Watershed

August 2020

Mississippi River – La Crescent Area Watershed Restoration and Protection Strategy Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Acronyms

ACPF	Agriculture Conservation Planning Framework
AUID	Assessment Unit Identification
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
DNR	Minnesota Department of Natural Resources
DWSMA	Drinking Water Supply Management Area
EOR	Emmons and Olivier Resources, Inc.
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentive Program
FIBI	Fish Index of Biotic Integrity
GHG	Greenhouse Gas
GIS	Geographic Information Systems
HGM	Hydrogeomorphic Classification System
IBI	Index of Biotic Integrity
IPHT	Imminent Public Health Threat
IWM	Intensive Watershed Monitoring
LiDAR	Light Detection and Ranging
MAWQCP	Minnesota Agriculture Water Quality Certification Program
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
MIBI	Macroinvertebrate Index of Biotic Integrity
MPCA	Minnesota Pollution Control Agency
MRLCW	Mississippi River – La Crescent Watershed
MS4	Municipal Separate Storm Sewer System
MSHA	Minnesota Stream Habitat Assessment
N	Nitrogen
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service

NRS	Nutrient Reduction Strategy
P	Phosphorus
PCB	Polychlorinated biphenyl
SDS	State Disposal System
SFIA	Sustainable Forest Incentive Act
SID	Stressor Identification
SSTS	Subsurface Septic Treatment System
SWCD	Soil and Water Conservation District
SWPPP	Stormwater Pollution Prevention
TAC	Technical Advisory Committee
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
TP	Total Phosphorus
USDA	United States Department of Agriculture
WLA	Wasteload Allocation
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	Watershed Restoration and Protection Strategy
WWTP	Wastewater Treatment Plant

Executive summary

This Watershed Restoration and Protection Strategy (WRAPS) report for the Mississippi River – La Crescent Area Watershed (MRLCW) is a strategic document outlining critical areas and best strategies for protecting and restoring the watershed's streams. The goal of this document is to accurately describe the existing characteristics, condition, and water quality trends of important resources in the watershed, and to lay out a plan for a protection and restoration aiming to 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.

The MRLCW is located in northeast Houston County and southeast Winona County. The watershed drains 95 square miles and includes a collection of tributaries that flow directly to the Mississippi River. Pine Creek is the largest stream in the watershed. Beginning just south of Interstate 90, the stream flows south then east before meeting the Mississippi River in La Crescent.

The watershed is located entirely in the Driftless Area, known for its karst features, deep limestone valleys and coldwater streams. The landscape is dominated by hills and valleys, with moderate to well-drained soils over bedrock. Designated trout streams (managed by the Minnesota Department of Natural Resources [DNR]) provide highly desirable fishing opportunities. The MRLCW includes the city of La Crescent (population 4,830) as well as towns of New Hartford, Dresbach, and Dakota.

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. Several streams, including Rose Valley Creek, Pine Creek (headwaters), and Dakota Creek are meeting aquatic life uses. Dakota Creek was found to be meeting exceptional use criteria for biology, indicating a very high quality biological stream community. The most downstream section of Pine Creek was found to be impaired by *Escherichia coli (E. coli)* bacteria and total suspended solids (TSS), and have an unsatisfactory Fishes Bioassessment. The MRLCW Stressor Identification (SID) Study identified temperature, TSS, and lack of habitat as stressors to the fish community.

Tools used to target geographic areas for restoration and protection included a geomorphic stream survey to identify areas of streambank erosion along Pine Creek, and the Agricultural Conservation Planning Framework (ACPF) storage pond tool to identify existing and potential storage ponds to reduce total and peak flows to Pine Creek and other MRLCW streams. Four priority subwatersheds were identified by local partners: Pine Creek Headwaters and Pine Creek subwatersheds for restoration of TSS and *E. coli* impairments, and Dakota Creek and Rose Valley Creek subwatersheds for protection of good existing water quality. Key strategies for restoration and projection include: buffer compliance/riparian shading, cover crops, Forest Stewardship Plans/land conservation, livestock management, solar runoff management, upstream water storage, and urban stormwater management.

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 monitoring and 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 Total Maximum Daily Load (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 local implementation planning •Summarize watershed approach work done to date including the following reports: •*Upper Iowa River, Mississippi River - Reno, Mississippi River - La Crescent Watersheds Monitoring and Assessment Report* •*Mississippi River - La Crescent Stressor Identification Report* •*Mississippi River - La Crescent Watershed Total Maximum Daily Load Report*
Scope	•Impacts to aquatic recreation and impacts to aquatic life in streams
Audience	•Local working groups (local governments, SWCDs, watershed management groups, etc.) •State agencies (MPCA, DNR, BWSR, etc.)

1. Watershed background and description

The MRLCW contains two HUC-10 subwatersheds that collectively drain 95 square miles of southeast Winona County and northeast Houston County. The watershed includes a collection of tributaries that flow directly to the Mississippi River. Pine Creek is the largest stream in the watershed. Beginning just south of Interstate 90, Pine Creek flows south then east before joining the Mississippi River in La Crescent. State, federal, and tribal lands comprise 14% of the MRLCW (Figure 1).

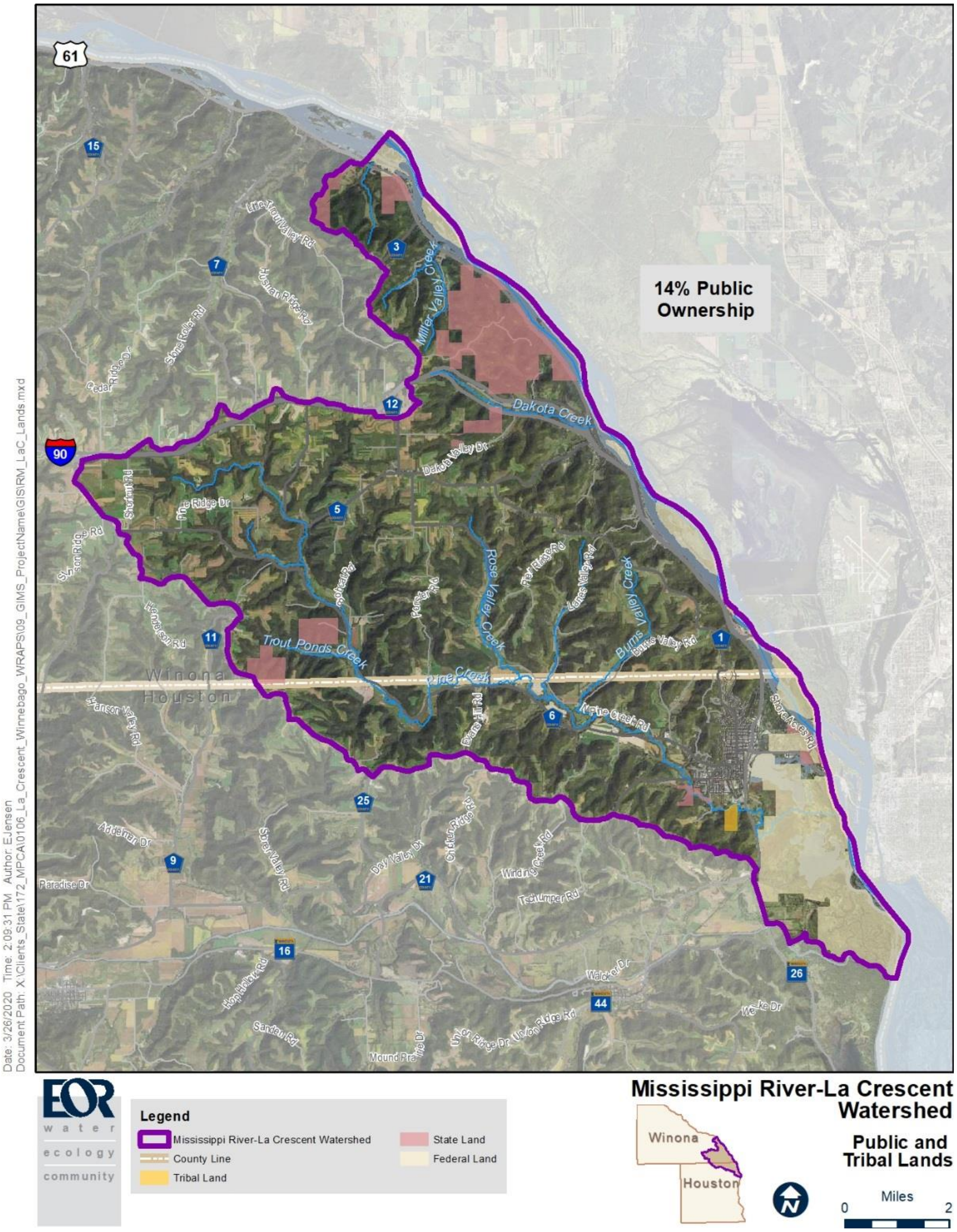


Figure 1. Public and tribal lands in the MRLCW.

The watershed is located entirely in the Driftless Area, a large region in Minnesota, Iowa, Illinois, and Wisconsin that was not impacted by the most recent glaciers (Figure 2). The area is known for its karst features (limestone bedrock that has been eroded to produce ridges, valleys, and sinkholes) and coldwater streams. Hunting, fishing, hiking and camping are popular recreational activities in southeast Minnesota.

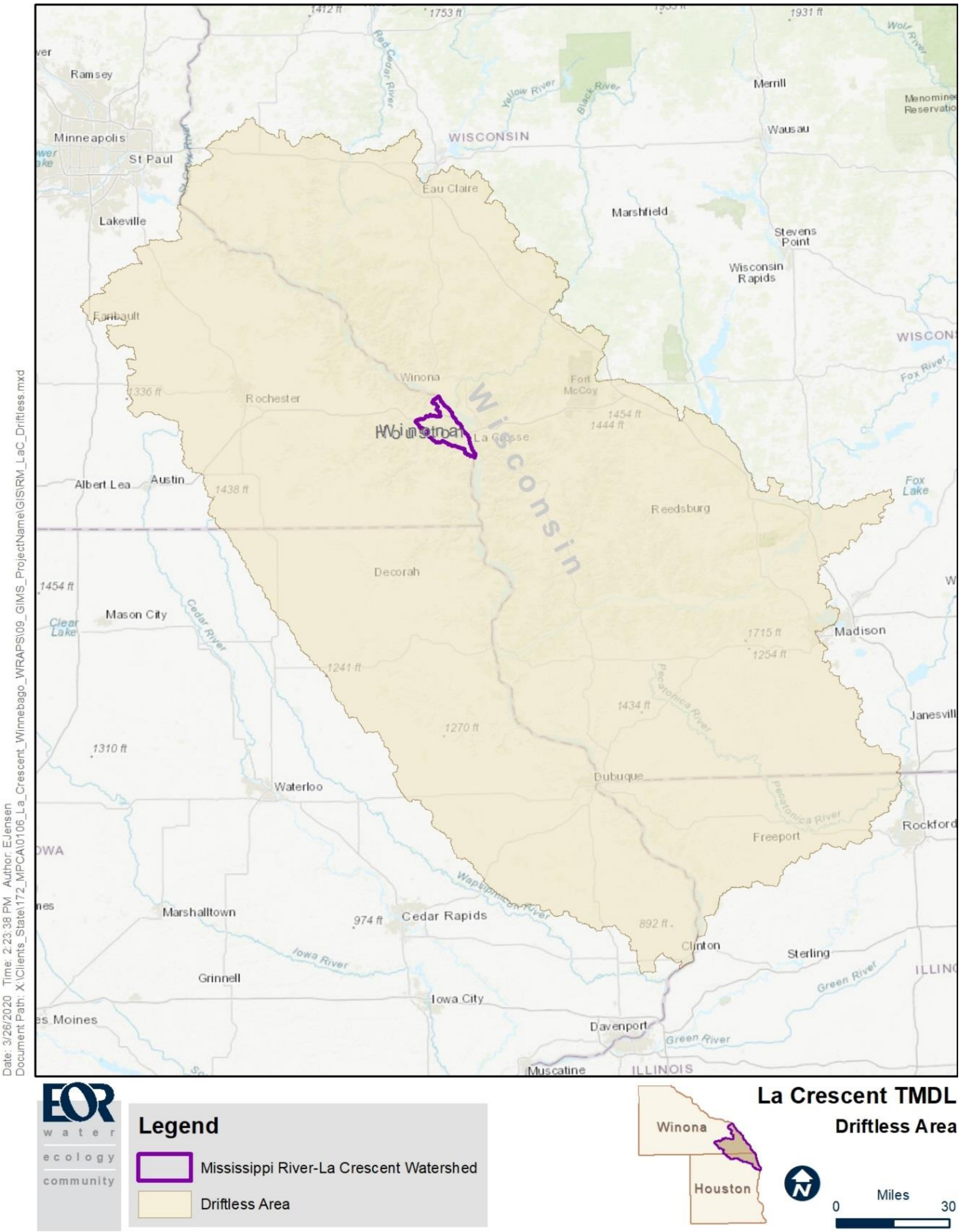


Figure 2. The Mississippi River-La Crescent Area Watershed is located in the Driftless Area.

The MRLCW contains a complex combination of different land use and land types (Figure 3). A large portion of the watershed is wooded (46.3%). The steep slopes and tight valley floors indicative of this bluff land karst watershed is not conducive to traditional agricultural practices found elsewhere in Minnesota, and only small portions of the watershed are cultivated row crop production (3.4%). Pastureland (23.4%) is often found in the valleys where the land is too steep to access with farming equipment. Pasture leaves vegetation on the land, but instances of over-grazing and trampling of stream banks can contribute to poor water quality. Conservation practices on agricultural land are common and include contour stripping, contour farming, field terraces, diversions and grass waterways. These practices help to prevent erosion and keep fields stable.

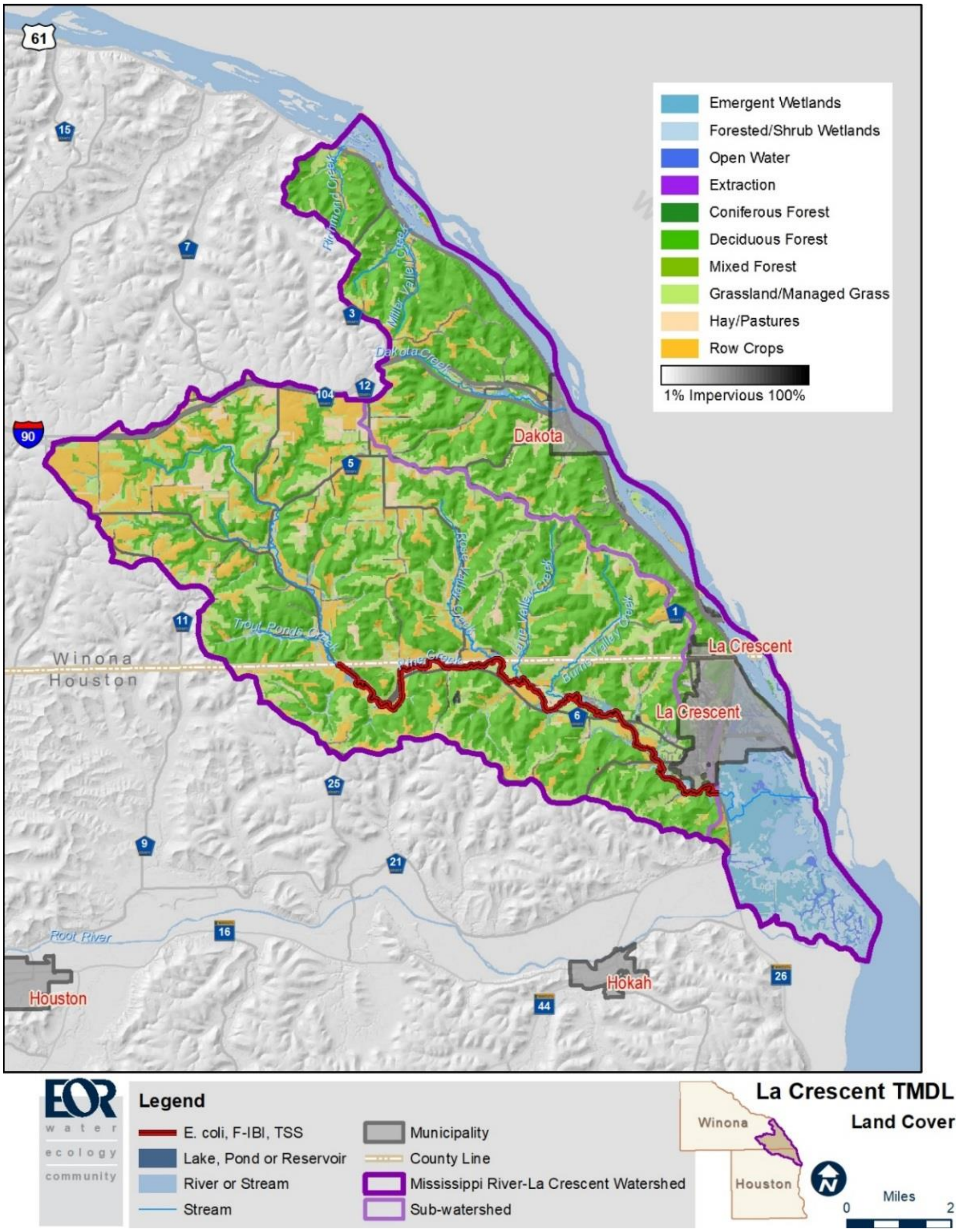


Figure 3. Minnesota Land Cover Classification System land cover for the Mississippi River – La Crescent Area Watershed.

The scenic karst ridges, valleys, and coldwater streams are a source of tourism in the area, providing income to a number of local businesses. La Crescent is the largest town in the watershed with a reported 2010 census population of 4,830. The city of La Crescent, the "Apple Capital of Minnesota," is nestled near the banks of the Mississippi River. In fact, the town is named for the crescent shape the Mississippi takes around the town. Other towns in the watershed include New Hartford, Dresbach, and Dakota.

Figure 4. Brook trout caught on a Southeastern Minnesota Stream: Image Source - Winonaflyfactory.com.

1.1 Climate Change – Potential Impacts

Hydrology

Over the last 50 years, average annual precipitation totals in the Midwest have increased by 5% to 10% (EPA 2016). This increase is largely being driven by an increase in the amount of rainfall that falls during the four wettest days of the year, which has increased by 35% (EPA 2016). In the MRLCW, a National Weather Service station (La Crescent Dam 7 station #214418) measures annual weather statistics. Since 1939, on average there has been 0.09 inches of increased precipitation each decade.

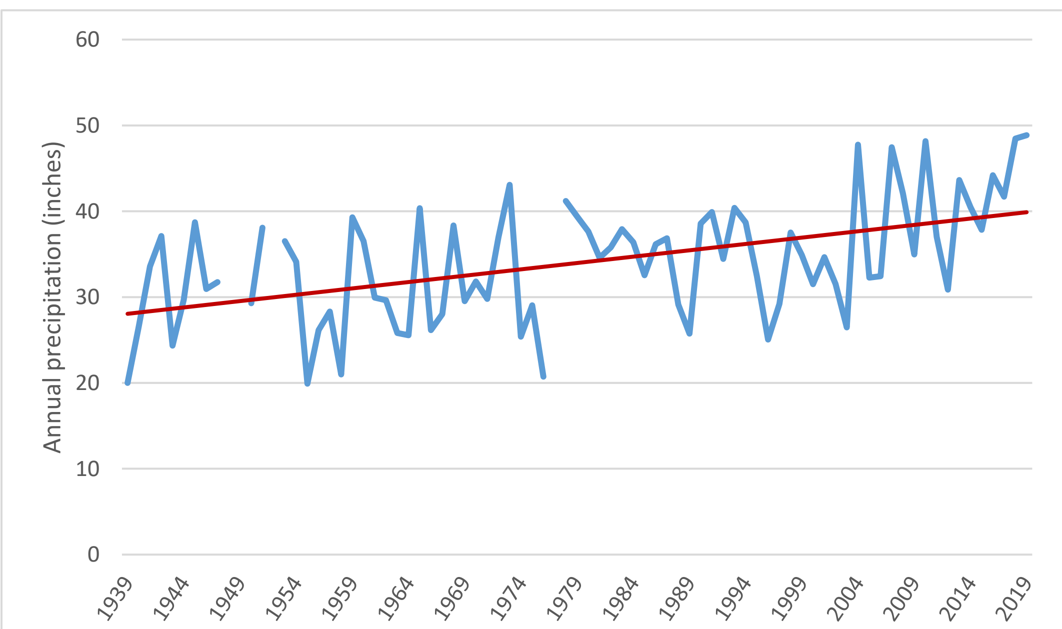


Figure 5. Annual measured precipitation for NWS station La Crescent Dam 7 (DNR 2020).

In 2007, a large flood devastated areas of southeast Minnesota. The MRLCW received 8 to 15 inches of rain in 24 hours. The floods washed out roads, buildings, and even railroad tracks. In some locations, stream channels were entirely changed or moved. Effects from the floods have diminished, but can still be seen in parts of the watershed. Subsequent floods in 2009 and 2010 added to the damage done in 2007. Large sections of streams were washed away, and people living near the downstream reaches were highly impacted.

