physical disturbance and “fish caused” turbidity during the growing season. Maintaining this drawdown until April facilitates adult northern pike access to breeding habitat within the lake by eliminating the differential between the crest of the dam and the tailwaters in Lime Creek in late winter and early spring. Successful winter kill reduces competition and depredation on pike fry. Pike recruitment from natural reproduction should be best following winterkill and when the lake has abundant littoral vegetation.

A temporary partial drawdown during the growing season can be implemented to maintain aquatic plants affected by turbidity or high water. It would extend the temporary winter control through the growing season, partially exposing bottom sediments around the margins of the lake, but leaving shallow water in most of the basin. This action would be used to 1) improve or maintain submersed vegetation such as sago, bushy pondweed, narrow-leafed pondweeds and wild celery when a complete or nearly complete dewatering is not required to reestablish emergent vegetation; 2) maintain improvements achieved through full drawdown; and 3) manage certain aquatic plants such as narrow-leafed forms of cattails and others. Stop logs are returned to normal controls as objectives are achieved and aquatic plants mature.

A third strategy, used rarely, is to periodically conduct a major or full drawdown. These drawdowns are intended to produce lake conditions like those observed during major droughts. Stop logs are removed from the dam to dewater the lake as far as practical. A major drawdown will expose bottom sediments to the air allowing consolidation and oxidation. Most emergent plants require mudflat conditions to grow from seed and major growing season drawdowns produce a flush of diverse annual and perennial emergent aquatic plants. Water level management implementation and submersed vegetation response since 1972 is summarized in Table 17. Since 1994, some progress was made toward maintaining submersed aquatic vegetation in the mid-2000s. Between 1991 and 2010, Bear Lake lost about 40% of its emergent vegetation. DNR began to fully implement drawdown strategies from the summer of 2002 through July 2004. Although precipitation prevented a full drawdown, a more aggressive partial drawdown was achieved and submersed plants responded well. The annual spring/summer partial drawdown continued into 2008 and submersed plants showed positive response, although with some exception, the pondweeds were generally sparse, subject to early decline and not available for fall migrants. The lake reverted to a stable, turbid water condition. Water level management for the purpose of benefitting wildlife was reinitiated in 2013, after the dam was reconstructed in 2011/2012. Habitat conditions and wildlife use responded positively to partial drawdowns in 2013 and 2014. Presently, the lake is reverting to the turbid state as common carp have become abundant with lack of winterkill in recent years. Additional drawdowns will be needed to manage the resource.

Table 17. Summary of water management efforts and habitat results for Bear Lake, 1972 to present (Table 2 in the DNR Bear Lake 2012 Lake Management Plan).

Year	Annual Temporary Summer Control Attempted (Y/N)	Habitat Objective Met	Winter Drawdown	Comment
1972	Y	Y	Y	Water management objectives met. Lush stands of submersed vegetation over about 90% of the lake.
1973	Y	N	Y	Lake remained high due to vandalism, water turbid, submersed vegetation rare.
1974	Y	Y	Y	New carp barriers installed. Submersed vegetation showing renewed vigor. Cattails dying out.
1975	Y	Y	Y	Good growth of submersed vegetation.
1976	Natural drawdown	Y	Natural	Major drawdown due to drought. Basin went entirely dry in winter 1976-77.
1977	Natural drawdown	Y	Natural	Drought conditions continue, some recovery of water, but lake remains low during growing season.
1978	N	N	N	Water level high, by fall no submersed vegetation; cattails and hardstem bullrushes doing well; dam repaired and modified late summer/fall.
1979	N	in part	N	No water management; submersed vegetation thin and spotty throughout open water areas.
1980	N	in part	N	No water management. Submersed plants confined to protected areas and emergent stands deteriorating.
1981	Y	in part	N	Water level remained high, submersed plants confined to protected areas. Large areas of cattails died back.
1982	Y	Y	N	
1983	N	in part	Y	Submersed plants confined to protected areas.
1984	Y	Y	N	
1985	N	ND	N	Water level remained high.
1986	Y	ND	N	
1987	Y	Y	N	Submersed plants abundant in protected areas and cover about 50% of open water area of lake.
1988	Natural drawdown	N	Natural	Natural drawdown was not as extensive as 1976. Water level more than a foot below normal by late summer.
1989	Natural drawdown	Y	N	Drought conditions continue. Water levels near normal by fall, no extension of emergent plants, good submersed vegetation.
1990	N	ND	N	Drought ended. Water levels return to more normal conditions.
1991	N	N	N	Summer control terminated early summer and lake remained high; lake nearly devoid of submersed vegetation.
1992	N	N	N	
1993	N	N	N	High water uproots large sections of cattail stands.
1994	N	N	Y	No hardstem bullrush found; open water areas devoid of submersed vegetation, some growing within emergent fringe.
1995	Y	N	Y	Some submersed vegetation noted early in growing season, gone by late summer.

Year	Annual Temporary Summer Control Attempted (Y/N)	Habitat Objective Met	Winter Drawdown	Comment
1996	Y	N	N	Submersed vegetation confined to stable openings within cattail fringe.
1997	Y	N	N	High water in summer, short mild winter - 1997-98.
1998	N	N	Y	Short, mild winter - 1998-99.
1999	Y	N	Y	Water remained above objective during summer; short, mild winter- 1999-2000.
2000	Y	N	Y	High water in summer.
2001	Y	N	N	Spring flooding in 2001 allowed early recolonization of carp. Short, mild winter 2001-02
2002	Y	N	Y	High water in summer. Effective winter drawdown 2002-03.
2003	Y	in part	Y	Submersed vegetation covered an estimated 300 acres in open water areas, common within emergent fringe. Emergents within objective. Effective winter drawdown, 2003-04.
2004	Y	in part	N	Submersed vegetation widespread, but not lush.
2005	Y	Y	N	
2006	Y	in part	N	Submersed vegetation widespread, but sparse, showed early decline.
2007	Y	in part	N	Submersed vegetation widespread, but sparse, showed early decline.
2008	Y	in part	N	Submersed vegetation widespread, but sparse, showed early decline. Emergent coverage below objective acres.
2009	N	ND	N	High water, uprooting of emergents.
2010	N	N	N	Emergents continue to decline, extensive uprooting of cattails caused by high water.
2011	Dam Construction	N	Dam Construction	Lake levels lowered to facilitate dam reconstruction
2012	Natural drawdown	N	Natural	Dam completed. Lake levels recede in summer due to drought, carp abundant
2013	Partial drawdown	Y	Y	Partial winterkill 2012-2013, submersed plants begin to recover
2014	Partial drawdown	Y	Y	Mudflats extend past existing cattail fringe, some regrowth of emergent
2015	Y	Y	N	
2016	Y	No Survey	Y	No winterkill observed ’15-’16. Water clarity and aquatic plants declining
2017	Y	No Survey	Y	No winterkill observed ’16 – ’17.
2018	Y	No Survey	Y	No winterkill observed ’17 – 18.

State Line Lake Management Strategies

The overall in-lake management strategy for State Line Lake is:

- Installing a barrier to fish migration on the outlet stream for State Line Lake.
- Constructing a new dam allowing for nearly complete drawdown in winter only.
- Restructuring the fish community and regenerating aquatic habitats.

Specific actions from the DNR 2012 Lake Management Plan (LMP) are included below:

A drawdown is the process of passively or actively removing water in a lake and exposing the lake bottom to the air to: a) oxidize and consolidate sediment, b) freeze curly-leaf pondweed turions, if present, c) kill undesirable fish, and d) promote new growth of native plant species. The State Line LMP includes two major drawdown strategies: 1) to lower the lake level up to 2.5 feet below normal runout during the growing season. This strategy would expose about a quarter of the lake bottom and allows for regrowth of emergent plants from seed; and 2) to lower the lake level to the greatest extent possible (up to about 3.5 feet). The lake plan also includes a minor or partial drawdown strategy up to 18 inches below normal runout as an intermediate strategy to prolong benefits when major drawdowns are not indicated.

In 2013, DNR began actively managing State Line Lake, initially lowering water levels in autumn to facilitate the dam and fish barrier construction. In 2014, a velocity tube fish barrier was installed at the first road crossing downstream of the lake and the new dam was constructed. The barrier is passive and designed to prevent fish swimming upstream. It is designed to prevent carp from recolonizing the lake from downstream sources. The new dam is designed to pass the same amount of water at full service level (full pool) as the existing dam. A major growing season drawdown was initiated in the summer of 2014 after the dam construction was completed. In the fall of 2014 the lake and tributaries were treated with rotenone, a fish poison, to try to eliminate remaining common carp populations. The following spring, water levels were returned to normal runout and the lake restocked with northern pike, yellow perch and bluegill sunfish in the spring of 2015. By the summer of 2016, however, water quality had deteriorated, aquatic plants were rare, and there was reason to believe common carp and black bullhead numbers had reached concerning levels.

A targeted survey was conducted on September 12, 2017, to assess the fish community. As suspected, common carp and black bullhead were the most commonly sampled fish species in the trap net sample. All three stocked game fish species were represented in the sample with northern pike the most common. Although northern pike fry stocking succeeded in creating a robust, fast growing population, yellow perch and bluegill failed to produce sizable year classes since being stocked in 2015. Additionally, undesirable species had returned to pre-reclamation levels and were responsible for the degraded condition the lake existed in. Another major drawdown was prescribed in late 2017, to once again reset the lake and fish community.