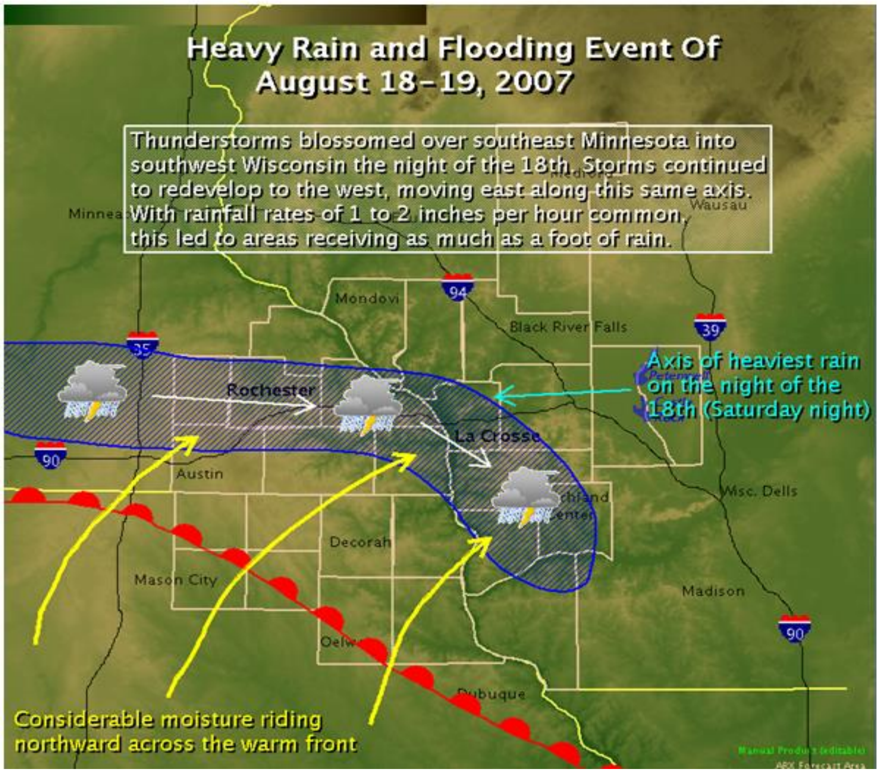


Figure 6. Description of August 18/19, 2007 flooding event. **Image Source: www.weather.gov/arx/aug1907.**

The MPCA does not currently maintain a stream flow gage in the MRLCW, but the northern neighboring watershed, Mississippi River – Winona, can be used an example of recent flow trends. The flow gage installed at watershed pollutant load monitoring station, “Whitewater River near Beaver, CSAH 30,” has seen an increase in annual flow volume of the Whitewater River (2009 through 2016). Because of the close proximity of this neighboring watershed, it can be assumed that this same increase in flow trend is occurring in the MRLCW.

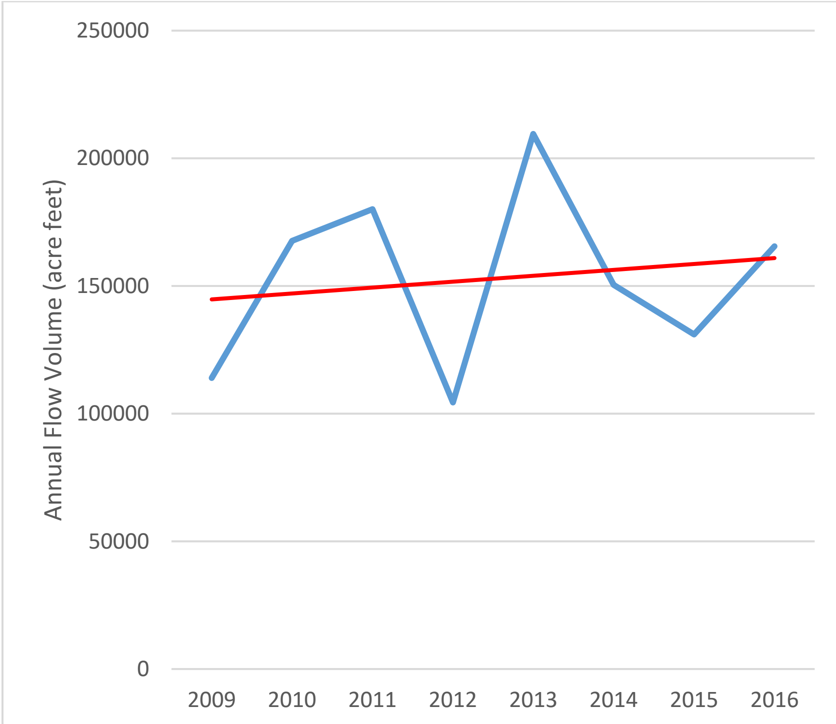


Figure 7. Annual flow volume from Whitewater River near Beaver CSAH 30 (2009 - 2016).

The susceptibility of MRLCW streams to streambank erosion increases during intense rainfall events, which are predicted to happen with greater frequency and intensity. Intense rainfall events are likely to result in an increased amount of sediment and pollutants that run off from land to streams in the MRLCW; consequently, the risk of pollution is likely to increase if the frequency and intensity of rainfall events becomes more severe.

There is some evidence that waterbodies in the MRLCW are already beginning to change. For example, a review of aerial photography for the previous 80 to 100 years indicates that the Pine Creek Channel appears to be evolving, likely because of the combined effects of land use changes, cattle hoof shear stress, and climate change (MPCA 2018b). Much of Pine Creek is currently in a state of accelerated change. When Pine Creek is classified using Rosgen stream types, 68% was classified as typically unstable stream types (63% F and 5% G), compared to only 32% as potentially stable stream types (22% C, 1% E, and 9% B). Over time Pine Creek will likely evolve to a narrower C stream type channel at a lower base level with less sinuosity then the original channel (MPCA 2018b).

Water Temperature

According to the DNR climate journal summary, 2016 was the fifth warmest year on record in Minnesota. The maximum temperature measurement over the four years of temperature data collected on Pine Creek was from July 22, 2016. On that day, station 15LM040 had a maximum temperature of 25.3°C (77.5°F) while the max at 15LM043 was just slightly lower, at 24.5°C (76.1°F). This maximum temperature is higher than many in the region and demonstrates a high potential for thermal stress in the summer months in Pine Creek. Warmer water tends to cause more algal blooms, carry lower dissolved oxygen, and impact coldwater biota.

Additional Mississippi River – La Crescent Watershed Resources

Houston County Soil and Water Conservation District – Contact Houston SWCD for additional information including updated 2007-2022 County Water Plan: https://www.co.houston.mn.us/departments/soil-and-water/

Minnesota Department of Natural Resources (DNR) Watershed Context Report: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/context_report_major_42.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_42.pdf

Minnesota Nutrient Planning Portal: https://mrbdc.mnsu.edu/mnnutrients/watersheds/mississippi-river-la-crescent

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

Mississippi River-La Crescent Stressor Identification Report: https://www.pca.state.mn.us/sites/default/files/wq-ws5-07040006a.pdf

Upper Iowa River, Mississippi River Reno, Mississippi River-La Crescent Watersheds Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-07010103b.pdf

2. Watershed conditions

The MRLCW contains several designated trout streams including Pine Creek (headwaters), Miller Creek, Rose Valley Creek, Trout Ponds Creek, and many protected tributaries (Figure 8). Natural channel conditions are found on 114 miles (or 50%) of the streams in the watershed, 61 miles (or 27%) of the stream channels are defined as altered, and 39 miles (or 17%) are defined as impounded (Figure 9). The MRLCW does not contain a long-term Watershed Pollutant Load Monitoring Network (WPLMN) monitoring site. Data collected through IWM in the MRLCW suggests that water quality conditions are generally good and can be attributed to the forests, pastures and hay land that dominate land cover. Portions of the watershed have steep valleys with highly erodible soils.

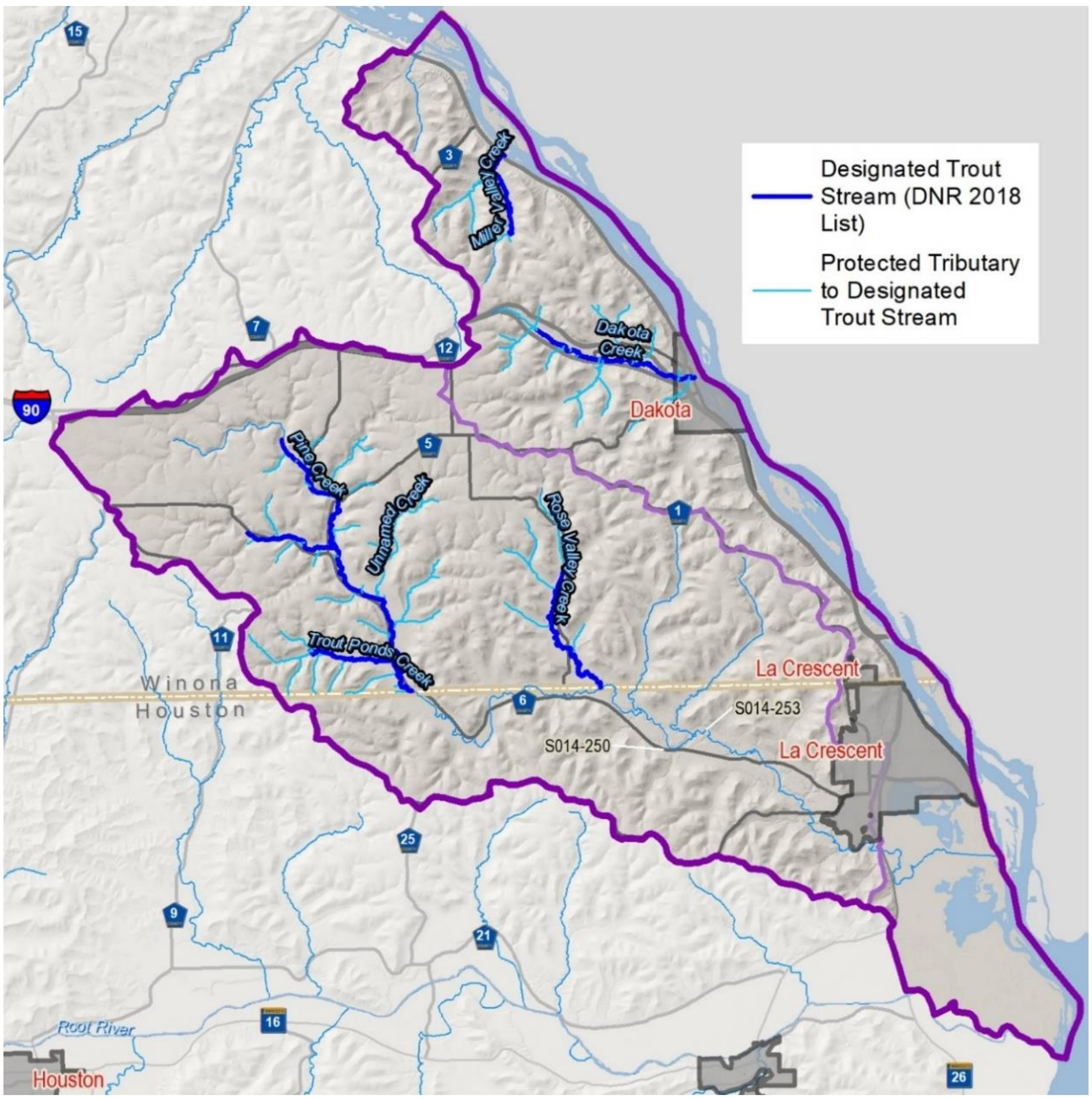


Figure 8. Minnesota DNR 2018 designated trout streams and protected tributaries to designated trout streams.

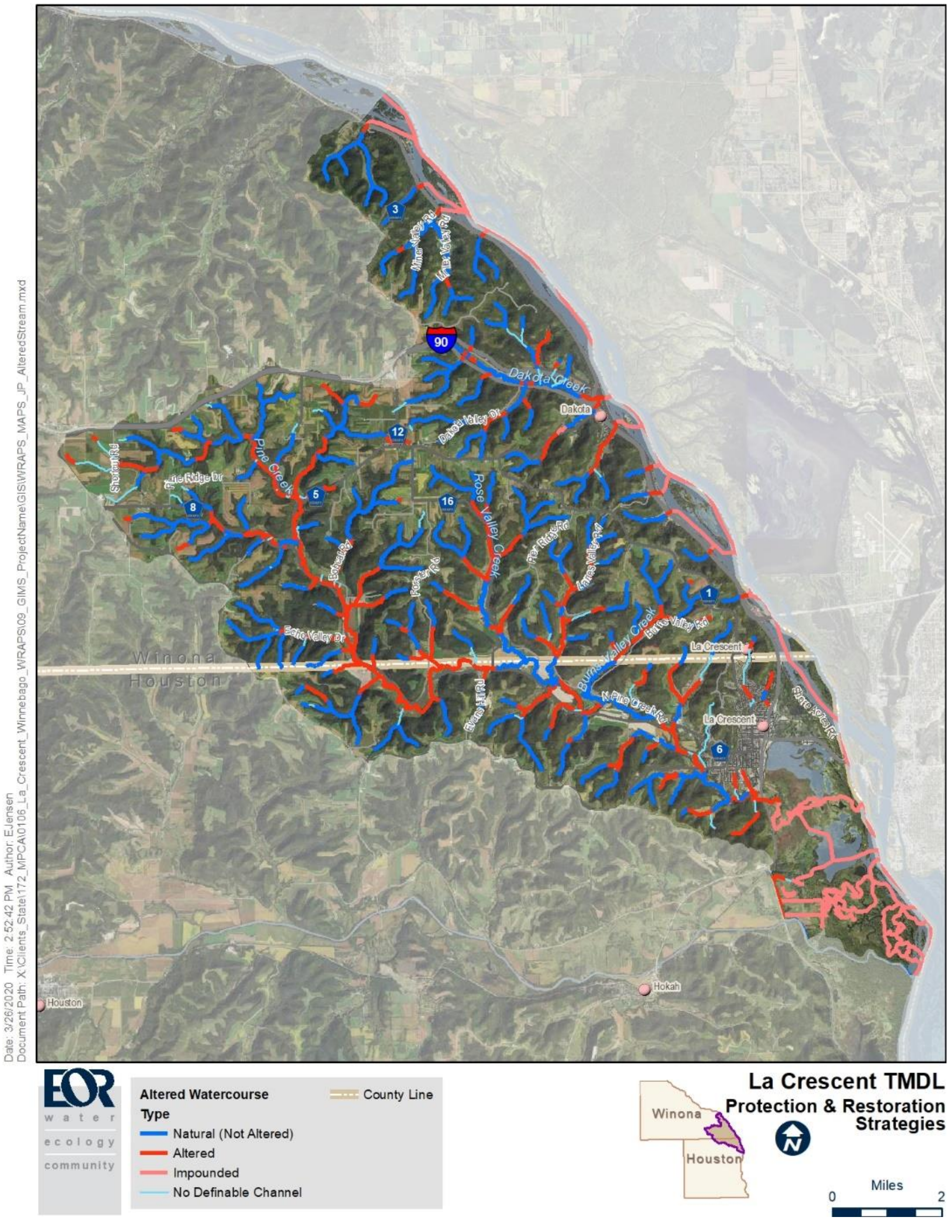


Figure 9. Altered watercourses in the MRCLW; MPCA 2019.

The watershed has many karst features (Figure 10), which include springs, sinkholes and disappearing streams. These karst features are concentrated on bluff tops in the western area of this watershed. Karst is a geography characterized by porous limestone. Imagined as the Swiss cheese of rock, water and any surface contaminants can move quickly to groundwater due to these pore spaces.

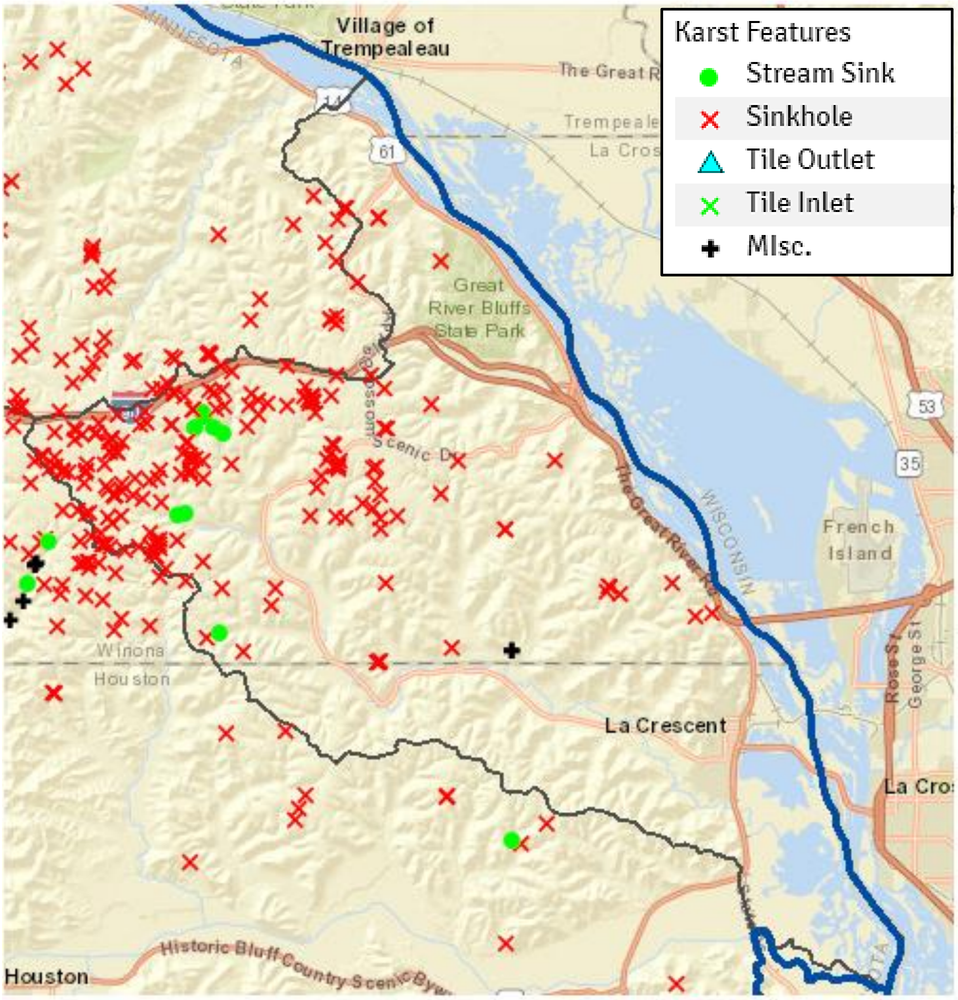


Figure 10. Karst features in the MRLCW (DNR 2019).

The watershed contains a large number of wetlands and interconnected deep water habitats that provide critical fish and wildlife habitat within the Mississippi River floodplain (MPCA 2018a). Most of the wetlands are dominated by herbaceous emergent vegetation or are floodplain forested wetlands associated with the Mississippi River backwater and floodplain complex. There are no lakes in the watershed.

2.1 Condition status

Beginning in 2015, the MPCA initiated IWM efforts on streams and wetlands within the Upper Iowa River, Mississippi River-Reno Area, and MRLC watersheds. This effort included data collection on five stream reaches within the MRLCW and a hydrogeomorphic classification of the watershed's wetlands (MPCA 2018). Fish contaminant samples (such as mercury and polychlorinated biphenyls [PCBs]) were not collected in the watershed. 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](https://www.pca.state.mn.us).

Assessments of use support in Minnesota are made for individual waterbodies. The waterbody unit used for river systems, lakes and wetlands is called the "assessment unit." A stream or river assessment unit usually extends from one significant tributary stream to another or from the headwaters to the first tributary. Therefore, a stream or river is often segmented into multiple assessment units that are variable in length. Multiple assessment units are identified by assessment unit identification numbers (AUIDs). Many times, AUIDs will be abbreviated to their last three digits (e.g. "-507").

Streams

Four stream reaches were assessed for aquatic life and a fifth stream reach did not have enough monitoring data available for assessment (Miller Valley Creek) (Figure 11). Of the reaches assessed, three are meeting aquatic life water quality standards (Pine Creek in Winona County, Rose Valley Creek, and Dakota Creek) and one (Pine Creek Reach -576) is impaired for aquatic life standards (Table 1 Figure 1). Only one reach, Pine Creek (Reach -576), had *E. coli* monitoring data available for aquatic recreation assessment and was found to be impaired by excess bacteria. As a result, Pine Creek is listed on Minnesota's 2018 303(d) list of impaired waters.

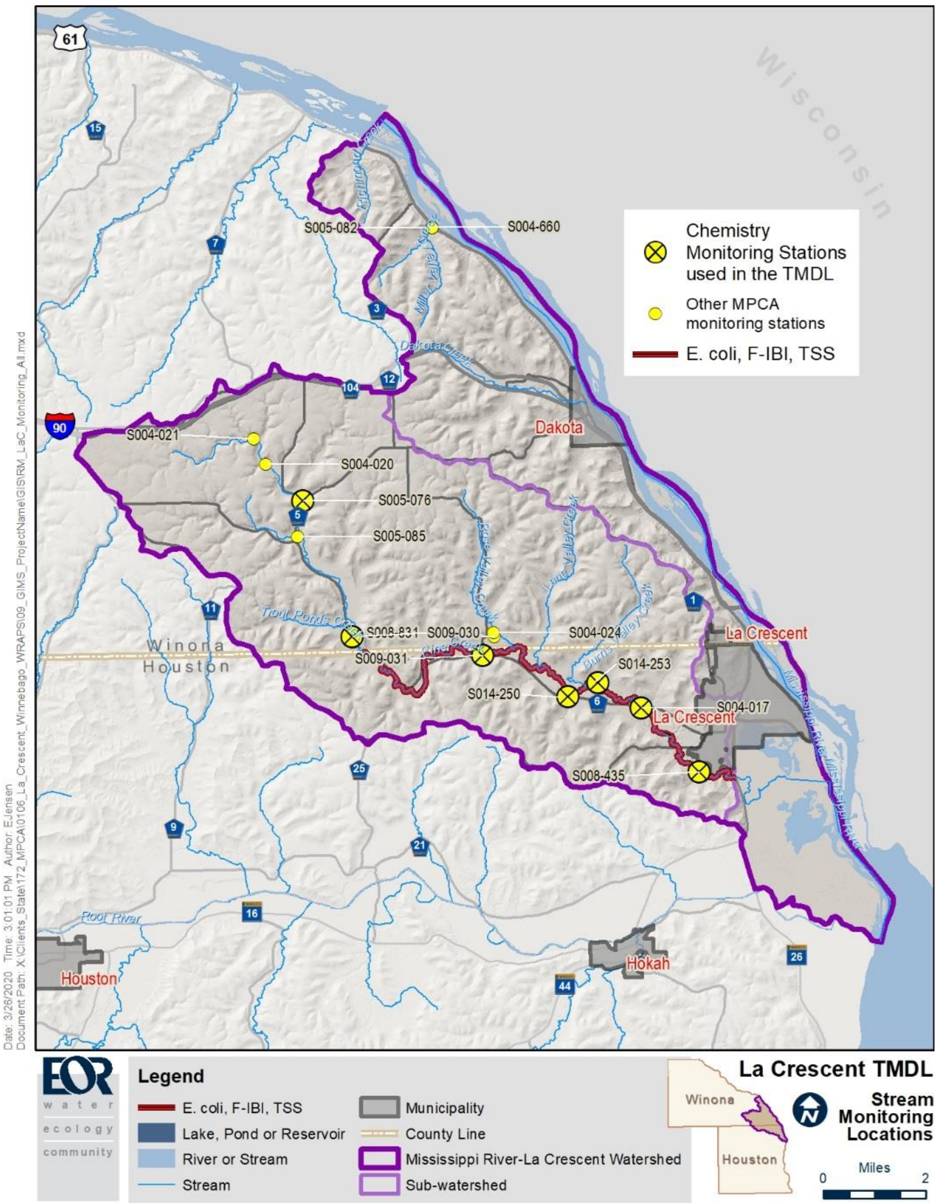


Figure 11. Biological and chemistry monitoring stations in the Mississippi River - La Crescent Area Watershed.

Table 1. Aquatic Life and Aquatic Recreation Use Assessments in the Mississippi River – La Crescent Area Watershed (MPCA 2018a).

Waterbody Name/ AUID	Reach description	Reach length (miles)	Use class	Aquatic life indicators:										Aquatic life	Aquatic recreation
				Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia-Nh3	Pesticides	Eutrophication		
Pine Creek 07040006-507	T105 R6W S13, north line to T105 R5W S32, south line	5.79	2Ag	MTS	MTS	IF	IF	IF	--	MTS	IF	--	IF	**SUP**	--
Rose Valley Creek 07040006-511	T105 R5W S22, north line to Pine Creek	4.60	2Ag	MTS	MTS	IF	IF	IF	--	IF	IF	--	IF	**SUP**	--
Pine Creek 07040006-576	T104 R5W S4, north line to Hwy 16	13.14	2Ag*	EXS	MTS	IF	EXS	EXS	MTS	IF	MTS	--	IF	**IMP**	**IMP**
Dakota Creek 07040006-512	T105 R5W S3, south line to Mississippi River	4.26	2Ag	MTS	MTS	IF	IF	IF	--	IF	IF	--	IF	**SUP**	--
Miller Valley Creek 07040003-594	T106 R5W S28, south line to Mississippi River	1.82	2Ag	--	--	--	--	IF	--	--	--	--	--	**IF**	--

Abbreviations for Indicator Evaluations: MTS = meets standard; EXS = fails standard; IF = insufficient information; IBI = Index of Biotic Integrity; TSS = total suspended solids
Abbreviations for Use Support Determinations: -- = no data NA = not assessed, IF = insufficient information, SUP= full support (meets criteria), IMP = impaired (fails standards)
Abbreviations for Use Class: 2Ag = Coldwater general; 2Bg = cool or warmwater general
** There is a proposed use class change for this reach of Pine Creek from 2Bg to 2Ag. The TSS and fish IBI impairments for this reach were based on the Coldwater general water quality standards, and are expected to be added to the impaired waters list following the 2021/2022 assessment cycle.*

Pine Creek (-576) currently has a warmwater (2Bg) designation. Fish, macroinvertebrate and water temperature data support a coldwater (2Ag) designation. The DNR has recognized that the stream supports coldwater species, but the reach designation was never changed to coldwater (MPCA 2018a). The MPCA will be proposing a change in use class designation for Pine Creek (-576). This change would re-classify 07040006-576 as a Class 2Ag stream.

Water chemistry and biological data collected during IWM was assessed against 2Ag standards. Given that this change in designation has not been approved, the Mississippi River – La Crescent Area TMDL proactively addresses TSS impacting the fish community. As a result of proposed designated use change, Pine Creek (-576) is impaired due to *E. coli*, F-IBI score, and TSS. For additional information on how the designated use change impacts Pine Creek's impairment listings, please see the Mississippi River – La Crescent Area TMDL (EOR 2020).

Wetlands

The surficial geology and steep topography of the MRLCW is not conducive to the formation of wetlands. However, a large number of critically important wetlands exist within the Mississippi River backwater and floodplain complex (Figure 12).

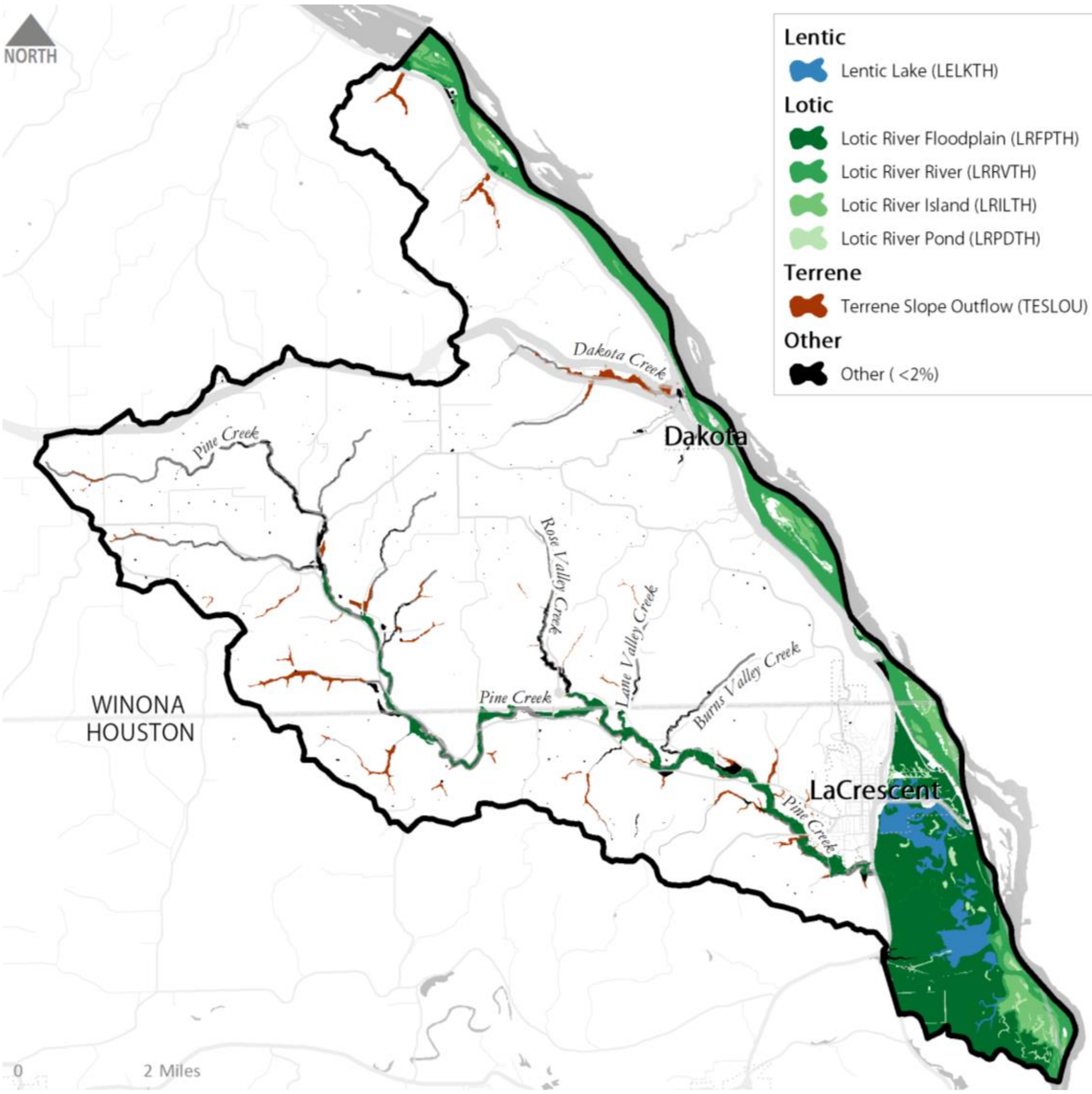


Figure 12. Distribution and types of wetlands according to the updated Minnesota National Wetland Inventory within the Mississippi River - La Crescent Area Watershed.

Given that not all wetlands provide the same functions, e.g. human benefits or services, the MPCA used the Hydrogeomorphic Classification System (HGM) to characterize the wetlands of the Mississippi River – Reno Area and Mississippi River - La Crescent Area watersheds, based on the hydrologic regime and expected primary water flow paths of individual wetlands (Tiner 2011). The HGM system aims to identify wetlands grouped by similar wetland function (e.g. nutrient cycling, flood storage). The classification uses fundamental hydrogeomorphic factors to classify wetlands based on landscape position, water source, and hydrodynamics. Twenty-one unique wetland HGM descriptor combinations were identified within the MRLCW. The majority of these wetlands consisted of lotic river floodplain throughflow systems associated with the Mississippi River. The MRLCW occurs entirely within the Mixed Hardwood Plains Ecoregion. Based on plant community floristic quality, 42% of the wetlands in the Mixed Hardwood Plains Ecoregion were estimated to be in fair condition, 40% in poor condition, and 6% in exceptional condition.

Table 2. Wetland HGM classes present (greater than 2% total area) in the Mississippi River - La Crescent Area Watershed.

HGM Class Code	Wetland HGM Landform Description	Simplified Wetland Plant Communities Present	% of Total Wetland Area	HGM Class Area (Acres)
LELKTH	Lotic Lake Throughflow	Shallow Open Water	7.9	742
LRFPTH	Lotic River Floodplain Throughflow	Emergent, Forested, and Scrub- Shrub, and Shallow Open Water	44.0	4,120
LRILTH	Lotic River Island Throughflow	Emergent, Forested, and Scrub- Shrub	8.6	801
LRPDTH	Lotic River Pond Throughflow	Shallow Open Water	2.7	258
LRRVTH	Lotic River River Throughflow	Emergent, Forested, and Scrub- Shrub	27.8	2603
TESLOU	Terrene Slope Outflow	Emergent, Forested, and Scrub- Shrub	5.1	480

Groundwater

Southeastern Minnesota water resources are challenging to protect, because limestone is slowly dissolved by infiltrating rainwater and creates hidden pathways through which pollution can easily contaminate drinking water wells or surface water. These pathways can be widened, interconnected fractures or caves in the subsurface. Sometimes the process of dissolving limestone forms distinctive landforms on the ground surface, and in other places there is no distinctive landform at all. Together, the processes that dissolve limestone bedrock and the landforms that result are called karst (MPCA 2019).

It can be assumed that all citizens of the MRLCW rely on groundwater for their source of drinking water. Of the estimated 3,649 households in this watershed (2010 Census), approximately 70% are estimated to be served by community public water supply systems from the city of La Crescent based on the number of households present within the city boundaries. The remaining 30% of the households obtain water from private wells. Two Drinking Water Supply Management Areas (DWSMAs) exist in the MRLCW.

There are a total of 14 active public water suppliers in the watershed. Green Terrace Mobile Estates is the only community, nonmunicipal system and is considered nonvulnerable. There are also 12 noncommunity, nontransient water suppliers. Of the noncommunity, nontransient systems, seven wells are considered vulnerable; one of them is at Great River Bluffs State Park. Many of these wells show detections or low concentrations of nitrate. Primary reasons for vulnerable status are well construction or general aquifer vulnerability.

In karst landscapes, which encompass the entire MRLCW, the distinction between groundwater and surface water can be difficult to determine. Groundwater may emerge as a spring, flow a short distance above ground, only to vanish in a disappearing stream, and perhaps re-emerge farther downstream again as surface water as shown in Figure 13.

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. The vulnerability determination is made considering the geologic sensitivity, well construction, water chemistry data, and isotopic composition (age) of the source water. The western half of the "La Crescent 3 DWSMA," (red area on the map inset in Figure 13) is considered highly vulnerable to contamination, while the eastern half (yellow area on the map inset in Figure 13) is considered to be moderately vulnerable. The "La Crescent Central DWSMA" (green area on the map inset in Figure 13) was determined to have low vulnerability to contamination. The City of La Crescent upgraded their water treatment plant in 2008 at a cost of $4 million dollars in an effort to gain compliance with the EPA's 5 pCi/L maximum contaminant level for radium 226 and radium 228 (MDH 2009).

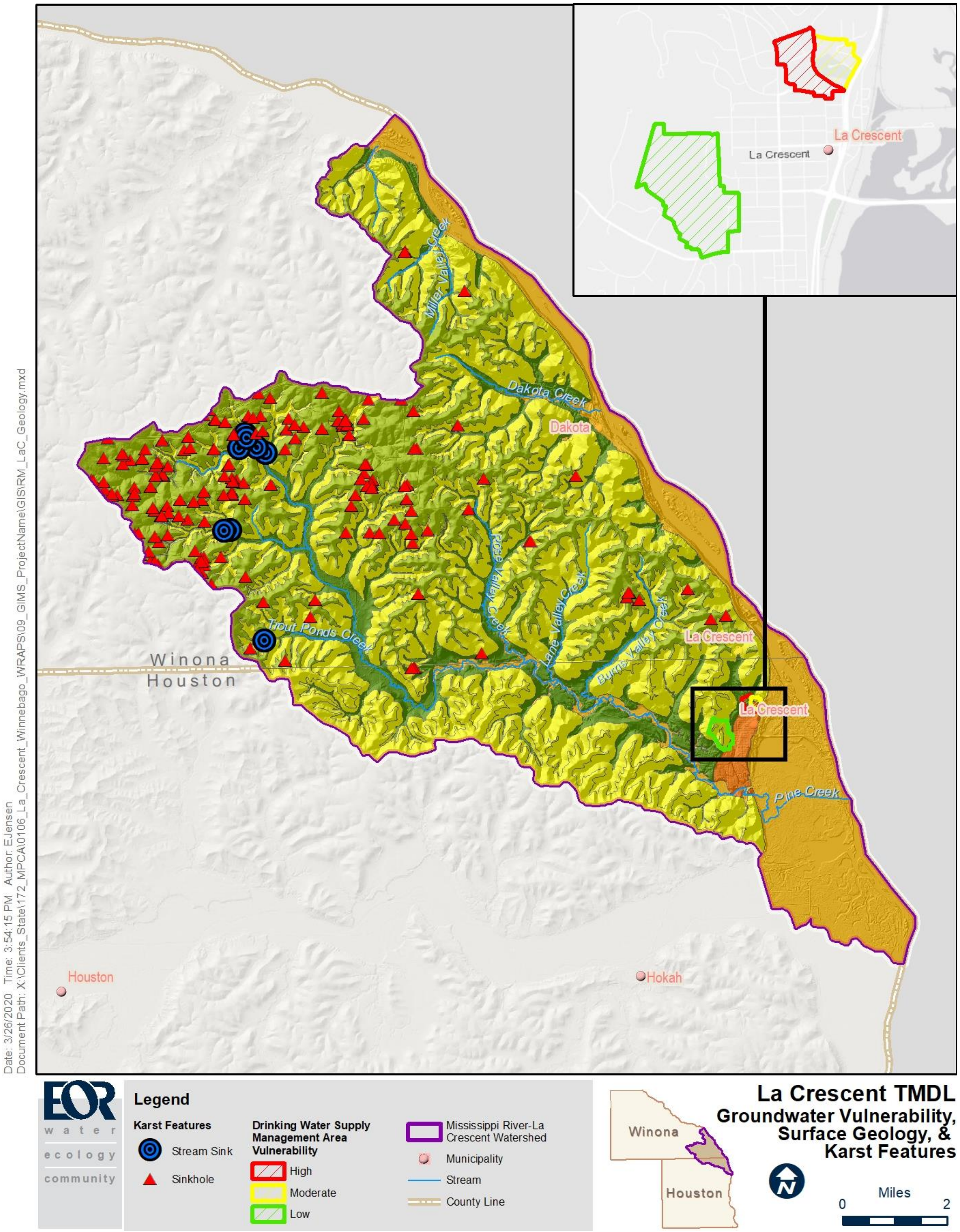


Figure 13. Groundwater vulnerability, surface geology, and Karst Features.

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.

Trends in parameters related to sediment

The Mississippi River - Winona Area WRAPS Report (MPCA 2016) recognized that in southeastern Minnesota, patterns of suspended sediment concentration (SSC) reflect influencing factors such as climate (especially rainfall) and the properties of the rocks and soils that are exposed to erosion. Sediment loads in most streams are largely driven by flood and other high flow events.

Water quality parameters related to SSC/TSS include total phosphorus (TP), total Kjeldahl nitrogen (TKN), transparency, biochemical oxygen demand (BOD) and turbidity. While there are no long-term monitoring sites in the MRLCW, data collected at the MPCA milestone site near Utica on the South Fork of the Whitewater River shows an increasing trend in nitrate and a decreasing trend in both TSS and BOD. The overall trend at the milestone site of Garvin Brook, southwest of Minnesota City also shows an increase in nitrate and a decrease in concentrations of TSS, TP and BOD. These reference streams can serve as an indication of the overall improving general trend of water quality in southeastern Minnesota.

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 **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, phosphorus (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. In cases of aquatic life use impairment, stressors to the aquatic community must be identified in order to translate the problem from an integrative measure(s) to causal factors. This is accomplished by further examining streams (via both field work and desktop work) that show low IBI values for fish and bugs, with a focus on linking the biotic communities to probable stressors. For example, if a macroinvertebrate community sampled in a given stream reach is composed primarily of nitrate-tolerant species and the stream shows high nitrate values in baseflow, a likely conclusion is that nitrate is a stressor to the invertebrate biota.

SID is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act. A SID study was conducted from 2015 through 2018 to identify the factors (i.e., stressors) that are causing a fish community impairment in the MRLCW. For more details on the MRLCW stressors and the process used to identify the stressors causing the biological impairments, please consult the 2018 MRLCW SID Report (MPCA 2018b).

In the MRLCW, Pine Creek was the only stream of the four streams assessed that was considered to be nonsupportive of designated aquatic life uses. Table 3 provides the Fish Index of Biotic Integrity (FIBI) and Macroinvertebrate Index of Biotic Integrity (MIBI) scores for each of the biological monitoring stations in the MRLCW. A total of six biological stations were sampled in the watershed, with three in Pine Creek below their FIBI impairment threshold (highlighted red). Pine Creek generally had fewer coldwater species like trout (with the exception of 15LM041 in the headwaters), while sites at other streams in the watershed were dominated by coldwater species.

Table 3. Summary of FIBI and MIBI scores for biological monitoring stations in the Mississippi River La-Crescent Area 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)
Rose Valley Creek	**511**	04LM093 (2015)	Southern Coldwater	50		Southern Coldwater	43	49
Pine Creek	**576***	15LM039 (2015)			38			57
		15LM043 (2015)			42			57
		15LM043 (2016)			12			49
		15LM040 (2015)			36			52
		15LM040 (2016)			30			42
Pine Creek (headwaters)	**507**	15LM041 (2015)			77			86
Dakota Creek	**512**	15LM042 (2016)			78			73

*The downstream reach on Pine Creek (-576) was previously designated as warm water. Fish, macroinvertebrate and water temperature data support a coldwater designation. The DNR have recognized that the stream supports coldwater species, but the coldwater status is not yet in place.