In winter of 2016/2017 a minor winter drawdown had been initiated to control undesirable fish, but was unsuccessful due to excessive fall precipitation and mild winter conditions. Lake levels were returned to normal for the growing season. A major drawdown was completed for the 2017/2018 winter season with water levels returned to normal in spring. Observations in spring and summer suggested the drawdown was at least partially successful for controlling common carp.

A point-intercept aquatic plant survey was completed by Emmons & Olivier Resources on September 7th, 2018, on State Line Lake to assess the impacts of the winter 2017/2018 drawdown on the aquatic plant community in State Line Lake (see Appendix A). The 2018 aquatic plant survey was compared with an aquatic plant point-intercept survey completed by DNR on September 11th, 2017, as part of the DNR 2017 Wildlife Lake Habitat Survey.

The 2017 drawdown allowed for a moderately healthy aquatic plant community to become established in 2018. Sago pondweed was found at more than 94% of sampling locations in 2018, compared to 1.9% of sampling locations in 2017. It should be noted that a significant number of waterfowl species were observed during the 2018 survey including 220 American coots, 30 Blue-winged teal, 5 Ruddy ducks, 2 Trumpeter swans, 1 Northern shoveler, 1 Canada goose, and 1 Pied-billed grebe. While it is encouraging that sago pondweed will provide a valuable food refuge for waterfowl, the prolific nature and largely monotypic distribution of this species is indicative of a disturbed ecosystem.

Funding Sources

There are a variety of funding sources to help cover some of the cost to implement practices that reduce pollutants from entering surface waters and groundwater. There are several programs listed below that contain web links to the programs and contacts for each entity. The contacts for each grant program can assist in the determination of eligibility for each program as well as funding requirements and amounts available.

On November 4, 2008, Minnesota voters approved the Clean Water, Land and Legacy Amendment to the constitution to:

- protect drinking water sources;
- protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat;
- preserve arts and cultural heritage;
- support parks and trails; and
- protect, enhance, and restore lakes, rivers, streams, and groundwater.

The Clean Water, Land, and Legacy Fund and other funding sources have several grant and loan programs that could potentially be used for implementation of the BMPs and education and outreach activities. The various programs and sponsoring agencies related to clean water funding and other sources of funding are listed below in hyperlinks.

- Agriculture BMP Loan Program (MDA)
- Clean Water Fund Grants (BWSR)
- Clean Water Partnership (MPCA)
- Environment and Natural Resources Trust Fund (Legislative-Citizen Commission on Minnesota Resources)
- Environmental Assistance Grants Program (MPCA)
- Phosphorus Reduction Grant Program (Minnesota Public Facilities Authority)
- Clean Water Act Section 319 Grant Program (MPCA)

- Small Community Wastewater Treatment Construction Loans & Grants (Minnesota Public Facilities Authority)
- Source Water Protection Grant Program (MDH)
- Surface Water Assessment Grants (MPCA)
- Wastewater and storm water financial assistance (MPCA)
- Conservation Partners Legacy Grant Program (DNR)
- Environmental Quality Incentives Program (Natural Resources Conservation Service)
- Conservation Reserve Program (USDA)
- Clean Water State Revolving Fund (EPA)

Public notice for comments

An opportunity for public comment on the draft WRAPS report was provided via a public notice in the *State Register* from April 20, 2020 to May 20, 2020. There was one comment letter received and responded to as a result of the notice.

Table 18: Strategies and actions proposed for Stateline Lake (24-003-00).

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
Excess Nutrients (TP)	Existing TP Load - 1,839.5 lbs Conc. - 550 ug/L	Targeted TP Load 1,667.5 lbs Conc. - 90 ug/L	**Improve upland/ field surface runoff controls**	Conduct regular site visits and necessary maintenance on existing WASCOBs to ensure they are functioning properly	2 WASCOBs present in the watershed are functioning as designed	WASCOBs are functioning as intended	2	# of WASCOB that are functioning as designed.
				Grassed Waterways	9	9	9	Number of Grassed Waterways Implemented and Maintained as Grassed Waterways
				Maintain and/or enhance existing constructed stormwater ponds	2	2	2	Number of functioning stormwater ponds that serve as nutrient and sediment sinks.
				Conduct regular site visits and necessary maintenance on existing wetland restoration is functioning as designed	1 wetland restoration on property owned by Diamond Jo's	Wetland continues to function as a nutrient sink	1	# of existing wetland restoration projects that are functioning as nutrient sinks
				Sediment Basins/ Terraces	2 terraces currently installed	2	2	# of terraces/basins implemented and maintained
				Maintain/Increase perennial cover in watershed through incorporation of critical area plantings/ pollinator habitat, and/or other native perennial plantings	40	40	40	Critical area (acres) planted in perennial/ native vegetation conducive to supporting pollinators
				Addition of cover crops species to crop rotation (Oats)	N/A	100 Acres	200 Acres	Cropland acres with cover crops implemented

Table 19: Strategies and actions proposed for Judicial Ditch 25 (07080203-515).

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
Excess Nutrients (TP)	Existing Conc. - 262 ug/L	Targeted Conc. - 90 ug/L	**Implement BMPS identified in the Lime Creek Watershed**. These BMPS include projects in the Judicial Ditch 25 Watershed	Implement Lime Creek BMPs	See Lime Creek BMPs	N/A	N/A	N/A
				Addition of cover crops species to crop rotation (Oats)	N/A	1,987 Acres	3,975 Acres	Cropland acres with cover crops implemented
Altered hydrology; peak flow and/or low base flow (Fish IBI)	Fish IBI = 0	Fish IBI = 15	**Improve drainage management**	Increase tile drainage waters draining into wetlands, saturated buffers and other practices	Low	Medium	High	Adoption rate amongst landowners in the watershed
				Controlled drainage on suitable tile-drained row cropland	Low	Medium	High	Adoption rate amongst landowners in the watershed

Table 20: Strategies and actions proposed for Unnamed Creek (07080203-506).

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
Excess Nutrients (TP)	Existing TP Load – 3,645 lbs	Targeted TP Load 2,130 bs	**Improve upland/field surface runoff controls**	Addition of cover crops species to crop rotation (Oats)	N/A	1,626	3,252	Cropland acres with cover crops implemented

Table 21: Strategies and actions proposed for Lime Creek (Bear Lake to MN/IA Border, 07080203-501).

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
Excess Nutrients (TP)	Existing TP Load - 127 lbs Conc. - 175 ug/L	Targeted TP Load 125 lbs Conc. - 150 ug/L	**Improve upland/field surface runoff controls**]	Conduct maintenance on alternative tile inlets currently installed on 21 sites adjacent to Lime Creek to ensure they are functioning according to their designated use which includes the removal of any accumulated sediment and/or trash.	21	21	21	# of properly functioning alternative tile inlets implemented
				Grassed Waterways	5	5	5	Number of Grassed Waterways Implemented and Maintained as Grassed Waterways

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
				Explore options for incentivizing landowners who currently use or are interested in purchasing or renting no-till drill equipment	1	5	10	Number of landowners in the watershed implementing no-till BMPs
				Addition of cover crops species to crop rotation (Oats)	N/A	3,905	7,810	Cropland acres with cover crops implemented
				Maintain/Increase perennial cover in watershed through incorporation of critical area plantings/ pollinator habitat, and/or other native perennial plantings	Two (nonwetland) CRP fields currently located in the watershed	80	80	Maintain critical area (acres) planted in perennial/native vegetation conducive to supporting pollinators
				Sediment Basins/ Terraces	2 terraces currently installed	2	2	# of terraces/basins implemented and maintained
				Identify and map significant gullies	Significant gully identified, plans are underway to address the gully using a grade stabilization structure which will be implemented by 2020	100%	100%	% of gullies addressed
				Conduct regular site visits and necessary maintenance on existing wetland restorations and permanent wetland restoration easements to determine wetlands are functioning as designed	2 wetland restorations, 2 CRP wetland restorations, 2 Permanent Wetland Restoration Easements	2 permanent restoration easements, including 1 to be built in 2019	8, includes 2 permanent wetland restoration easements	Number of wetland restoration/ permanent wetland restoration easement projects Implemented
E. coli	Average monthly geometric mean for June 2008-2017 = 262 cfu/100ml, July = 147 cfu/100ml 1 sample > 1,260 cfu/100ml	Monthly geometric means during June and July < 126cfu/100mL	**Improve management on all nonNPDES feedlots**	Inspect and correct feedlot open lot noncompliance.	13 feedlots in the watershed have already signed the MPCA Open Lot Agreement (OLA)	75%	100%	% of open feedlots issues that have been corrected following inspection on all 28 feedlots.
				Cedar River Bacteria TMDL Strategy 1: Reduce cattle in streams by 40%	N/A	20%	40%	Percentage of cattle with direct access to streams including intermittent waterbodies.
				Cedar River Bacteria TMDL Strategy 2: Unpermitted feedlots will control/capture the first one-half inch of rain	N/A	75%	100%	% of unpermitted feedlots that are capturing the first one-half inch of rain