The major stressors that are contributing to the proposed fish impairment in Pine Creek (-576) are temperature, TSS, and lack of habitat (Table 4). Moving downstream from New Hartford, Pine Creek changes dramatically. Shading decreases and direct stress to the stream channel becomes very apparent with multiple areas of extreme bank erosion. These issues are linked to all of the biological stressors observed in Pine Creek.

Table 4. Summary of probable stressors to impaired biological communities in the Mississippi River - La Crescent Area Watershed.

Stream Name	AUID	Biological impairment	Stressors					
			Temperature	Nitrate	TSS	Dissolved Oxygen	Lack of Habitat	Connectivity / Fish Passage
Pine Creek	576	Fish	●		●		●	

● = probable stressor; o = inconclusive stressor; blank = not a stressor

According to a DNR Culvert Inventory and Prioritization Report, the MRLCW has seven culverts recommended for replacement. Forty-six stream crossings were visited in the watershed; 20 culverts and 26 bridges. The culverts recommended for replacement are considered significant barriers, but were located on tributaries to Pine Creek, not Pine Creek itself. These barriers could have impacts on some migration to a lesser degree and/or could cutoff fish from potential spawning habitat. No culvert barriers were identified on the impaired reach of Pine Creek. The locations of culverts and bridge crossings within the MRLCW are available through the DNR's Watershed Health and Assessment Framework (WHAF) website: https://arcgis.dnr.state.mn.us/ewr/whaf2.

Sediment

TSS are materials suspended in the water. 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. Furthermore, sediment is the focus of TSS issues and is addressed in the corresponding sections of this report. TSS directly affects aquatic life by reducing visibility, clogging gills, smothering substrate, and limiting reproduction. Excessive TSS indirectly affects aquatic life by reducing the penetration of sunlight, limiting plant growth, and increasing water temperatures.

Temperature

The thermal regime in Pine Creek has been identified as a limiting factor as far back as 1991. Temperature data collected from 2013 through 2016 demonstrated higher peak temperatures than the stress threshold (24°C). Additionally, the stream was above 19°C, the stress threat threshold for trout and other coldwater species, for significant periods of time. Beaver dams have historically been an issue, but presently do not seem abundant, and not likely a significant contributor to current thermal issues. Overall, there are many potential factors including lack of shade, extreme bank erosion, ponded springs, and sedimentation that are all contributing to the thermal stress observed in Pine Creek (MPCA 2018b). Coldwater sources in the Pine Creek Watershed (i.e. springs and coldwater tributaries) should be protected, as they are vitally important to maintaining adequate temperatures in this stream. Increased shading near the stream, better riparian buffers, and decreased sedimentation are especially important in the area downstream of New Hartford to CR16 (15LM040).

Lack of Habitat

In this report, habitat refers to the in-channel and riparian 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. Throughout the MRLCW, 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 (45-66) and good (>66) categories. Generally, "good" habitat scores (>65) are necessary to support healthy, aquatic communities. MSHA scores in the MRLCW range from 44 to 73, with an average score of 50.67.

The best MSHA score was at 15LM041, the headwater station near New Hartford, with a score of 73. Biology and habitat are good in this location but when moving downstream to the impaired reach, MSHA scores are worse and vary from fair to poor, depending on the site and year (Table 5). The largest discrepancy between the two impaired stations is the "riparian" metric. The upstream station in blue (15LM040) occurs in a pasture, while station 15LM043 (green) is surrounded by woodland. The other sub metric scores are fairly comparable between the two stations." (DNR 2017).

Table 5. MSHA results for the Mississippi River – La Crescent Area Watershed.

Biological Station ID	Reach Name	MSHA Score (0 – 100)	MSHA Rating
15LM041 (2015)	Pine Creek – Reach 507	73	Good
15LM040 (2015)	Pine Creek – Reach 576	48	Fair
15LM040 (2016)	Pine Creek – Reach 576	44	Poor
15LM043 (2015)	Pine Creek – Reach 576	45	Fair
15LM043 (2016)	Pine Creek – Reach 576	44	Poor
15LM039 (2015)	Pine Creek – Reach 576	50	Fair
Average Habitat Results		***50.67***	***Fair***

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

2.3.2. Pollutant sources

This section summarizes the sources of pollutants (bacteria and sediment) to water resources in the MRLCW. The 2020 MRLCW TMDL Study identified the relative contribution of point and nonpoint P sources to the watershed's impaired streams.

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. The regulated sources of TSS and *E. coli* within the impaired subwatershed (Pine Creek -576) include three MS4 areas, construction stormwater, and industrial stormwater. Current permit conditions for these point sources are sufficient to meet wasteload allocations (WLAs) of the MRLCW TMDL. Additional information on pollutant loading from point sources is provided in the following subsections.

Table 6. Permitted point sources in the Mississippi River – La Crescent Area Watershed.

Point Source Name	Permit #	Type	Receiving water body	Receiving water body impairment
La Crescent City MS4	MNR040000	MS4	Pine Creek	TSS, Bacteria (*E. coli*), Fish-IBI
Houston Co MS4	MNR040000	MS4	Pine Creek	TSS, Bacteria (*E. coli*), Fish-IBI
MN DOT Outstate District	MNR040000	MS4	Pine Creek	TSS, Bacteria (*E. coli*), Fish-IBI
-------	*MNR100001*	Construction stormwater	Pine Creek	TSS, Bacteria (*E. coli*), Fish-IBI
-------	MNG490000	Industrial stormwater	Pine Creek	TSS, Bacteria (*E. coli*), Fish-IBI

Regulated Stormwater:

Municipal Separate Storm Sewer Systems

A municipal separate storm sewer system (MS4) is a conveyance or system of conveyances (roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, storm drains, etc.) that is also:

- Owned or operated by a public entity (which can include cities, townships, counties, military bases, hospitals, prison complexes, highway departments, universities, sewer districts, etc.)
- Designed or used for collecting or conveying stormwater
- Not a combined sewer
- Not part of a publicly owned treatment works

When the U.S. Census is completed every 10 years, MS4s with a population greater than 5,000 based on the latest U.S. Census and that have been assigned a WLA in an approved TMDL are required to obtain coverage under the MS4 permit. Acreage under the Minnesota Department of Transportation (MnDOT) right of way (ROW) that lies within the urbanized portion of impaired AUIDs also requires a MS4 permit.

The City of La Crescent, Houston County, and MnDOT Outstate District are all regulated MS4 permittees located within the MRLCW. Regulated stormwater delivers and transports pollutants to surface waters and is generated during precipitation events. The sources of pollutants in stormwater are many, including decaying vegetation (leaves, grass clippings, etc.), domestic and wild animal waste, soil, deposited particulates from air, road salt, and oil and grease from vehicles.

MS4s in Minnesota must satisfy the requirements of the MS4 general permit. The MS4 general permit is designed to reduce the amount of sediment and other pollutants entering state waters from stormwater systems. Entities regulated by the MS4 general permit must develop a stormwater pollution prevention program (SWPPP) and adopt best practices.

Regulated 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.

Regulated Industrial Stormwater

As of December 2019, there were nine industrial stormwater sites in the MRLCW. Three of these facilities have claimed a no exposure exclusion; meaning that their facility is not exposed to precipitation. There are three MNG49 nonmetallic mining and associated activities permitted sites whose TSS discharges are covered under the Pine Creek TSS TMDL categorical industrial stormwater WLA. Industrial stormwater is regulated by the state's NPDES/SDS Industrial Stormwater Multi- Sector General Permit (MNR050000), or NPDES/SDS General Permit for Construction Sand & Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000) if the industrial activity has the potential for significant materials and activities to be exposed to stormwater discharges.

Municipal Wastewater

Municipal wastewater is the domestic sewage and wastewater collected and treated by municipalities before being discharged to waterbodies as municipal wastewater effluent. The City of La Crescent’s WWTP was connected to the neighboring City of La Crosse WWTP in 2012. No WWTP discharge points currently exist in the MRLCW.

Land Application of Biosolids

The City of La Crosse is permitted to land apply and inject biosolids produced from their WWTP in Minnesota. The application of biosolids from WWTP are highly regulated, monitored, and tracked (see Minn. R. ch. 7041, *Sewage Sludge Management* and Minn. R. ch. 7080, *Individual Subsurface Sewage Treatment Systems [SSTSs]*). Pathogen reduction in biosolids is required prior to spreading on agricultural fields. Disposal methods that inject or incorporate biosolids within 24 hours of land application result in minimal possibility for mobilization of bacteria to downstream surface waters. While surface application could conceivably present a risk to surface waters, little to no runoff or bacteria transport are expected if permit restrictions are followed. Therefore, land application of biosolids was not included as a source of bacteria.

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. As the runoff moves, it picks up and carries away natural and human-caused pollutants and deposits them into lakes and streams. In the MRLCW, the primary pollutants leading to impairments are TSS (sediment) and bacteria (*E. coli*). In addition, P and nitrogen (N) reductions from nonpoint sources are also important to identify for Minnesota’s Nutrient Reduction Strategy (NRS). Significant nonpoint sources identified in the MRLCW include:

- **Unstable Stream Banks:** Evaluation of two reaches along Pine Creek identified a high level of streambank instability resulting from a loss of sinuosity over time. These unstable stream banks represent a significant source of sediment to the creek channel. The two stressors most likely causing the instability are hoof shear stress and intense riparian grazing by livestock with direct access to the stream channel.

- **Livestock Manure:** Runoff from 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.
- **Failing Septic systems:** Septic systems that are not maintained or are failing can contribute excess P, N, and bacteria.

E. coli

The following text, which provides an overview of nonpoint sources of fecal coliform and *E. coli* bacteria and associated pathogens, is excerpted and adapted with new information from *the Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota* (MPCA 2006). 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. This narrative is included to underline and provide examples of the complex relationship between land use and *E. coli* concentrations.

> 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 nonstorm-event samples. A study of the Straight River Watershed divided sources into continuous (failing SSTSs, unsewered communities, industrial and institutional sources, wastewater treatment facilities) 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.
>
> 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." Sadowsky et al. (in 2010) studied reproduction and survival of *E. coli* in ditch sediments and water in the Seven Mile Creek Watershed near St. Peter, Minnesota. Sadowsky 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. Chandrasekaran et al. (in 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.

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 MRLCW:

Non-NPDES permitted feedlots

Runoff from non-NPDES permitted livestock feedlots, pastures, and land application areas can 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 local government units (LGUs). Winona and Houston counties administer the non-NPDES portion of the feedlot program in the MRLCW. On-site feedlot inspections are conducted by compliance staff to verify open lot discharge compliance.

Sixty-one registered feedlots are documented for the MRLCW, as of January 2020. Of the feedlots in the watershed, 60 (98%) are documented as having open lots, presenting a potential for *E. coli* contaminated runoff if proper animal lot management is not occurring and lot runoff reaches surface waters. This is especially true for feedlots that are located in shoreland. In the MRCLW, 19 feedlots exist within shoreland; all 19 have open lots. Considerable grazing of cattle still occurs at 46 (75%) feedlots that have pastures as part of their facility. Since 2009, there have been 42 feedlot facility inspections in the MRLCW with 28 inspections deemed compliant, and 3 inspections with major noncompliance. Major noncompliance means the feedlot facility did not meet water quality discharge standards at the time of inspection. One of these facilities was noted as being located in the Pine Creek drainage area. Eleven inspections deemed minor noncompliance (a record keeping violation). Two of the major noncompliant feedlot facilities have used the southeast Minnesota regional Clean Water Act Section 319 grant, "Reducing Bacteria from Southeast Minnesota Feedlots" funds to cost-share facility upgrades.

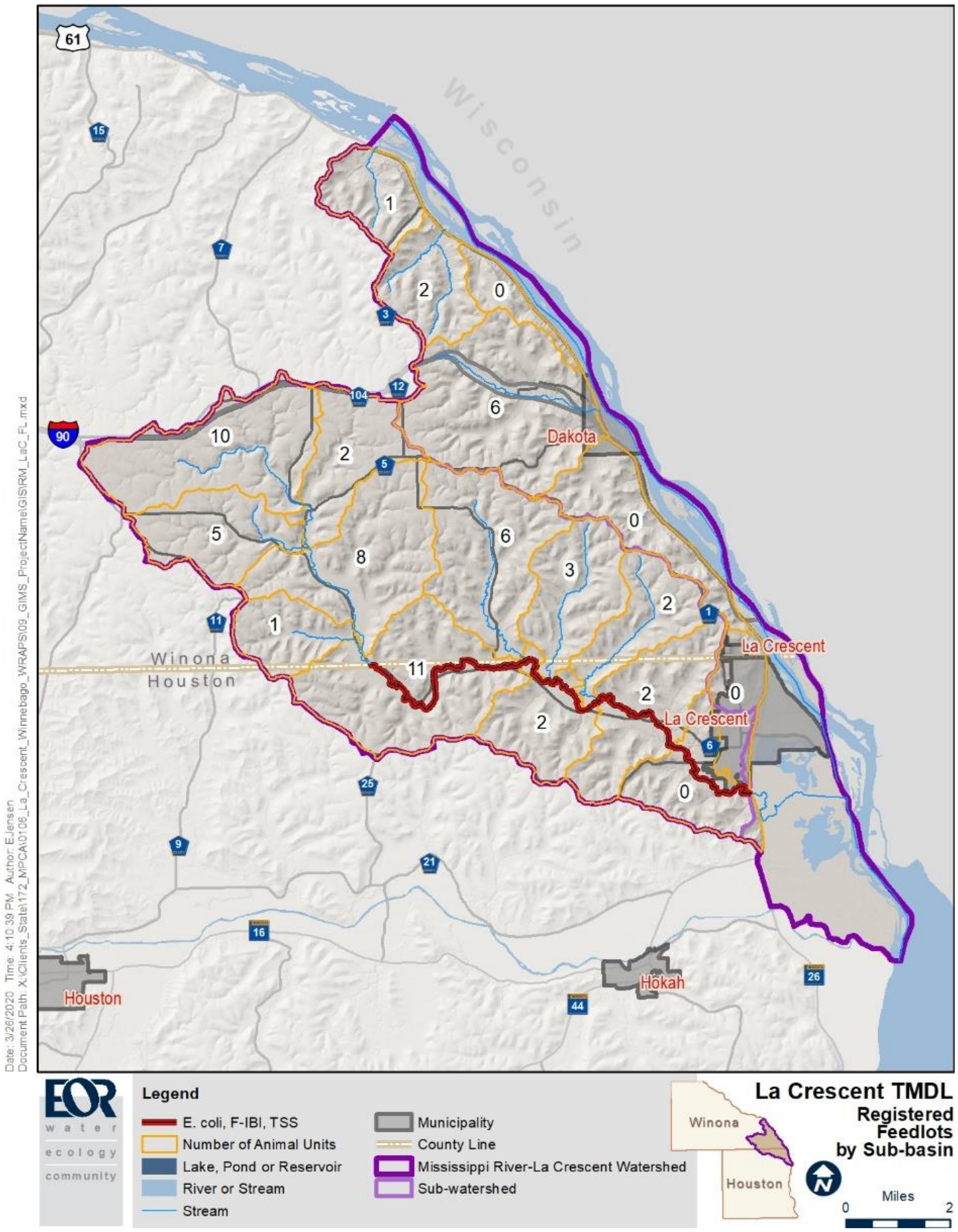


Figure 14. Registered animal feedlots in the Mississippi River – La Crescent Area Watershed.

The land application of manure can also present an increased risk of *E. coli* runoff into surface and groundwater. Approximately 99% of the 7,183 animal units (AUs) in the watershed are either cattle or dairy cows, which generally produce manure as a solid. Of the 61 facilities in the MRLCW, 58 facilities are less than 300 AU. Many smaller feedlots have limited manure storage, requiring frequent manure application. Solid manure left on the surface and not incorporated into the soil prior to a rainfall or a runoff event presents an elevated risk for contaminated runoff. Winter application of manure on steep slopes presents a higher risk for contaminated runoff. Discovery Farms programs of Wisconsin and Minnesota have estimated that late winter, February and March timeframe manure application can increase P loss in snowmelt by two to four times when compared to early winter applications (Discovery Farms 2019). One study completed by Discovery Farms Wisconsin provides a visual picture of the difference between early and late winter application of manure from two adjacent fields with similar slope and tillage practices (Figure 15). One field (bottom) only had manure applied in November while the other field (top) had manure applied in February.

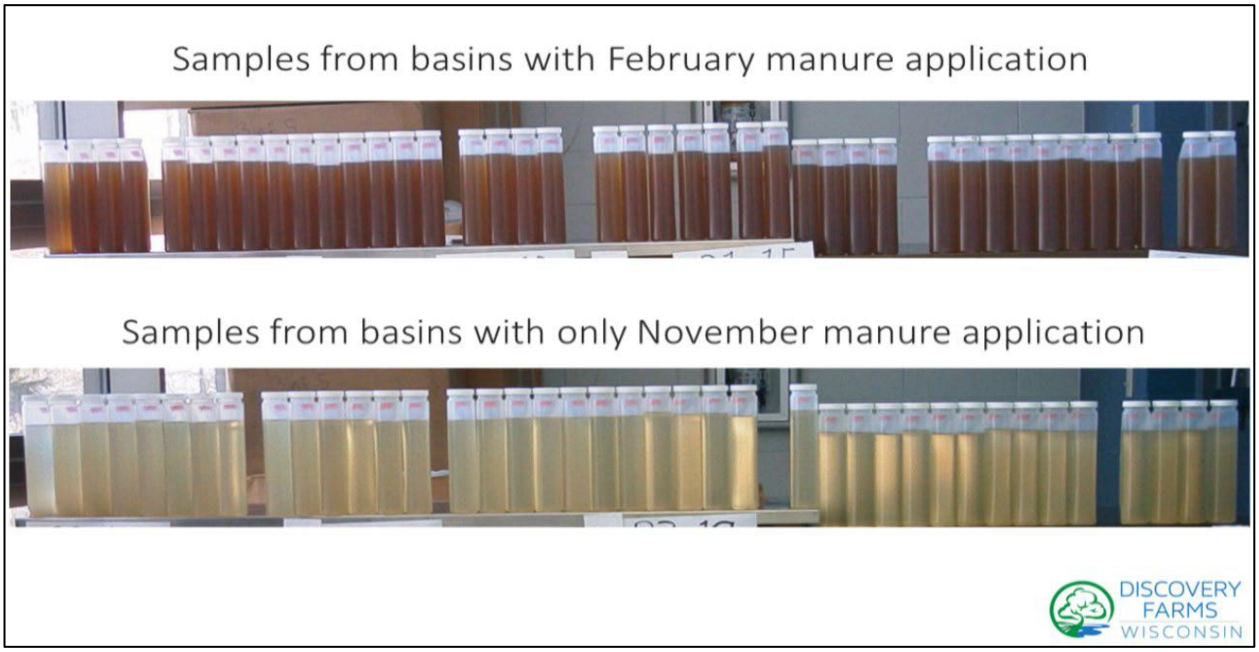


Figure 15. Comparison of runoff when manure is applied in early and late winter (photo from Discovery Farms Wisconsin).

The Minnesota Department of Agriculture (MDA) has recently developed an interactive model, "Runoff Risk Advisory Forecast," to assist livestock producers in evaluating the potential runoff risk for manure applications. Runoff risk is 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.

Minn. R. ch. 7020 requires application setback distances, winter application restrictions and incorporation requirements for spreading manure in close proximity to sensitive features (Figure 16).

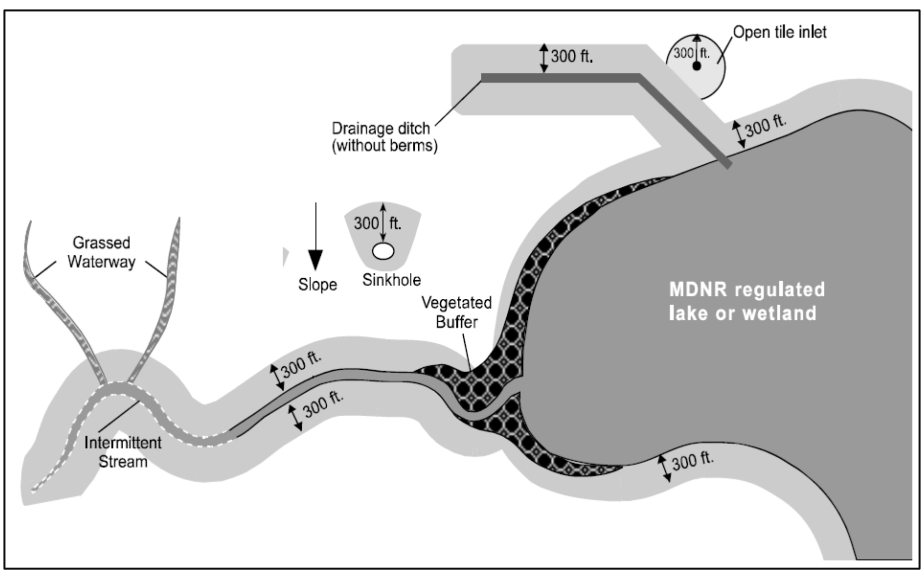


Figure 16. Manure application setback distances around sensitive landscape features. MPCA 2011.