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
			Manure Management and Feedlot Runoff Controls	Reduce runoff and bacteria loss through adoption of manure management plans	Currently 440 AU in the Lime Creek Watershed	50%	100%	% of animal units in the watershed with approved manure management plans and feedlot runoff controls
				Cedar River Bacteria TMDL Strategy 3: Cropland bacteria loading will be reduced by 40% through proper timing and application of animal waste, waste storage structures, and clean water diversions	N/A	20%	40%	Bacteria load reduction achieved through installation of buffers, livestock access control, waste storage structures, and clean water diversions
			Monitor facilities registered as being close to a stream or lake shoreline	Freeborn County to conduct monitoring to ensure proper management and storage of manure	Four facilities identified as being close to a stream, additional facilities immediately upstream of Bear Lake	75%	100%	% of 4 open feedlots model that are in close proximity to a water resource with an updated MinnFARM model developed that is based on current monitoring and inspection data
			Address failing septic systems	Replace all systems deemed Imminent Threat to Public Health (ITPHSS), including leaking septic systems using Ag BMP Loan Program.	26% of facilities are failing to protect groundwater, 14% or ITPHSS	100%	100%	% of noncompliant ITPHS septic systems upgraded or relocated
			Reduce Industrial/Municipal wastewater bacteria	Cedar River Bacteria TMDL Strategy 4: Meet WLAs, All Effluent from WWTP must also meet the Iowa WQS.	City of Emmons is currently meeting effluent standards	100%	100%	% of effluent samples in compliance with permit
Altered hydrology; peak flow and/or low base flow (Fish/Macroinvertebrate IBI)	Fish IBI Biological Station ID 15CD001 = 28.5, 34.6 Biological Station ID 15CD002 = 55.8, 28.7	20% reduction in peak flows; fish IBI = 35	**Increase living cover**	Increase living cover in watershed through cover crops, perennials and well-managed pastures	N/A	25	50	% of watershed area
			Restore Near Channel Habitat	Implement two staged ditch at locations identified in the Freeborn County Ditch 5 Drainage Water Management Plan	0	1	2	# of two staged ditch projects implemented
			Improve drainage management	Increase tile drainage waters draining into wetlands, saturated buffers and other practices	N/A	15	20%	% of drained cropland acres going into treatment systems
					N/A	50%	100%	

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
			Improve irrigation water management	Implement irrigation water management plans to minimize water withdrawals on irrigated crops.				Adoption rate for all 8 irrigators identified in Lime Creek Watershed
Nitrate	Existing TN Load at Lime Creek Outlet (HSPF Reach 310) - 30,887 lbs/year	Cedar River Nitrate TMDL - 37% Reduction	**Nutrient/Soil Management**	Spring or split nitrogen application	N/A	Gulf of Mexico hypoxia task force - 20% reduction goal	Cedar River Nitrate TMDL - 35% reduction	Implementation helps to achieve progress towards nitrate reduction goals
				Use nitrogen application rates based on the Late-Spring Soil Nitrate Test	N/A	Gulf of Mexico hypoxia task force - 20% reduction goal	Cedar River Nitrate TMDL - 35% reduction	Implementation helps to achieve progress towards nitrate reduction goals
				Adoption of no-till or strip-till systems combined with injection of nitrogen fertilizers.	N/A	Gulf of Mexico hypoxia task force - 20% reduction goal	Cedar River Nitrate TMDL - 35% reduction	Implementation helps to achieve progress towards nitrate reduction goals
				Ensuring that an appropriate nitrogen credit is subtracted from application rates for corn when rotating from a legume crop such as soybeans or alfalfa	N/A	Gulf of Mexico hypoxia task force - 20% reduction goal	Cedar River Nitrate TMDL - 35% reduction	Implementation helps to achieve progress towards nitrate reduction goals
			Cover Crops	Addition of perennial species to crop rotation (Cover Crops)	N/A	25	50	% of cropland acres with cover crops implemented
			Land use	Replace targeted row crop agriculture with select best management practices such as CRP and wetlands	N/A	Gulf of Mexico hypoxia task force - 20% reduction goal	Cedar River Nitrate TMDL - 35% reduction	Implementation helps to achieve progress towards nitrate reduction goals

Table 22: Strategies and actions proposed for Bear Lake (24-0028-00).

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
Excess Nutrients (TP)	Existing TP Load - 15,204.8 lbs Conc. - 262 ug/L	Targeted TP Load 10,097.8 lbsConc. - 90 ug/L	**Improve upland/field surface runoff controls** [to reduce or intercept farm field erosion]	Conduct regular site visits and necessary maintenance on existing WASCOBs to ensure they are functioning properly. Install 2 additional WASCOBS	14 Currently Installed including 9 that address small erosion sites near Bear Lake	2	16	# of WASCOBs Implemented.
				Sediment Basins/ Terraces	1 sediment basin and 1 terrace currently installed	2	4	# of terraces/basins implemented

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
				Grassed Waterways	36	37	37	Number of Grassed Waterways Implemented/Maintained as Grassed Waterways
				Alternative (Rock) tile inlets	Six rock tile inlets to be built in 2019, none currently installed	6	6	Number of Rock Tile Inlets installed
				Maintain and/or enhance existing constructed stormwater ponds	5	5	5	Number of functioning stormwater ponds that serve as nutrient and sediment sinks.
				Conduct regular site visits and necessary maintenance on existing wetland restorations and permanent wetland restoration easements to determine wetlands are functioning as designed	3 wetland restorations currently installed including a 153 acre CRP Wetland Restoration 5 Permanent Wetland Restoration Easements	5 additional wetland restoration projects, including 3 to be built in 2019	15, includes 3 additional permanent wetland restoration easements	Number of wetland restoration/ permanent wetland restoration easement projects Implemented
				Inspect and maintain existing filter strips within the watershed, Implement additional filter strips, including proposed filter strip/wetland restoration project	2	3	3	# of filter strips installed in the watershed
				No-till	0	Identify producers willing to implement no-tillage systems on their farms	40	# of cropland acres using no-till practices
				Addition of perennial species to crop rotation (Cover Crops)	N/A	25	50	% of cropland acres with cover crops implemented
			Protect/stabilize banks/bluffs	Two-Staged Ditch	Two sites identified along Stewart Creek to be built by 2023	3,000 acres	6,000 acres	Drainage area to the portions of Stewart Creek that will be transformed into a two-staged ditch
			Increase vegetative cover/root duration	Maintain/Increase perennial cover in watershed through incorporation of critical area plantings/ pollinator habitat, and/or other native perennial plantings	10	20	30	Critical area (acres) planted in perennial/native vegetation conducive to supporting pollinators

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
			Improve urban/residential stormwater management [to reduce sediment and flow]	Work with the City of Conger to implement at least one raingarden	0	1	>1	# of Raingardens Implemented

Table 23: Strategies and actions proposed for Steward Creek – County Ditch 23 (07080203-504).

Parameter (incl. nonpollutant stressors)	Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy Type	Current strategy adoption level, if known	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level	Units
Excess Nutrients (TP)	Existing TP Load to Bear Lake - 7,624.5 lbs	Targeted TP Load to Bear Lake 4,539.5 lbs	**Implement BMPS identified in the Bear Lake Watershed**. These BMPS include projects in the Steward Creek-County Ditch 23 Watershed	Implement Bear Lake BMPs	----	----	----	----

4. Monitoring plan

The collection of current land and water data is an important component to both assess progress, and inform management and decision-making. For improved watershed management to work in the Winnebago River Watershed, there needs to be reliable data that can be used to generate information.

Monitoring of both land and water components is needed, and data is then used to inform and calibrate watershed models, and evaluate progress towards defined goals and desired outcomes. Section 7 of the Winnebago River TMDL includes more information on monitoring.

It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. Evaluation of watershed surface waters and BMPs will occur during implementation. The response of the lakes and streams will be monitored and subsequently evaluated as management practices are implemented. Data will be evaluated and decisions will be made as to how to proceed for the next five years. The management approach to achieving the goals should be adapted as new monitoring data is collected and evaluated (Figure 41). Continued monitoring and “course corrections” responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in the Winnebago River TMDL. Management activities will be changed or refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies.

Again, this is a general guideline. Factors that may mean slower progress include limits in funding or landowner acceptance, challenging fixes (e.g., restoring ditched peatlands, invasive species) and unfavorable climatic factors. Conversely, there may be faster progress for some impaired waters, especially where high-impact fixes are slated to occur.

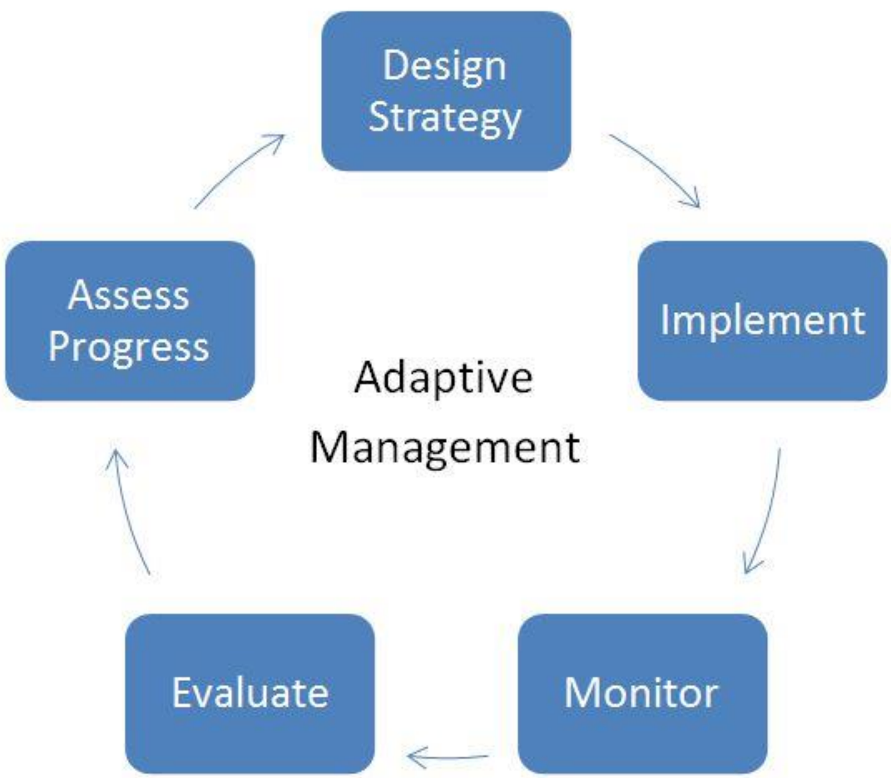


Figure 41. Adaptive Management

Monitoring strategies should include:

- increasing the monitoring of DO in the watershed's streams and ditches to better assess if they are supporting aquatic life;
- continued monitoring of Bear Lake and State Line Lake; and
- monitoring BMPs. Monitoring does not need to take place on all BMPs or at too fine of a scale, but should focus on practices with similar criteria and scenarios to others in the watershed. This monitoring will provide the necessary information for evaluating the success of conservation efforts in the watershed and to determine future prioritization needs for restoration and protection.

As part of the MPCA IWM strategy, four stream sites and two lakes were monitored in 2015 and 2016 for biology (fish and macroinvertebrates). Details about the MPCA IWM strategy can be found in the Winnebago River and Upper Wapsipinicon River Watersheds Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-07080203b.pdf

The second round (Cycle 2) of intensive water quality monitoring in the Winnebago will begin in 2019. Lime Creek (15CD001) and Steward Creek (15CD003) will be monitored for fish and invertebrates; Lime Creek (S007-338) will be monitored for chemistry.

The Winnebago River Watershed is planning a comprehensive watershed plan (Shell Rock River/Winnebago Watershed CWMP), beginning in 2019. Implementing and monitoring BMPs is recommended to be included as a priority within this plan.

Winnebago River Watershed Reports

All Winnebago River Watershed reports referenced in this watershed report are available at the Winnebago River Watershed webpage: https://www.pca.state.mn.usaz/water/watersheds/winnebago-river.

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6. Appendix

Table 24. Scenario B BMP reduction estimates and sources.

HSPF Reach ID	Implemented / Proposed BMP	Area (acres) treated	TN Reduction		TP Reduction		TN Load Reduction	TP Load Reduction
	(number)	(acres)	(lb/acre treated)	Source	(lb/acre treated)	Source	(lb/year)	(lb/year)
251	Critical Area Planting (1)	5	14.3	Iowa NRS	0.5	Iowa NRS	71.7	2.4
	Grassed Waterway (6)	120	4.0	Ag BMP Handbook	1.1	Iowa NRS	477.0	129.6
	WASCOB (2)	20	------		2.2	Modeled Average	------	44.1
	Filter Strip (1)	40	14.3	Iowa NRS	0.5	Iowa NRS	573.6	19.2
	Wetland Restoration (1)	153	6.2	NBMP Spreadsheet	0.0	PBMP Spreadsheet	941.0	0.0
253	Critical Area Planting (1)	5	14.3	Iowa NRS	0.5	Iowa NRS	71.7	2.4
	Basin Berm (1)	20	9.9	Iowa NRS	1.4	Iowa NRS	198.6	28.7
	Filter Strip (1)	20	14.3	Iowa NRS	0.5	Iowa NRS	286.8	9.6
	Grassed Waterway (17)	340	4.0	Ag BMP Handbook	1.1	Iowa NRS	1,351.5	367.2
	WASCOB (2)	20	------		2.2	Modeled Average	------	44.1
	Two-Staged Ditch (2)	6000	4.2	MN Drainage Law Analysis and Evaluation	------		25,200.0	------
	Wetland Restoration (4)	1600	6.2	NBMP Spreadsheet	0.0	PBMP Spreadsheet	9,840.0	0
255	Filter Strip (1)	20	14.3	Iowa NRS	0.5	Iowa NRS	286.8	9.6
	Grassed Waterway (4)	80	4.0	Ag BMP Handbook	1.1	Iowa NRS	318.0	86.4
	Alternative (Rock) Inlet (1)	10	------		0.15	Local Partners	------	1.5
	Critical Area Planting - 15 YR CRP (1)	20	14.3	Iowa NRS	0.5	Iowa NRS	286.8	9.6
	Constructed Pond (1)	20	------		1.1	Local Partners	------	22.9
	Controlled Drainage (1)	80	3.37	Local Partners	0.15	Local Partners	269.6	12.0
	Pollinator habitat (1)	15	14.3	Iowa NRS	0.5	Iowa NRS	215.1	7.2
	Wetland Restoration (3)	1200	6.2	NBMP Spreadsheet	0.0	PBMP Spreadsheet	7,380.0	0.0
257	Controlled Drainage (3)	240	3.37	Local Partners	0.15	Local Partners	808.8	36.0