Septic Systems

Failing SSTS are specifically defined as systems that are failing to protect groundwater from contamination. Based on County SSTS compliance reports, failing SSTS were not considered a significant source of fecal pollution to surface water because these systems do not discharge partially treated sewage to the ground surface. However, systems which discharge partially treated sewage to the ground surface, road ditches, tile lines, and directly into streams, rivers, and lakes are considered imminent public health threats (IPHT). IPHT systems also include illicit discharges from unsewered communities (sometimes called “straight-pipes”). Straight-pipes are illegal and pose an imminent threat to public health as they convey raw sewage from homes and businesses directly to surface water. Community straight-pipes are more commonly found in small rural communities.

SSTS compliance data is from annual county reporting of estimates of SSTS compliance for the county boundary and not specifically for the MRLCW boundary. Overall estimated percentages of IPHT are low, at approximately 13% of total systems recently reported (Figure 17). 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. SSTS compliance has remained fairly consistent for Winona and Houston Counties in the last few years. Reported compliance from the past five years indicates that approximately 53% of the SSTS in the MRLCW are compliant. Failing SSTS account for approximately 34% of all SSTSs in the MRLCW.

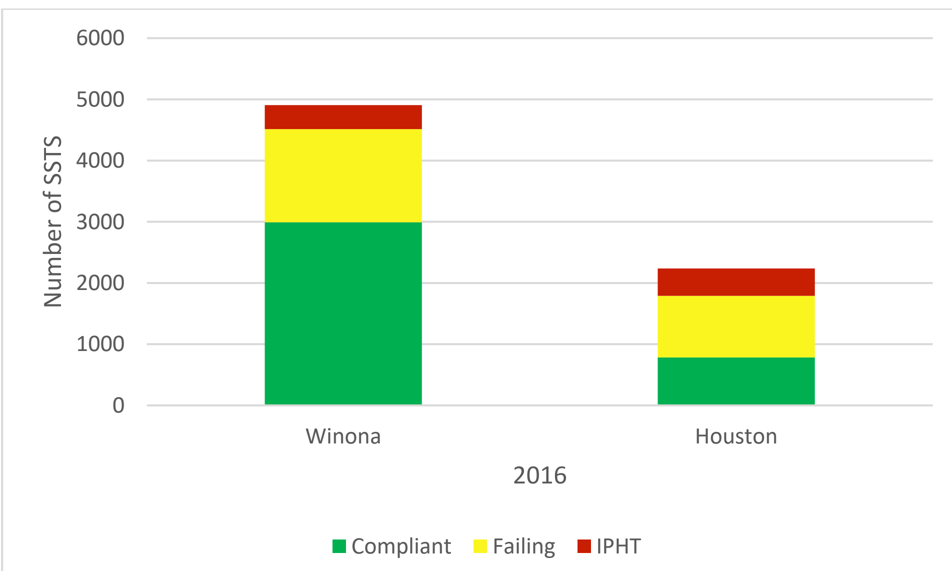


Figure 17. SSTS compliance reported from Winona and Houston County.

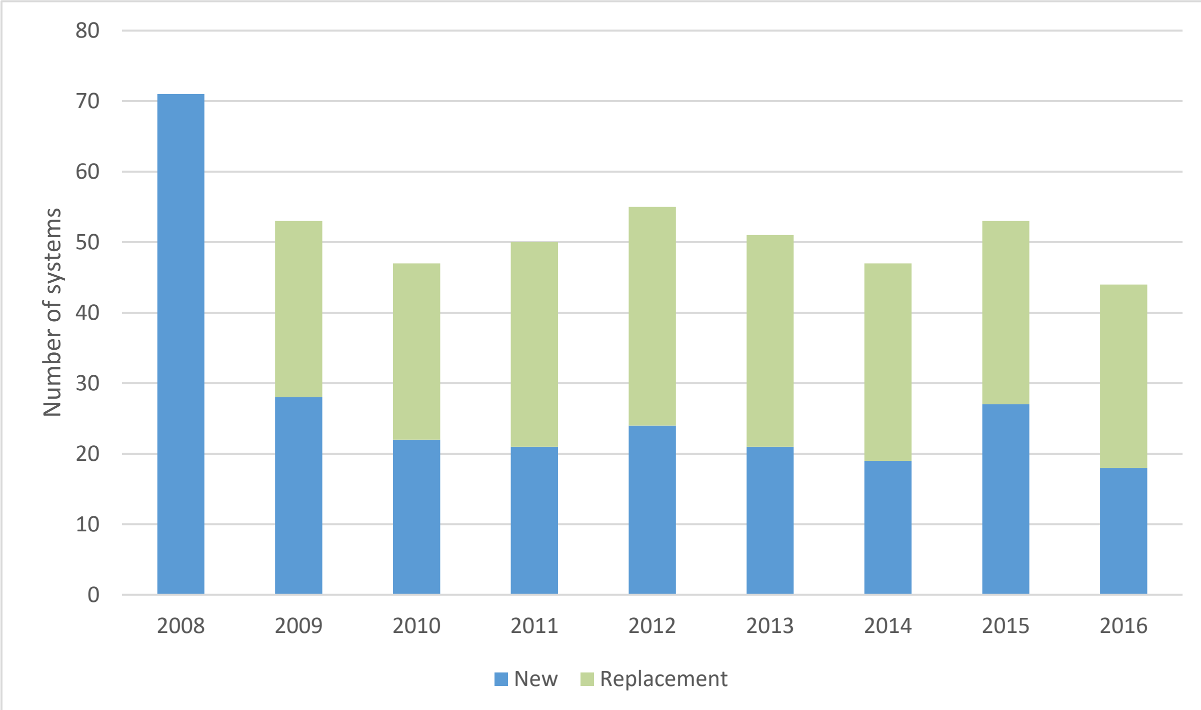


Figure 18. New and replaced SSTS reported for Houston County 2008-2016.

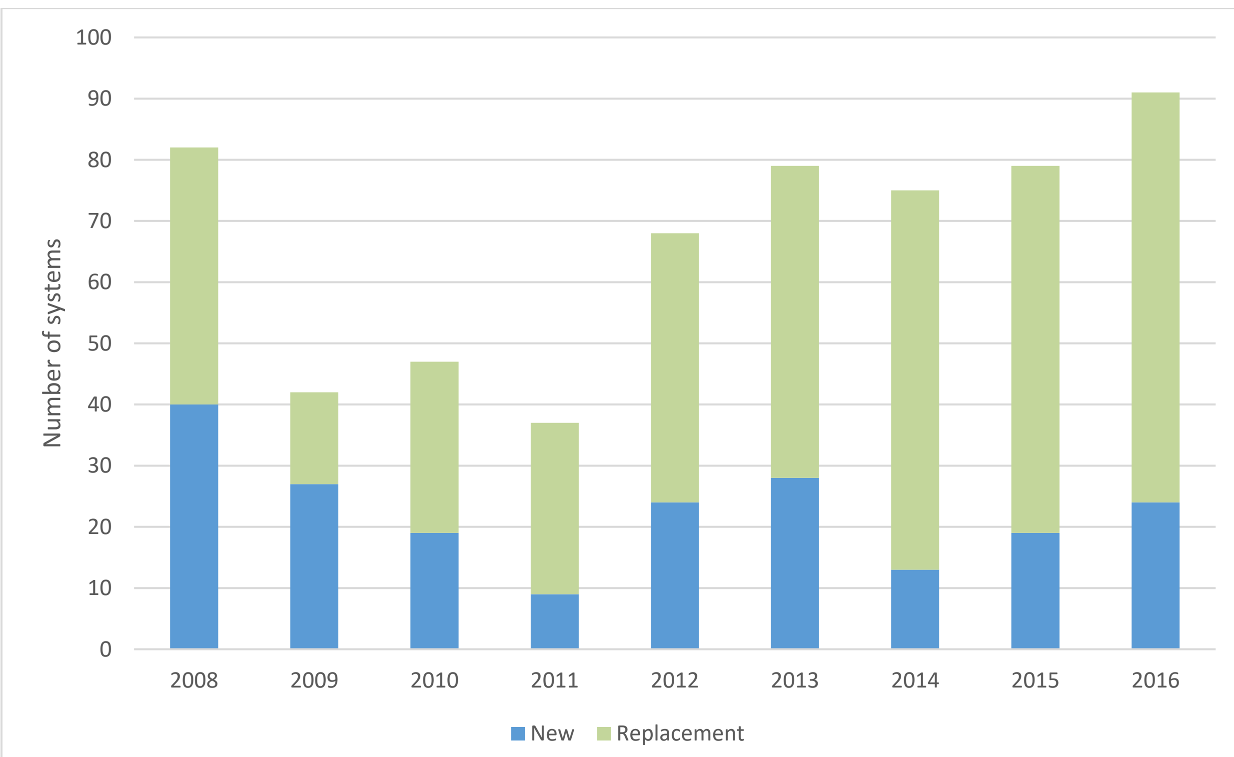


Figure 19. New and replaced SSTS reported for Winona County 2008-2016.

Pets

Human pets (dogs and cats) can contribute bacteria to a watershed when their waste is not properly managed. When this occurs, bacteria can be introduced to waterways from:

- Dog parks

- Residential yard runoff (spring runoff after winter accumulation)
- Rural areas where there are no pet cleanup ordinances
- Animal elimination of excrement directly into waterbodies

Dog waste can be a significant source of pathogen contamination of water resources (Geldreich 1996). Dog waste in the immediate vicinity of a waterway could be a significant local source with local water quality impacts. Domestic cats, even those that spend some time outdoors, are most likely to have their waste collected indoors and were not considered a source of bacteria for this TMDL study. Feral cats may contribute to bacteria levels in urban streams and rivers (Ram et al. 2007). However, it is generally thought that these sources may be only minor contributors of fecal contamination on a watershed scale because the estimated magnitude of this source is very small compared to other sources. Dog and cat waste as sources of bacteria to Pine Creek may be more significant within the city of La Crescent.

Wildlife

Wildlife (e.g., waterfowl and large-game species) also contribute bacteria loads directly by defecating while wading or swimming in the stream, and indirectly by defecating on lands that produce stormwater runoff during precipitation events. Bacteria loads that are contributed by wildlife are generally considered to be natural background. Some BMPs that reduce loads from livestock and other sources can also reduce loads from wildlife. Nearly half of the drainage area to Pine Creek is forested and could provide wildlife habitat encouraging congregation, and thus could be potential sources of higher fecal coliform due to the high densities of animals. Deer densities in the deer permit area within the MRLCW were estimated at 29 deer per square mile in 2017 (DNR 2017). This compares to registered livestock animal densities in watershed of approximately 125 animals per square mile. Waterfowl populations are difficult to obtain for this watershed because it is outside the DNR monitored breeding areas. Because of the watershed's proximity to the Mississippi River and floodplain backwaters, it is likely that large waterfowl congregations occur outside of this watershed. Smaller congregations of ducks and geese are potential sources of fecal coliform within the watershed, particularly in public parks and open spaces.

E. coli Source Summary:

The most likely contributor of fecal contamination in the MRLCW is livestock manure, due to the large numbers of AUs in the drainage area and the presence of facilities with livestock access directly to or near Pine Creek. Imminent threat to public health septic systems may also contribute fecal contamination to Pine Creek, based on the percentage of imminent threat to public health systems reported by Houston (20%) and Winona (8%) counties. Pets may contribute fecal contamination to Pine Creek within the city of La Crescent if pet waste is not management properly, but are likely minor contributors of fecal contamination on a watershed scale. The contribution of fecal contamination from wildlife sources and natural growth of *E. coli* within Pine Creek are unknown but likely minor contributors.

Total Suspended Solids

The MRLCW is especially vulnerable to soil erosion because of its geology and soil types. Soil erodibility is related to the integrated effects of rainfall, runoff and infiltration on soil loss and is commonly called the soil erodibility factor (K), which represents the effect of soil properties and soil profile characteristics on soil loss, and takes into account soil texture, structure, permeability, and organic matter content. K was developed by the Natural Resource Conservation Service (NRCS) for use in estimating soil losses with the Universal Soil Loss Equation (USLE). Values of K range from 0.02 (lowest erodibility) to 0.69 (highest erodibility). In general, the higher the K value the greater the susceptibility of the soil to rill and sheet erosion by rainfall. Figure 20 shows the K value of the soils of the MRLCW.

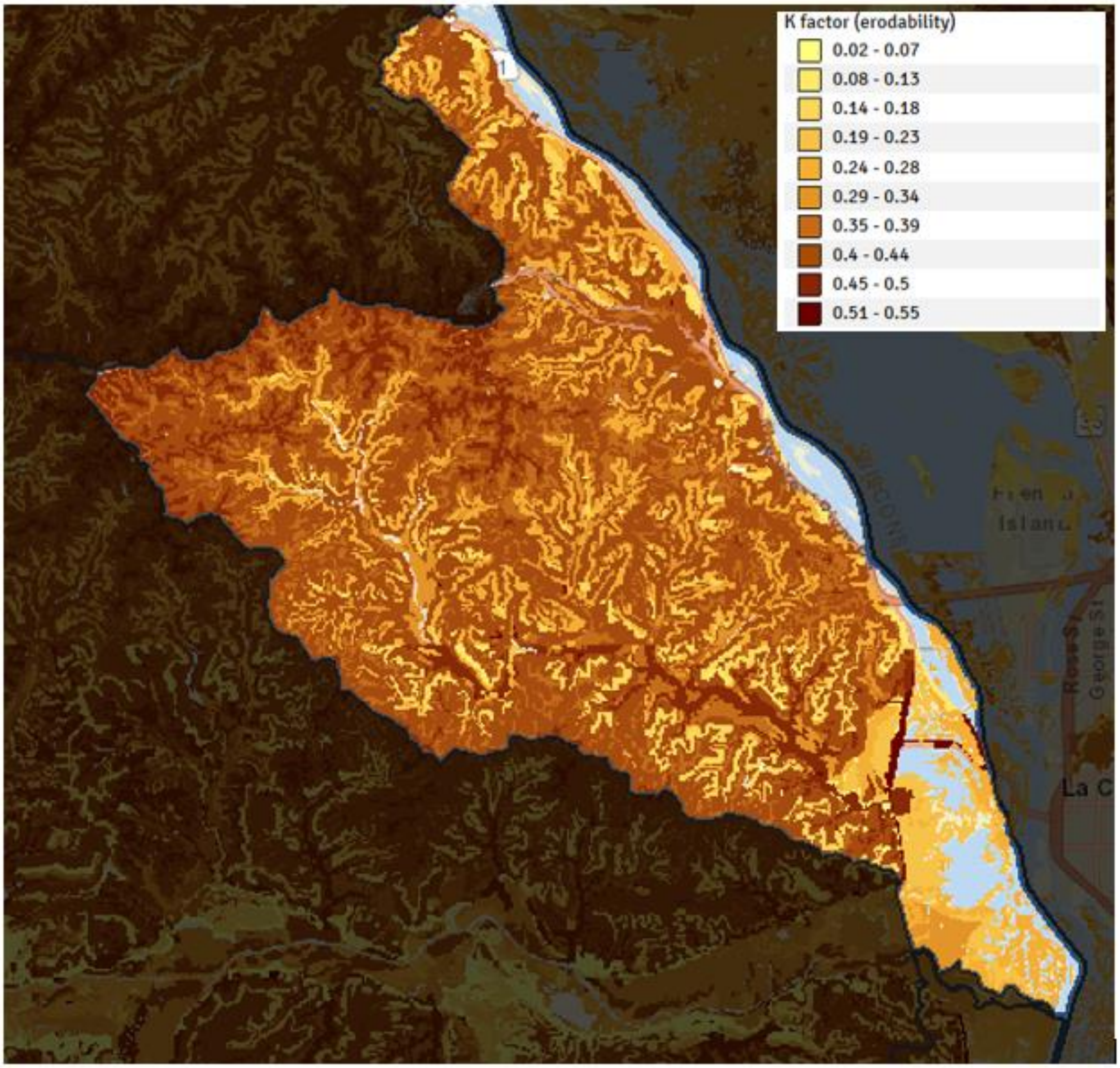


Figure 20. Whole soil erodibility (K factor) for the Mississippi River - La Crescent Area Watershed.

To address erosion issues on Pine Creek, a geomorphic stream survey was conducted by DNR in 2018 to identify stressors to streambank erosion, including large peak flows from land use change and riparian grazing (included as an appendix to MPCA 2018b).

The MRLCW is vulnerable to soil erosion because of the underlying geology of the area where steep slopes, typical of the Driftless area, are combined with loamy gravel, sand, and silt soils. This vulnerability is exposed by shifting land use and climate. The land use of the watershed has changed greatly over time. Starting in the 1850s, the land use shifted from forest to agriculture in parts of the watershed. Then a change in agriculture from crop production to grazing animals converted cropped fields to pasture, with reforestation in the uplands. Further impacting the conditions in the watershed in more recent history is climate change. The higher runoff potential of agricultural land use coupled with larger rain events cause the streams in the watershed to carry larger peak flows, destabilizing the soil and stream banks.

The 2018 geomorphic survey conducted by the Minnesota DNR of Pine Creek, indicated that Pine Creek is in a state of accelerated change, with 68% of the survey reaches in an unstable condition (appendix to MPCA 2018b). Evaluation of two reaches along Pine Creek resulted in estimated erosion rates of 0.054 tons/year/foot (unstable) and 0.084 tons/year/foot (highly unstable). This instability is resulting in a loss of channel sinuosity (Figure 21). In addition to increased velocity from precipitation events, certain streambank areas are further impacted by livestock hoof shear and intense riparian grazing.

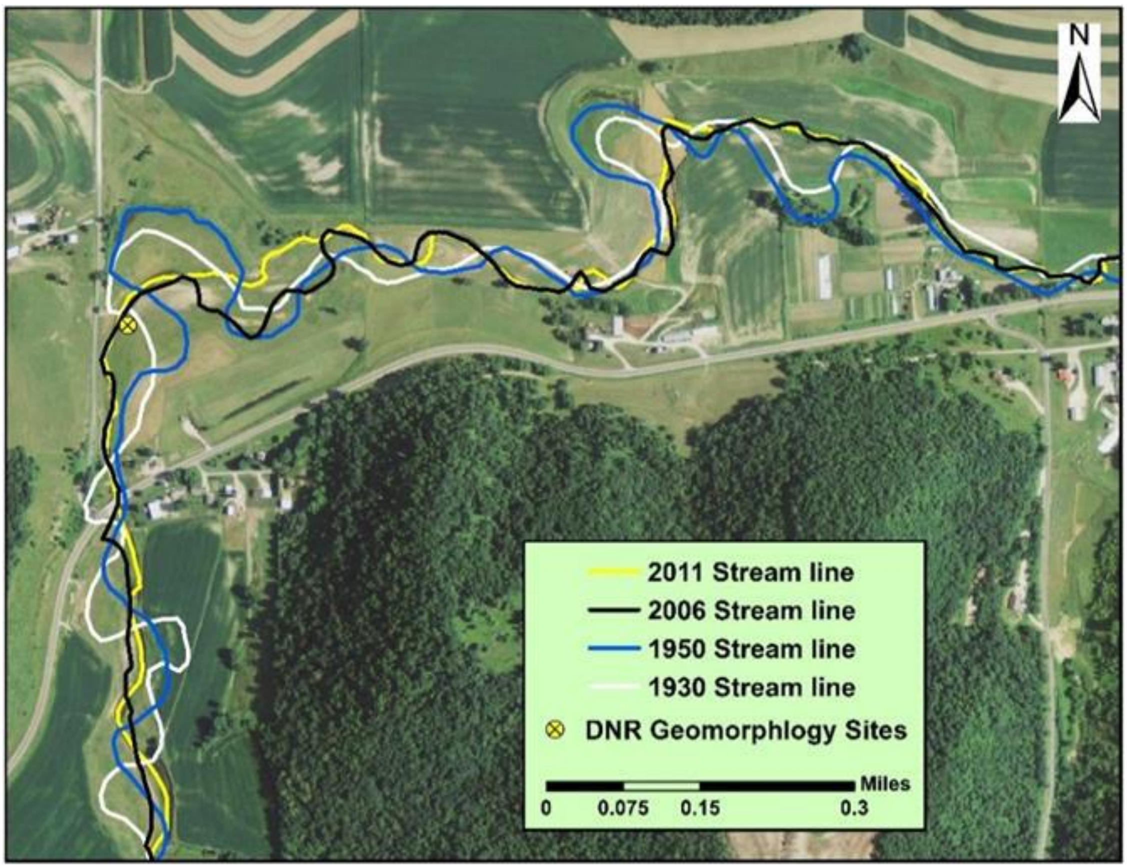


Figure 21. Stream centerlines from 1937, 1952, 2006, and 2011 illustrating lateral movement of the stream overtime and the loss of sinuosity (MPCA 2018).

The geomorphic survey identified areas along Pine Creek that can be targeted for livestock exclusion and streambank stabilization practices. The sources of TSS to Pine Creek are bank erosion, poor pasturing practices, aggradation, loss of sinuosity, and other near channel sediment impacts including natural stream movement. Overall, the valleys in the MRLCW are very steep and have a loamy soil characteristic susceptible to erosion. Coupling these watershed features with excessive grazing (un-vegetated pastures and unrestricted cattle access) favors turbid stream conditions.

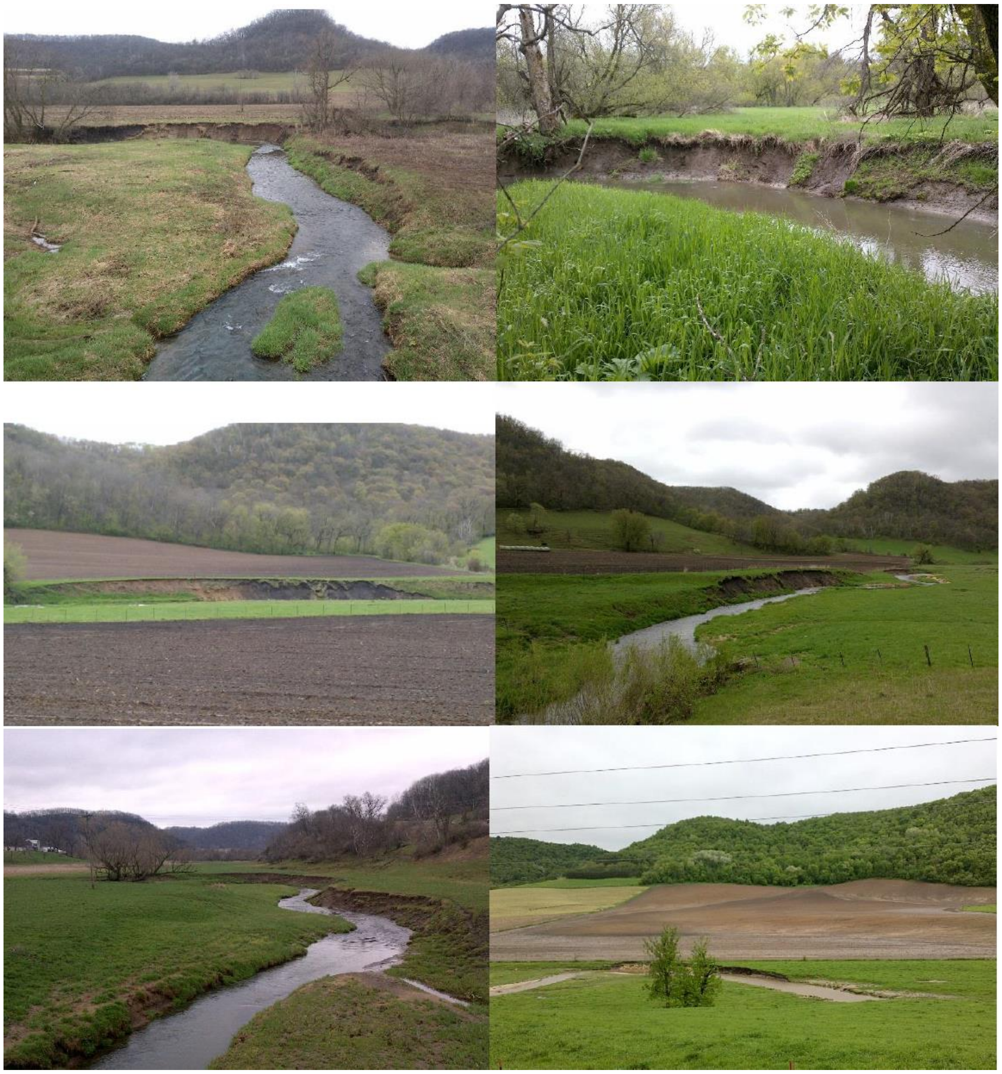


Figure 22. Collection of photos from the impaired reach of Pine Creek, documenting many areas of severe bank erosion. MPCA Photos 2017.

Figure 23 shows stacked aerial images of the same stream section of Pine Creek (-576) captured nearly 10 years apart. The top photo is from 2008 and captures large changes to the stream channel due to the 2007 flood. The bottom photo, from 2017, shows that while the riparian corridor appears to be recovering, areas of bank erosion are still present. Note the ravine in upper right corner of photos that appears to be contributing a large amount of sediment to the stream.

Image credit: Pictometry Houston County

Figure 23. Images of bank erosion in the impaired reach of Pine Creek; top (2008), bottom (2017).

While the majority of TSS originates from mineral/sediment and not organic solids, it is still uncertain if sediment is coming from the stream channel itself or upland erosion. Shallow marshes exist in the lower end of the watershed, and could be TSS sources as they may have acted as sediment sinks from past land use practices (2018b). It is also possible that significant groundwater flow paths exist, which may be contributing to the sediment load near Pine Creek. In the neighboring Mississippi River – Reno Area Watershed, HSPF model simulations were performed and indicated that near-channel and pasture sources are the largest contributors of sediment (TetraTech 2019).

Based on assessments from SID staff, it is likely that sources of TSS are bank erosion, poor pasturing practices, and other near channel sediment impacts. A detailed TSS longitudinal study in 2018 revealed that the largest sources of sediment (where sediment increased exponentially) was downstream of New Hartford to County Road 16 (CR16). The precise percentage of upland vs near/channel sources is not known. However, a detailed study of the sediment budget in the Root River Basin, located south and west of the MRLCW and of similar characteristics, identified similar trends in stream channel widening and migration rates (Dogwiler and Kumarasamy 2016). Furthermore, fingerprinting of the sediment load in the Root River indicated that nearly half of the sediment that reaches the mouth of the river was derived from agricultural fields within the past two to four decades. The next largest portion of the sediment load (also nearly half) was derived from stream banks. About 90% of this portion was originally derived from agricultural fields in the past 150 years. Therefore, a large portion of sediment in the stream has moved from its origin to the floodplain and then is further displaced during flood events. These trends are expected to be similar in the MRLCW.

2.4 TMDL summary

A TMDL is a calculation of how much pollutant a lake or stream can receive before it does not support recreational uses or support aquatic life. These studies are required by the Clean Water Act for all impaired lakes and streams. Pine Creek is the only stream in the MRLCW in which a TMDL Study is necessary (Table 7).

See the MRLCW TMDL Report for the existing pollutant loading, WLAs and LAs, load reductions needed to meet water quality goals, and pollutant source summaries for each impaired stream.

Table 7. Mississippi River-La Crescent Area Watershed Impaired Streams with TMDLs

Waterbody Name	Reach Description	Stream AUID	Use Class	Year Added to List	Affected Use	Impaired Waters Listing	Pollutant or Stressor	TMDL Developed
Pine Creek	T104 R5W S4, north line to Highway 16	(07040006-576)	2Bg, 3C*	2018	Aquatic Recreation	*E. coli*	*E. coli*	Yes: *E. coli*
				2022**	Aquatic Life	Total Suspended Solids (TSS)	Total Suspended Solids (TSS)	Yes: TSS
						Fish Index of Biological Integrity (FIBI)		

Pine Creek *E. coli* and TSS impairment will be addressed by the 2020 Mississippi River – La Crescent Watershed TMDL

* Use Class Change to 2A being proposed but not yet finalized.

** Aquatic life listing not yet on 303(d) list; expected following approval of the designated use class change.

Dissolved oxygen, turbidity and macroinvertebrate/fish bioassessment impairments can sometimes be linked back to a pollutant, such as the TSS impairment on Pine Creek. However, other stressors (e.g. temperature and fish passage) either lack a standard, the stressor is connected to a stressor already being addressed, or the stressor is nonpollutant based. A mass reduction is not the appropriate means of addressing these issues, thus no TMDL is completed. A list of the aquatic life use impairments or proposed impairments not addressed by TMDL calculations in this report are provided in

Table 8. These impairments will be addressed through restoration strategies identified in Section 3.2 of this WRAPS report.

Table 8. Mississippi River-La Crescent Watershed aquatic life stressors not addressed by TMDLs.

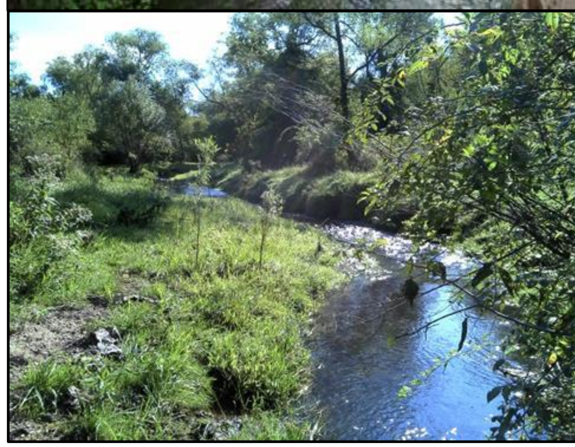
Waterbody Name (AUID)	Listed Pollutant/ Stressor		Reason
	Aquatic Life: MIBI	Aquatic Life: FIBI	
Pine Creek (576)		✓	Non-pollutant based stressors: temperature & aquatic habitat

2.5 Protection considerations

Pine Creek Headwaters

The headwaters of Pine Creek near New Hartford had the highest overall MIBI score at 86. At biological monitoring station 15LM041, near the headwaters at New Hartford, 99% to 100% of observed species were coldwater fish species. All coldwater springs in the Pine Creek Subwatershed should be protected, as they are vitally important in maintaining adequate temperatures in this stream.

Dakota Creek



Dakota Creek is a small, direct tributary to the Mississippi River located in the far northern edge of the MRLCW. Observed fish and MIBI scores nearly met the exceptional use criteria for both fish and macroinvertebrates. Observed nutrient concentrations were low during one biological sample (Nitrates 0.85 mg/L and P 0.044 mg/L). Bank erosion and instability, including sedimentation, in addition to potential impacts from Interstate-90 are the main threats to aquatic life in this stream.

Rose Valley Creek

Rose Valley Creek, a small tributary to Pine Creek, is a stream with fish and macroinvertebrate scores above impairment thresholds, but may be at risk of impairment and is needing protection. Fish and macroinvertebrate IBIs scored above impairment thresholds, however macroinvertebrates scores only exceeded the threshold by six points. This is an indication of a near impairment. Nitrate concentrations are consistently at about 2 mg/L, well below the 10 mg/L standard. P was generally low and meeting standards for these samples as well, except during times of excess sediment (high TSS). Interestingly, of nine samples taken in 2015 and 2017, eight exceeded the TSS standard of 10 mg/L for coldwater streams. However, many of these samples were taken in May of 2017 during storm events (to compare the tributaries to the main stem of Pine Creek). While this stream often is flowing clearer then Pine Creek, it does underscore the tributaries as sources of sediment in the watershed. Continued protection practices, including good pasture management, cattle restrictions and soil conservation practices will help prevent future aquatic life impairment listings.

3. Prioritizing and implementing restoration and protection

The Clean Water Legacy Act (CWLA) requires that WRAPS reports summarize information and tools to support prioritizing areas for strategies to improve water quality.

This section of the report provides a summary of information, tools and results to support 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 best management practices (BMPs). Thus, effective ongoing public and stakeholder participation 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, watershed surveys, 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 strategies outlined are subject to adaptive management—an iterative approach of implementation, evaluation and course correction.

3.1 Targeting of geographic areas

Key issues in the MRLCW include sediment and *E. coli* in Pine Creek. Tools used to target geographic areas that address sediment impairment include:

- Geomorphic survey of Pine Creek (see Section 2.3.2 and Appendix to MPCA 2018b)
- ACPF Geographic Information Systems (GIS) Toolset

Agricultural Conservation Planning Framework GIS Toolset

The ACPF GIS toolset was used to identify existing and potential BMPs in the drainage area of Pine Creek. The ACPF Toolbox software includes tools to process Light Detection and Ranging (LiDAR)-based digital elevation models for hydrologic analysis, which then allows a series of prioritization, riparian classification, and conservation-practice placement tools to be used. The ACPF framework identifies locations where specific landscape attributes are favorable for implementing certain conservation practices.

Two ACPF analysis were conducted for this WRAPS report:

1. Multiple sediment trapping and nutrient removal BMP suitability analysis at the HUC 12 scale (Winona County/St. Mary's University of Minnesota Geospatial Services).
2. Identify existing and potential water storage ponds in the drainage area of Pine Creek to reduce peak flows (EOR staff).

These practice-placement opportunities were mapped for the MRLCW to inform local watershed planning.

Multiple BMP suitability analysis

Outputs were produced for Pine Creek Subwatershed (070400060501) for ponds, grassed waterways, buffer strips and wetland creation/restoration. The suitability analysis identified 1.6 miles of contour buffer strips, five potential bioreactor sites, 2.15 acres of depression drainage areas (ponds), 0.6 miles of potential grassed waterways and 28 acres of potential wetlands (Figure 24).

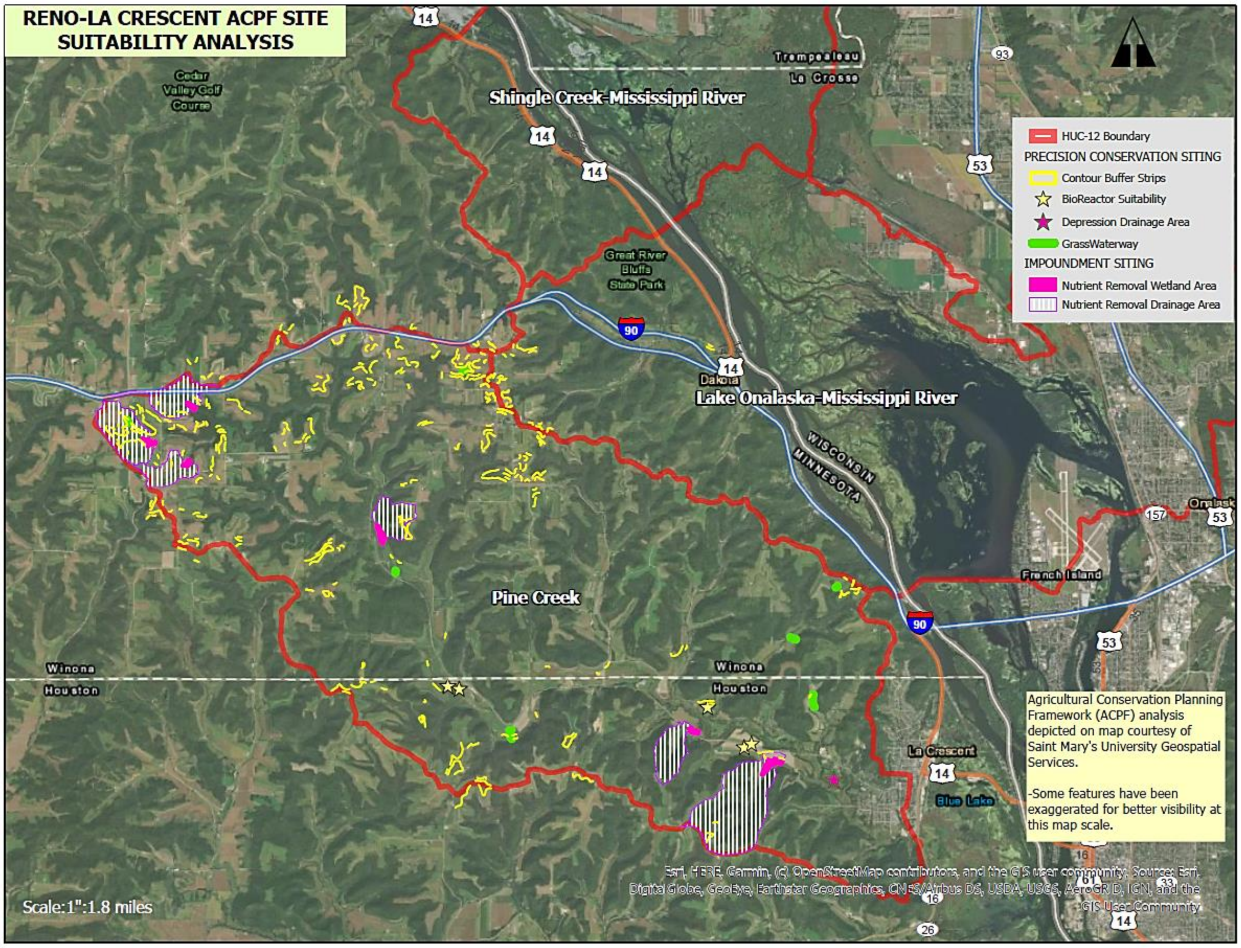


Figure 24. Suitability analysis of potential BMPs in the MRLCW.

Existing and potential water storage ponds are mapped by ACPF subbasin (Figure 25) as a percent of the total area that is treated by a basin and as the number of total basins in Figure 26 through Figure 29. Water storage BMPs should be targeted in subwatersheds with the greatest difference between existing and potential ponds first, as reported in Table 9 below.

Table 9. ACPF inventory of existing and potential ponds by subbasin.

Priority Subwatershed	ACPF subbasin name	Total Acres	Existing Ponds	Existing Drainage Area Treated (acres)	Existing Drainage Area Treated (%)	ACPF Potential Ponds	Potential Drainage Area Treated (acres)	Potential Drainage Area Treated (%)	FY2020 EQIP Cost ($)
--	Great River Bluffs	836	2	12	1%	23	311	37%	867,959
--	Long Lake Creek	2,019	6	68	3%	48	866	43%	2,943,326
--	Richmond Creek	1,655	10	52	3%	52	925	56%	2,684,469
--	Tribs to the Mississippi R.	2,379	3	14	1%	70	1,179	50%	3,281,068
Dakota Creek	**Dakota Creek**	**5,904**	**25**	**251**	**4%**	**146**	**2,696**	**46%**	**8,265,599**
Pine Creek	Burns Valley Creek	2,147	8	136	6%	50	874	41%	2,249,810
	City of La Crescent	1,498	1	291	19%	19	490	33%	1,522,764
	Lane Valley Creek	2,659	6	47	2%	76	1,241	47%	3,906,713
	Pine Creek 4	5,085	22	1,065	21%	143	2,659	52%	8,138,259
	Pine Creek 5	2,189	9	259	12%	46	833	38%	2,677,223
	Pine Creek 6	3,205	5	148	5%	76	1,212	38%	4,812,004
	Pine Creek 7	2,302	8	279	12%	54	998	43%	4,861,311
	Trout Pond Creek	1,599	8	69	4%	46	771	48%	2,641,796
	Total	**20,684**	**67**	**2,294**	**11%**	**510**	**9,078**	**44%**	**30,809,880**
Pine Creek Headwaters	Pine Creek 1	4,581	39	760	17%	59	1,949	43%	3,676,577
	Pine Creek 2	2,474	13	395	16%	40	1,233	50%	3,287,175
	Pine Creek 3	4,328	24	1,197	28%	108	2,463	57%	6,438,723
	Pine Creek South Fork	2,482	20	376	15%	41	1,078	43%	3,509,799
	Total	**13,865**	**96**	**2,728**	**20%**	**248**	**6,723**	**48%**	**16,912,274**
Rose Valley Creek	**Rose Valley Creek**	**4,124**	**30**	**383**	**9%**	**88**	**1,687**	**41%**	**4,655,704**
TOTAL		**51,466**	**239**	**5,802**	**11%**	**1,185**	**23,465**	**46%**	**70,420,279**

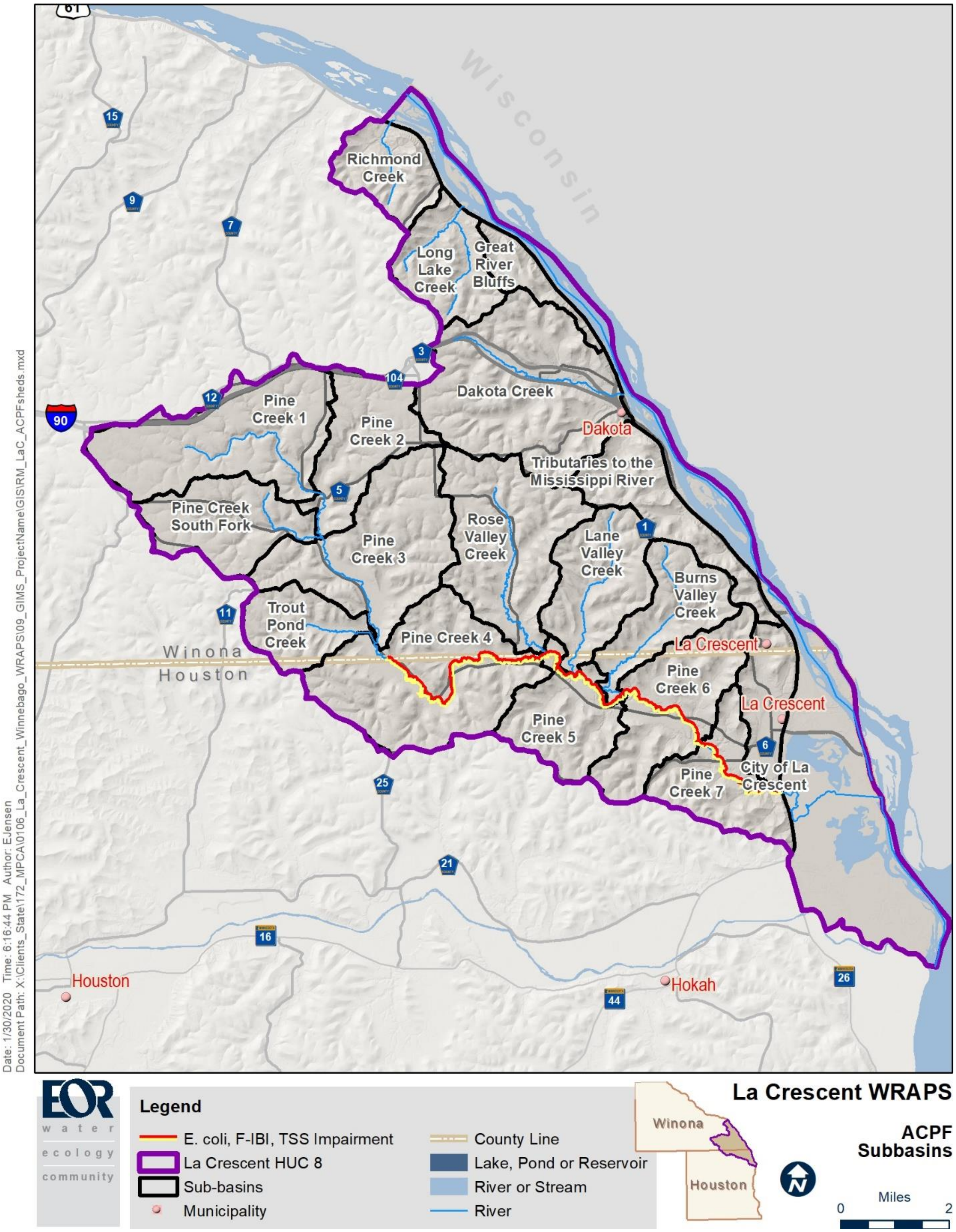


Figure 25. ACPF subbasins in the MRLCW.