HSPF Reach ID	Implemented / Proposed BMP	Area (acres) treated	TN Reduction		TP Reduction		TN Load Reduction	TP Load Reduction
	(number)	(acres)	(lb/acre treated)	Source	(lb/acre treated)	Source	(lb/year)	(lb/year)
	Grassed Waterway (6)	120	4.0	Ag BMP Handbook	1.1	Iowa NRS	477.0	129.6
	Alternative (Rock) Inlet (5)	50	------		0.15	Local Partners	------	7.3
	Constructed Pond (3)	60	------		1.1	Local Partners	------	68.7
	WASCOB (2)	20	------		2.2	Modeled Average	------	44.1
	Terrace/basin (2)	40	9.9	Iowa NRS	1.4	Iowa NRS	397.1	57.3
	Wetland Restoration (6)	2400	6.2	NBMP Spreadsheet	0.0	PBMP Spreadsheet	14,760.0	0.0
260	Nitrogen Bioreactor (2)	20	1.2	NBMP Spreadsheet	------	PBMP Spreadsheet	24.4	------
	Terrace (1)	20	9.9	Iowa NRS	1.4	Iowa NRS	198.6	28.7
	Constructed Pond (1)	20	------		1.1	Local Partners	------	22.9
	Erosion Site (Small WASCOBS) (9)	45	9.9	Iowa NRS	1.4	Iowa NRS	------	64.5
	Grassed Waterway (5)	100	4.0	Ag BMP Handbook	1.1	Iowa NRS	397.5	108.0
	Wetland Restoration (1)	400	6.2	NBMP Spreadsheet	0.0	PBMP Spreadsheet	2,460.0	0.0
	WASCOB (1)	20	------		2.2	Modeled Average	------	44.1
270	Alternative Inlet (3)	30	------		0.15	Local Partners	------	4.4
	WASCOB (6)	120	------		2.2	Modeled Average	------	264.5
271	WASCOB (1)	20	------		2.2	Modeled Average	------	44.1
	Critical Area Plantings (2)	40	14.3	Iowa NRS	0.5	Iowa NRS	573.6	19.2
	Constructed Pond (2)	40	------		1.1	Local Partners	------	45.8
	Terrace (2)	40	9.9	Iowa NRS	1.4	Iowa NRS	397.1	57.3
	Grassed Waterway (8)	160	4.0	Ag BMP Handbook	1.1	Iowa NRS	636.0	172.8
	Wetland Restoration (2)	800	6.2	NBMP Spreadsheet	0.0	PBMP Spreadsheet	4,920.0	0.0
272	Grassed Waterway (1)	20	4.0	Ag BMP Handbook	1.1	Iowa NRS	79.5	21.6
	WASCOB (1)	20	------		2.2	Modeled Average	------	44.1
273	Wetland Restoration (2)	800	6.2	NBMP Spreadsheet	0.0	PBMP Spreadsheet	4,920.0	0.0

HSPF Reach ID	Implemented / Proposed BMP	Area (acres) treated	TN Reduction		TP Reduction		TN Load Reduction	TP Load Reduction
	(number)	(acres)	(lb/acre treated)	Source	(lb/acre treated)	Source	(lb/year)	(lb/year)
	Grassed Waterway (2)	40	4.0	Ag BMP Handbook	1.1	Iowa NRS	159.0	43.2
290	Alternative Inlet (13)	130	------		0.15	Local Partners	------	18.9
	Critical Area Planting - 15 YR CRP (1)	40	14.3	Iowa NRS	0.48	Iowa NRS	573.6	19.2
	Grassed Waterway (1)	40	4.0	Ag BMP Handbook	1.1	Iowa NRS	159.0	43.2
291	Filter Strip (1)	40	14.3	Iowa NRS	0.5	Iowa NRS	573.6	19.2
	Grassed Waterway (2)	40	4.0	Ag BMP Handbook	1.1	Iowa NRS	159.0	43.2
	Irrigation BMP (1)	------	------		------		------	------
	Critical Area Planting - 15 YR CRP (1)	40	14.3	Iowa NRS	0.48	Iowa NRS	573.6	19.2
	No-till (1)	40	------		0.1	Local Partners	------	4.0
	Gully Grade Stabilization Structure	40	9.9	Iowa NRS	1.4	Iowa NRS	397.1	57.3
	Terrace (2)	40	9.9	Iowa NRS	1.4	Iowa NRS	397.1	57.3
	Tile cut (1)	------	------		------		------	------
	Wetland Restoration (1)	400	6.2	NBMP Spreadsheet	0.0	PBMP Spreadsheet	2,460.0	0.0
310	Alternative Inlet (5)	50	------		0.15	Local Partners	------	7.3
	Grassed Waterway (6)	120	4.0	Ag BMP Handbook	1.1	Iowa NRS	477.0	129.6