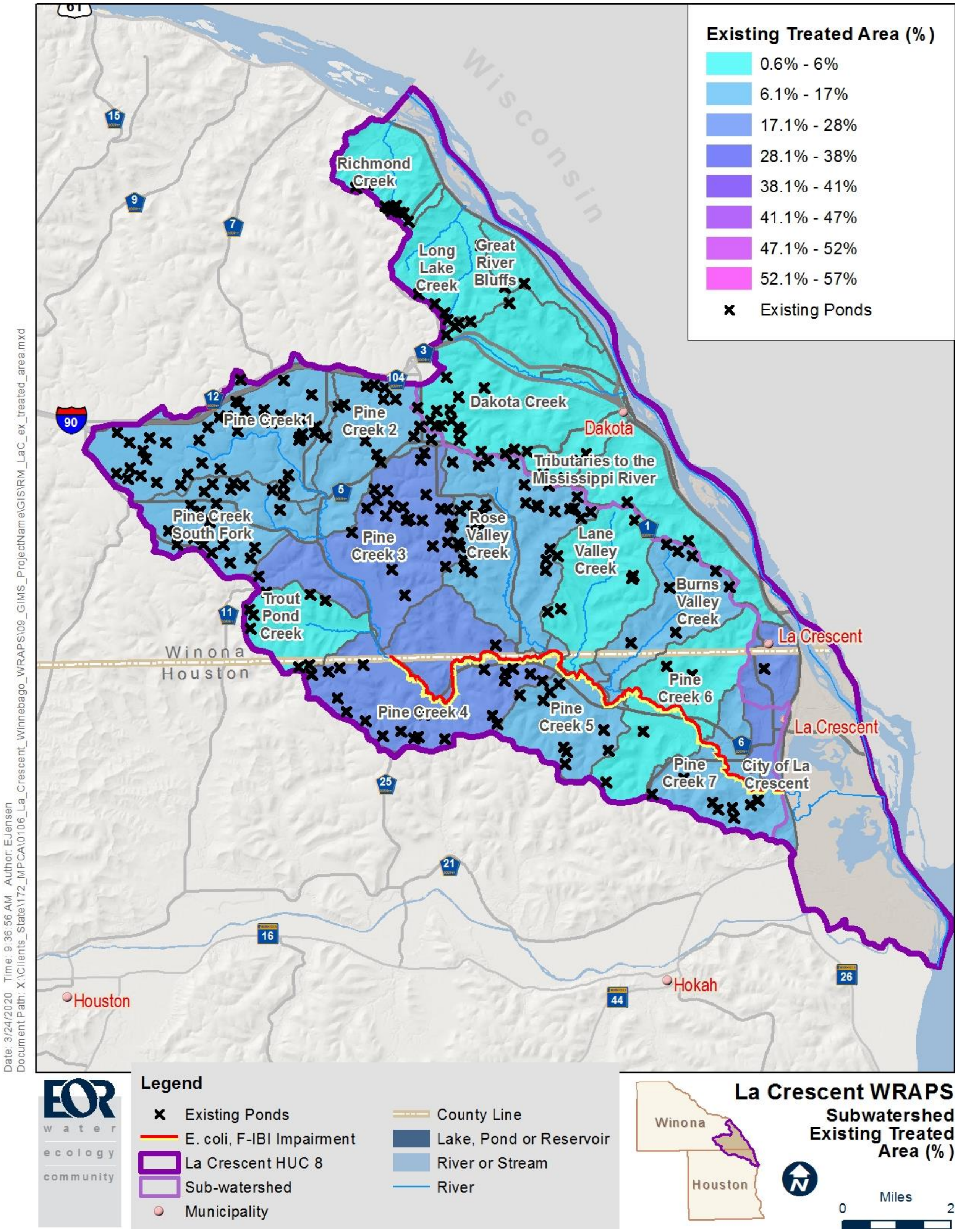


Figure 26. Modeled percent of treated area by existing storage ponds by subbasin in the MRLCW.

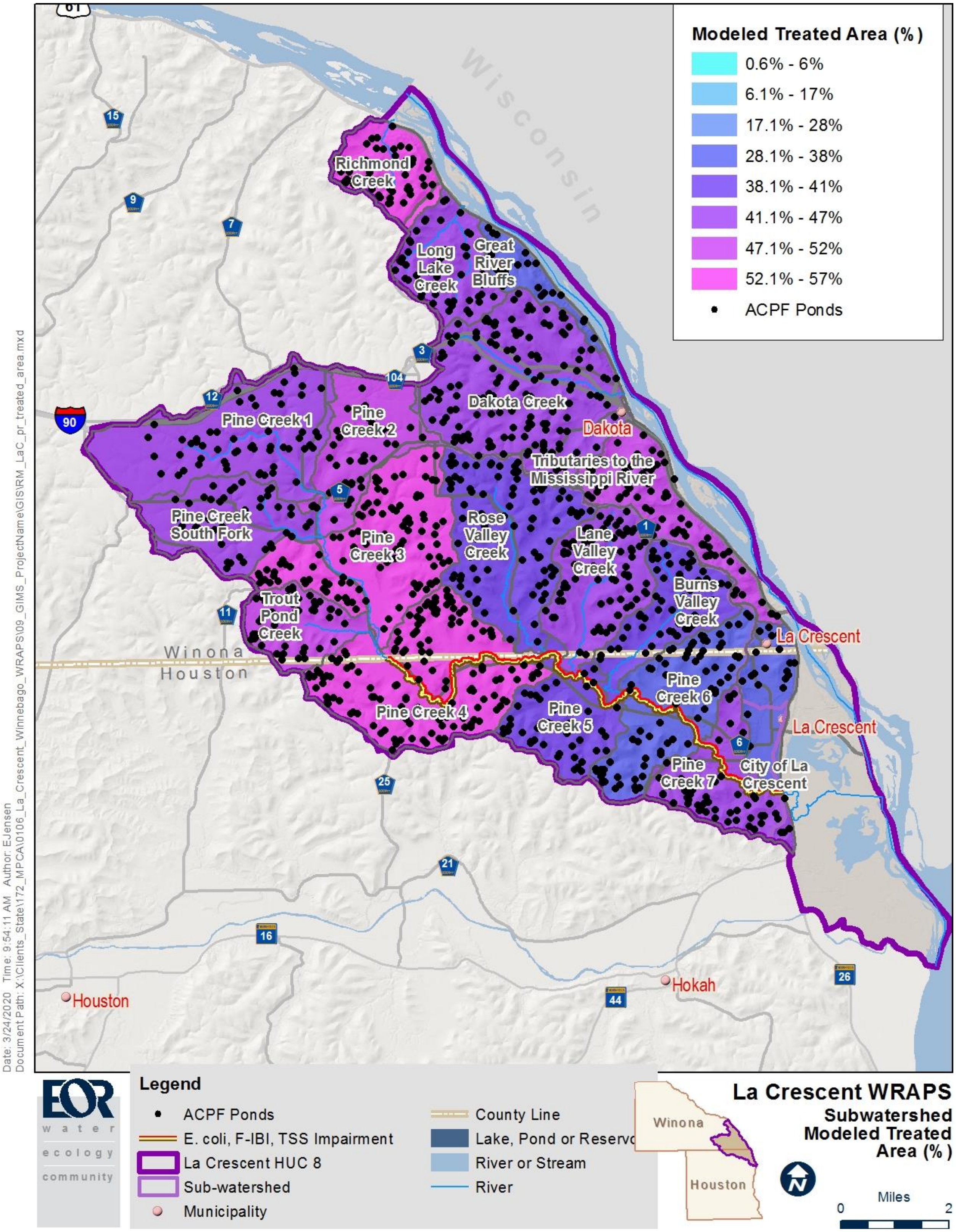


Figure 27. ACPF modeled percent of treated area by potential storage ponds by subbasin in the MRLCW.

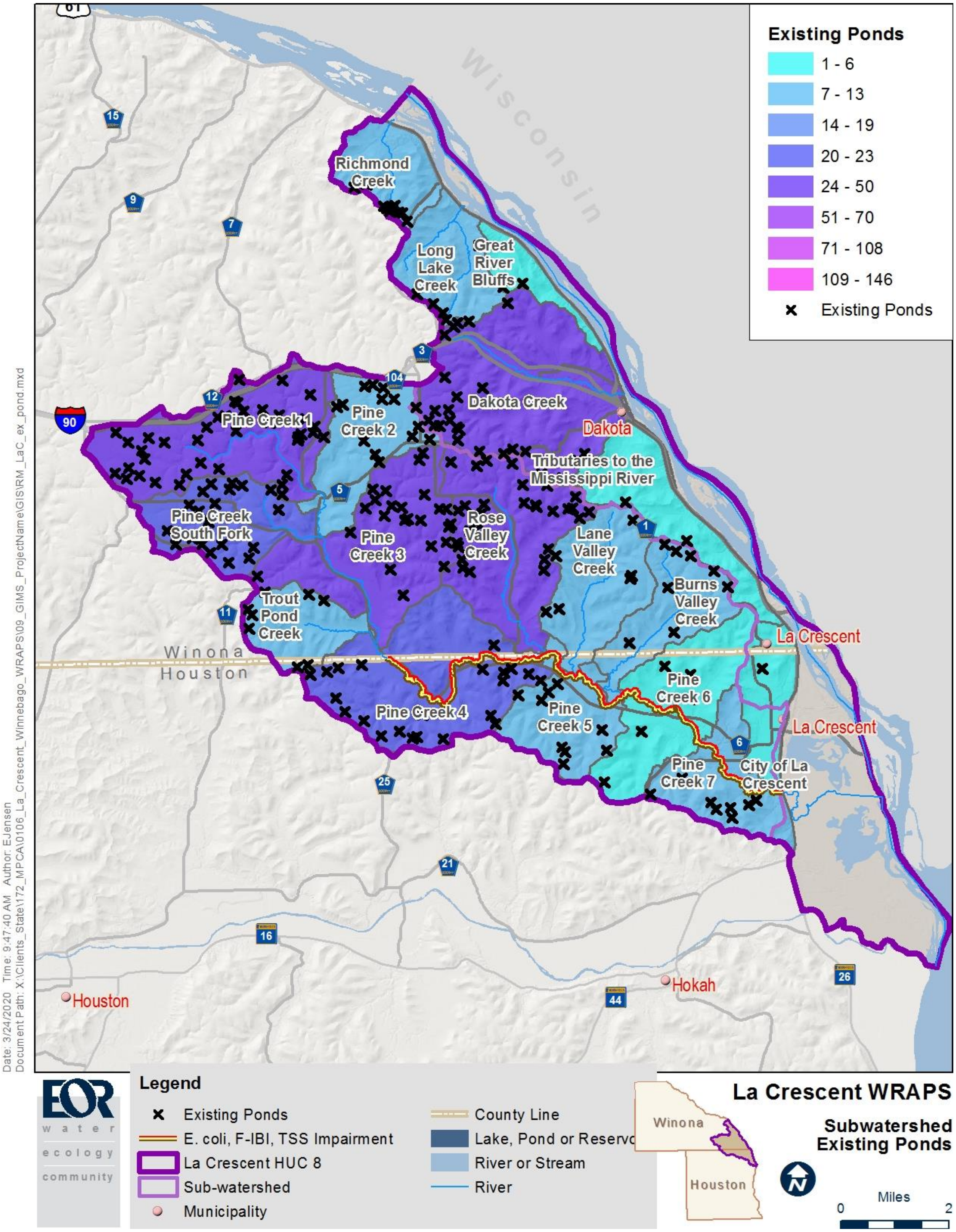


Figure 28. Number of existing ponds by subbasin in the MRLCW.

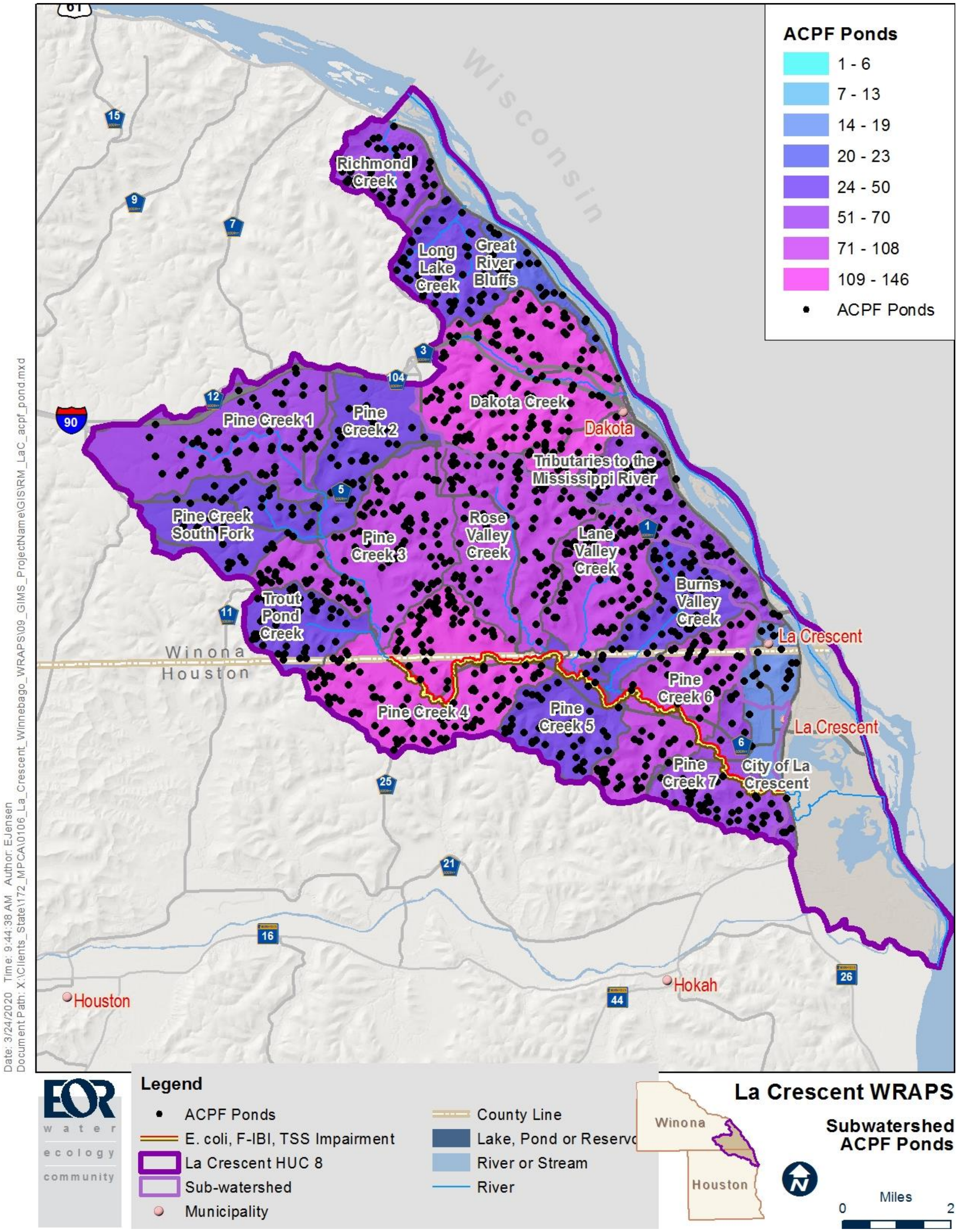


Figure 29. Number of ACPF modeled potential ponds by subbasin in the MRLCW.

3.2 Civic engagement

A key prerequisite for successful strategy development and on-the-ground implementation is meaningful civic engagement and public participation.

Accomplishments and future plans

Civic engagement and public outreach has been conducted in the MRLCW as part of many existing initiatives including a pre-WRAPS contract between Winona County and MPCA, and county-wide water quality programs. The following are organizations involved in the watershed and their work summaries.

Winona County:

- Led effort in developing report on watershed residents: *A Social Science-based Assessment of Conservation Practices in the La Crescent and Reno Watersheds* (Pradhananga etal 2019).
- Worked with NewGround Inc. to:
    - Produce a Civic Engagement Report: *Next Wise Steps for Engaging People in Southeast Minnesota.* (NewGround 2019 – available via Minnesota Water Research Digital Library).
        - Section 1 summarizes individual interviews on local water issues and what is happening in the area.
        - Section 2 describes outreach goals in plans and interviews with local leaders involved in executing plans, describes current work being done, and what is needed.
    - Developed "SmarterTogether.info" website: an online compilation of stories of farmers and agronomists who are working with neighbors, suppliers, and third party, private and public researchers to define optimum rates and ways to manage and apply N.
    - Designed an informational sign to be installed at the Dresbach Rest Area on U.S. Hwy 61 to educate about the karst landscape. Sign aims to educate the estimated 200,000 people that visit the rest area each year.
    - Produced a story for the City of the La Crescent's newsletter on Minnesota's watershed approach, the Mississippi River – La Crescent Area WRAPS Report, and photos and stories about local work for water quality.
- Developed Raingarden Educational Video
- Updated Local Water Plan in 2019.
- Volunteer Well Monitoring Network
- Conducted ACPF analysis to identify suitable areas for BMPs in the La Crescent Watershed.
- Winona County Zoning Ordinance of 2019 added requirements for Solar Energy Systems to include "perennial vegetation and pollinator friendly species" to reduce runoff from installed solar arrays.

- Staff recently attended BWSR, DNR and Fresh Energy Great Plains Institute Solar Summit; Winona County plans to use BWSR's Solar Site Pollinator Habitat assessment form for solar project planning; special focus will be rusty patch bumblebee habitat assessment.
- Using United States Department of Agriculture (USDA) cost share, Winona County authorized "seeding" of Apple Blossom Scenic Drive Park into prairie plantings; maintenance is provided by local landowners/ volunteers; Master Water Stewards volunteer, Robin Draves, completed Phase I of his capstone project to include removal of invasive species, a water retention demonstration for home rain gardens. Phase II will include educational signage.
- Provide technical support to private landowners who are awarded Lawns to Legumes funding for their property.

Winona SWCD

- Conservation Reserve Enhancement Program (CREP) and Conservation Reserve Program (CRP) acre enrollment;
- Tree sales;
- Volunteer conservation guidance;
- Monitor and assess public water buffers;
- Assist with administering Minnesota Agricultural Water Quality Certification Program (MAWQCP);
- Use social media and short videos posted on their website to engage landowners in soil health practices.

Houston County

- Updated Local Water Plan October 2017. Goals include:
    - Plan and implement grazing plans on 25 acres in sensitive areas annually;
    - Provide planning and financial assistance on one feedlot per year;
    - Promote residue management on 50 acres of highly erodible land per year;
    - Implement Cedar Tree Revetment Program and treat 0.25 miles of stream bank per year (targeting MRLC Watershed);
    - Install one raingarden within city of La Crescent per year;
    - Establish one flood control structure per year;
    - Provide stormwater retention through road culvert/ditch size reduction on one township or county road annually.

Root River SWCD

- Volunteer Well Monitoring Network
- CREP and CRP acre enrollment;

- Tree sales;
- Completed 42 conservation practices in 2018 throughout Houston County;
- Monitor and assess public water buffers;
- Assist with administering MAWQCP

Houston Co. MS4

- Updated MS4 Website: listing SWPPP information, education materials, and the Houston County Recycler, which provides Household Hazardous Material Collection recycling locations and collection schedule.
- Active Partnership with Root River SWCD: participating in and reviewing many water quality related issues through Water Planning meetings and site assessments for water impacts.

City of La Crescent MS4

- Elected to join the La Crosse Urban Stormwater Group, a collaboration of 10 local governments in the La Crosse MS4. This group educates and engages the public to reduce stormwater runoff. Membership in the stormwater group offers ongoing collaborative outreach such as the annual, "Soak It Up!" award for water-friendly landscaping on private property, monthly educational emails to a large outreach network, and presence on LaCrosseAreaWaters.org, an online resource for education and connection.
- Planned educational signage in oak savanna area of La Crescent.
- Bluffland management plan between City of La Crescent and Houston Township.

Additional work done by watershed partners:

- Trout Unlimited has done work in the Crooked Creek Watershed (Mississippi River – Reno Area Watershed);
- Pheasants Forever funded a position in the Root River SWCD office to promote and support native habitat work;
- DNR Habitat Improvement project is planned on the headwaters of Pine Creek (New Hartford area). The project will restore approximately 8,000 linear feet of Pine Creek to improve brook trout habitat over the next several years.

Technical Meetings

The Technical Advisory Committee (TAC) was comprised of representatives from the Soil and Water Conservation Districts (SWCD), Counties, nonprofit organizations (NewGround Inc.), and state agencies. Table 10 outlines the date, location and meeting focus of TAC meetings held during the TMDL development process.

Table 10. Mississippi River - La Crescent Area Watershed TAC Meetings.

Date	Location	Meeting Focus
7/23/2019	Winona County Government Center	TMDL and WRAPS Kick-off meeting

Date	Location	Meeting Focus
12/12/2019	Winona County Government Building	Reviewing draft TMDL and discussing preliminary comments
2/3/2020	Winona County Government Building	Reviewing draft WRAPS and discussing preliminary comments

Additional Resources Needed:

Additional resources are needed by watershed partners in order to support watershed restoration and protection initiatives. Specific needs requested by watershed stakeholders include:

- Continued and expanding funding of MDA's AgBMP Loan Program.
- Dedicated nonstate funding for pond clean-out and maintenance (bump up cost share from 75% to 90% in high priority areas).
- Factsheet on pasture and dairy improvements for feedlot compliance staff.
- Community/township cooperation and coordination to address IPHT and noncompliant SSTS.
- Consider revision of Houston County/City of La Crescent ordinances/codes for septic point of sale.
- Dedicated and accessible SSTS program training for County SSTS inspection staff.
- Additional funding and coordinated efforts between local and state agencies for a sequenced and targeted approach for stream bank restorations/stream bank stabilization projects.
- A curriculum for regular education for elected officials and watershed citizens on Minnesota's watershed approach to implement in regular meeting schedule.
- Fill data gaps to allow for modelled outputs of sediment reduction following stream projects.

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 June 1, 2020 to July 1, 2020. No comment letters were received during the public notice.

3.3 Restoration and protection strategies

Waterbody specific goals are set for the individual impairments in the watershed, and are reflected in a strategy table below. Final water quality goals for TSS and *E. coli* impaired Pine Creek are identified in the MRLCW TMDL (EOR 2020). Final water quality goals for biota impairments were determined using the applicable fish biocriteria (FIBI score) necessary to obtain the aquatic life use goals for Pine Creek. Goals for biota impairments are supported by the SID report.

This section includes watershed-wide restoration strategies, as well as customized strategies specific to achieving the water resource goals in the MRLCW. Example BMP scenarios that meet interim and final reduction goals, including the estimated scale of adoption, were developed with local stakeholder input and the ACPF toolset.

While high levels of N and P are not contributing to current impairments in the MRLCW, watershed-wide N and P reduction goals were set for the MRLCW as part of Minnesota's NRS (MPCA 2014).

Minnesota Nutrient Reduction Strategy

The NRS outlines state-wide goals and milestones for N and P reductions, as well as recommended strategies to meet the reductions. To address downstream impacts, the NRS set a goal of reducing N and P loading by 45% by 2040; interim goals of 25% (N) and 12% (P) by 2025. Specific annual load reductions for N and P were estimated in the NRS report using SPARROW model outputs (Table 11).

Table 11. Nitrogen and phosphorus annual load reductions for the MRCLW (MPCA 2014). MT = metric ton

Nitrogen		Phosphorus	
Estimated Existing Load (MT/year)	Cropland Load Reduction (MT/year)	Estimated Existing Load (MT/year)	Cropland Load Reduction (MT/year)
412.4	26.8	30.0	0.5

Estimated scales of adoption of N and P -related BMPs were determined using the University of Minnesota Agricultural BMP Scenario Tools (N and P BMP Tools). The N and P BMP Tools were developed by the University of Minnesota to assist resource managers in better understanding the feasibility and cost of various BMPs in reducing nutrients from Minnesota cropland. The tool also translates "percent adoption rates" for specific BMPs into numbers of "acres treated" based on the number of acres suitable for the practice. Counties could utilize these acre and adoption goals for grants and other incentives for landowners to implement these practices. Estimated adoption rates in Table 12 represent the cumulative adoption rates of BMPs to achieve nutrient reduction goals. While the tables below give general reductions, it is noted that it does not summarize all nutrient reduction practices. For example, using more diverse cover crop species (as recommended by Winona and Root River SWCDs) could result in further N and P reductions not provided in the table. Additionally, associated sediment reductions are not quantified in the table even through many practices, particularly cover crops and riparian buffers, also have sediment reduction benefits.

In addition to the NRS, other N reduction initatives are occuring throughout the state. The MDA is regulating commerical N fertilizer through the Groundwater Protection Rule. The Rule contains two parts aiming to promote N fertizlier BMPs to reduce nitrate in groundwaer. Part 1 focuses on restrictions of fall applied N fertilizer in vulnerable groundwater areas or DWSMAs with high nitrate levels. Part 2 responds to DWSMAs with elevated nitrate levels by incorporatin voluntary and regulatory actions based on nitrate concentrations fo roundwater and the use of BMPs. As described in Section 2.1, the western portion of the MRLCW is noted as having highly vulnerable groundwater and would be a targeted area for restriction of fall applied commerical N. For additional information on how the Rule impacts this portion of the watershed, refer to MDA's Pesticide and Fertilizer program.

Table 12. Watershed-wide Nitrogen and Phosphorus Reduction Scenarios (N and P BMP Spreadsheet).

Parameter (incl. non-pollutant stressors)	2040 Minnesota Nutrient Reduction Strategy Goal	Strategy Type	Suitable acres treated	Interim 10-year Milestone Adoption Level	Interim 10-year Treatment Cost ($/acre watershed treated)	Interim 10-year reduction in watershed N load	Required Adoption Level to reach Long-term goal	Long-term Treatment Cost ($/acre watershed treated)	Long-term reduction in watershed N load
Nitrogen	45% reduction in nitrogen by 2040 from baseline conditions (mid-1990's)	Corn acres receiving target N rate, no inhibitor or timing shift	1,600	50%	($2.91)	8.9%	100%	($5.83)	17.7%
		Fall N target rate acres receiving N inhibitor	90	50%	($0.41)	0.4%	100%	($0.82)	0.8%
		Fall N applications switched to spring, % of fall-app. acres	50	50%	($0.09)	0.5%	100%	($0.18)	1.0%
		Fall N switch to split spring/side-dressing, % of fall acres	50	50%	$0.21	0.5%	100%	$0.42	1.1%
		Riparian buffers 50 feet wide	280	100%	$9.36	4.5%	100%	$9.36	4.5%
		Corn grain & soybean acres w/cereal rye cover crop	1,010	25%	$8.46	2.1%	100%	$33.84	8.3%
		Short season crops planted to a rye cover crop	320	80%	$2.90	3.2%	100%	$3.63	4.0%
		Perennial crop % of corn & soy area, marginal only	140	35%	$1.54	2.2%	100%	$4.41	6.4%
		Cumulative total (some BMPs are on same acres)				**20.0%**			**35.6%**
Phosphorus	12% reduction in phosphorus by 2025 from baseline conditions (mid-1990's)	Adopt BMP P2O5 rate, Apply U of M recs	2,420	50%	($16.37)	2.6%	50%		2.6%
		50 ft buffers, perm & intermit streams, 100 ft treated	870	100%	$71.58	7.4%	100%		7.4%
		Corn grain & soybean acres w/cereal rye cover crop	1,010	25%	$48.84	2.7%	25%		2.7%
		Short season crops planted to a rye cover crop	340	80%	$55.97	1.9%	80%		1.9%
		Perennial crop % of marginal corn & soy land	130	35%	$56.67	1.2%	35%		1.2%
		Cumulative total (some BMPs are on same acres)				**14.7%**			**14.7%**

Key strategies identified by local partners

The following key strategies were identified by the local partners:

- **Buffer Compliance/Riparian Shading –** a maintained vegetative buffer along Pine Creek is needed to reduce streambank erosion and increase riparian shading. Streambank erosion and higher water temperatures were identified as stressors to the aquatic life community in Pine Creek. Increased shading is particularly needed between New Hartford and CR16 (see Section 2.3.2).
- **Forest Stewardship Plans/Land Conservation –** protecting forestland improves water quality by absorbing rainfall and snow melt, slowing storm runoff, recharging aquifers, sustaining stream flows, filtering pollutants from the air and runoff before they enter the waterways, and providing critical habitat for fish and wildlife. For example, management activities in Great River Bluffs State Park include: prescription burns, brush-cutting, invasive species control and re-seeding. Forestland can be protected through forest protection programs – such as:
    - **Forest Stewardship Plans:** a voluntary plan for forest landowners who own 20 acres or more of forestland that offers land management recommendations to landowners based on their goals for their property from a natural resource professional. Plans are updated every 10 years to stay current with the landowner's needs and forest condition. A Forest Stewardship Plan registered with the DNR qualifies the landowner for woodland tax and financial incentive programs.
    - **Sustainable Forest Incentive Act (SFIA):** SFIA is a tax incentive program available for landowners that have a registered Forest Stewardship Plan. This program offers an annual tax incentive payment per acre based off the amount of forest stewardship acres enrolled. Payments per acre range from the $9 to -$16.50, based off the length of covenant the landowner decides to enroll into. SFIA restricts land use conversion and subdivision of the parcel(s). A minimum of 3 acres must be excluded from the SFIA program if there is a residential structure present; landowners can exclude more acres if they plan to make future improvements on the land.
    - **Conservation Easements:** Conservation easements are voluntary, legally binding agreements by the landowner to give up some of the rights associated with their property such as the right to develop, divide, mine, or farm the land to protect conservation features such as wildlife habitat, water quality, and forest health, to name a few. Most, but not all conservation easements are perpetual. Some landowners want to ensure their land will never be developed or converted to another use by selling or donating a conservation easement.
    - **Land Acquisition:** Land acquisition is an option to permanently protect the land by selling the land to a conservation organization, agency, or other land trust. Once purchased, land is restored or maintained to perpetually protect important natural resource values.

One implementation activity for the watershed is to complete a Landscape Stewardship Plan to identify conservation opportunities in the watershed, similar to the 2015 Mississippi River-Winona Landscape Stewardship Plan.

Table 13. Forest Protection Areas (DNR, Woodland Stewardship, SFIA) and Goat Prairies by Subwatershed.

SubwWatershed Name	Area (ac)	DNR Lands (acres)	Woodland Stewardship Area (WSA) Lands (acres)	WSA Lands under SFIA	Goat Prairie
Pine Creek	13,264	76	625	153	37
Mississippi River	13,904	943	204	0	102
Pine Creek Headwaters	13,939	111	134	0	17
Lane Valley Creek	2,654	0	3	0	0
Trout Ponds Creek	1,603	388	0	0	10
Burns Valley Creek	2,122	0	63	0	2
Dakota Creek	5,778	1,091	0	0	90
Lone - Miller Creek	1,936	356	75	0	69
Richmond Creek	1,262	301	295	0	10
Rose Valley Creek	4,074	0	189	189	0

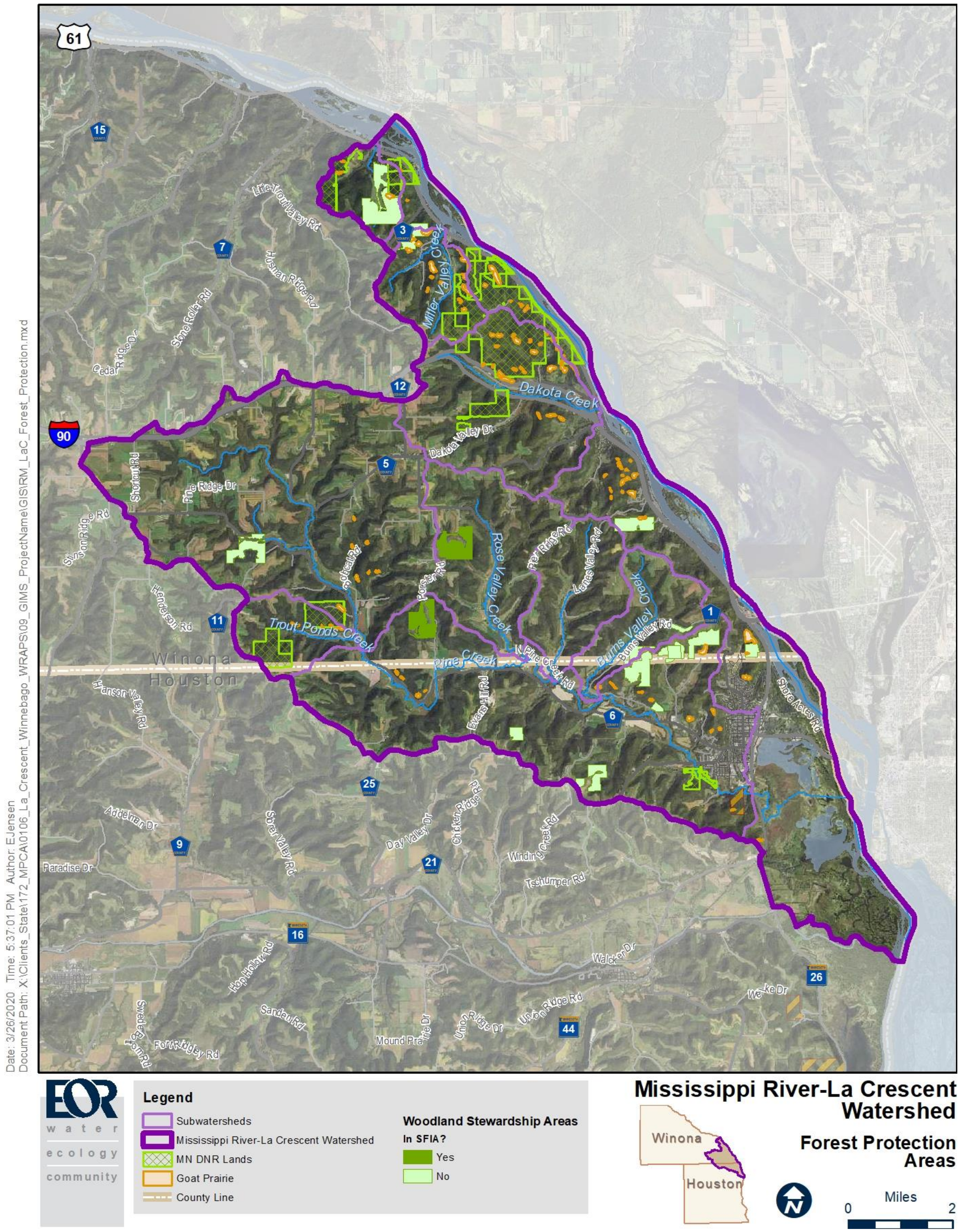


Figure 30. MRLCW Forest protection areas.

- **Cover Crops –** according to the Minnesota Ag BMP Handbook (Lenhart and Peterson 2017), cover crops are the use of grasses, legumes, and forbs planted with annual cash crops to provide seasonal soil cover on cropland when the soil would otherwise be bare. In Minnesota, the cover crop is commonly winter rye (*Secale Cereale L.*), although oats (*Avena sativa*), alfalfa (*Medicago sativa*), buckwheat (*Fagopyrum esculentum*), and other small grains and other crops are also used. The short growing season in Minnesota, paired with the use of full season corn and soybean, creates obstacles for adequately establishing cover crops, although there is much evidence of cover crops' potential for improving water quality (Carlson and Stockwell, 2013). Cover crop use is expanding as farmers see the environmental and financial benefits of the practice (SARE/CTIC, 2016). Cover crops are gaining in popularity in the Houston County portion of the watershed. There is low local interest in Farmer Led Councils, therefore implementation will likely be through identification of key individuals in the community providing cover crop examples and demonstration sites. There is one cover crop demonstration site located in Winona County in the neighboring Mississippi River-Winona Area Watershed, which resulted in 45 active cover crop contracts (3 years on 1,203 acres). Videos are available from Winona SWCD: CC1 and CC2. The U of M tillage transect study results can be used to track implementation of cover crops in the watershed.

- **Upstream Water and Sediment Storage –** increasing the amount of water storage in the upstream portion of the Pine Creek drainage area was identified as a key strategy for reducing bed and bank erosion through the reduction of total and peak flows. The 2018 geomorphic report (appendix to MPCA 2018b) noted that climate change will complicate the evolution to channel stability. More frequent and larger rain events would increase the risk of instability to the stream. There is evidence using historical aerial photos of the current channel evolution process likely ongoing for 80 to 100 years. This process may continue at this same rate without active intervention. A passive restoration approach would allow the channel to naturally evolve and may take another 50 to 100 years establish a stable C channel at a lower elevation. Management through active restoration such as bank stabilizations and full channel restorations would speed up the timeline but require significant investment of money and local participation. A sequenced and targeted approach is needed to make the best use of limited financial resources. A likely area to target initially would be to address the larger headcuts to stop further degradation while using a watershed approach (i.e. water and sediment storage BMPs) to address the systemic stressors responsible for the excess sediment. ACPF was used to estimate the number and acres of drainage area treated by existing and potential ponds, as described in Section 3.1. Landowner surveys of existing ponds identified cleanout funding as a limitation.
- **Livestock Management –** livestock access to streams and grazing on streambanks increases sources of TSS through hoof shear and physical trampling. The 2018 geomorphic report (appendix to MPCA 2018b) noted instances where hoof shear stress is causing bank erosion and active cattle pastures are destabilizing some stream reaches. In addition, instances of improperly managed manure can contribute *E. coli* to streams. Management strategies, such as rotational grazing and promoting the growth of perennial vegetation, would help strengthen and stabilize banks during and after evolution to a stable condition. Climate change will complicate the evolution to channel stability. More frequent and larger rain events would increase the risk of instability to the stream. Local partners will target instances of poor livestock management through landowner outreach.

- **Solar Runoff Management –** there is an increasing number of solar farms being developed in the MRLCW. Plantings of native, perennial vegetation should be included in the landscape plan (SWPPP) beneath the panels (and in areas immediately surrounding the panels) to achieve many water quality benefits, such as:
    - Increased erosion control
    - Increase soil capacity for water storage
    - Improved downstream water quality via reduced nutrient/sediment/herbicide runoff for improved downstream drinking water / aquatic ecosystem health
    - Provide valuable habitat and numerous ecological benefits across a wide range of species including pollinators, insects, reptiles, small wildlife, and ground-nesting birds
    - Increased soil fertility through increased soil organic carbon content, improved soil structure, and microbiome building
    - Alleviate downstream water quality and capacity issues improving their ecological, recreational, and physical value as well as resiliency in the event of an extreme weather event

  DNR has established guidelines for prairie establishment and maintenance and siting of solar projects.
- **Urban Stormwater Management –** stormwater BMPs and infrastructure updates (where planned) to manage urban runoff in developed portions of the City of La Crescent to reduce TSS, *E. coli* and peak runoff flows. Implementation of stormwater retrofits could be in partnership with the Green Step Cities program, La Crosse Urban Stormwater group, MNDOT, and the City of La Crescent. Stormwater retrofits could be implemented as city streets and I-90 are improved. Neighborhood raingardens could provide rusty patch bumblebee habitat through incorporation of the Lawn to Legumes program.

Climate protection co-benefit of strategies

Many agricultural BMPs which reduce the load of nutrients and sediment to receiving waters also act to decrease emissions of greenhouse gases (GHGs) to the air. Agriculture is the third largest emitting sector of GHGs in Minnesota. Important sources of GHGs from crop production include the application of manure and N fertilizer to cropland, soil organic carbon oxidation resulting from cropland tillage, and carbon dioxide (CO_2) emissions from fossil fuel used to power agricultural machinery or in the production of agricultural chemicals. Reduction in the application of N to cropland through optimized fertilizer application rates, timing, and placement is a source reduction strategy; while conservation cover, riparian buffers, vegetative filter strips, field borders, and cover crops reduce GHG emissions as compared to cropland with conventional tillage. More information can be found at: https://www.pca.state.mn.us/sites/default/files/p-gen4-19.pdf

The USDA NRCS has developed a ranking tool for cropland BMPs that can be used by local units of government to consider ancillary GHG effects when selecting BMPs for nutrient and sediment control. Practices with a high potential for GHG avoidance include: conservation cover, forage and biomass planting, no-till and strip-till tillage, multi-story cropping, nutrient management, silvopasture establishment, other tree and shrub establishment, and shelterbelt establishment. Practices with a medium-high potential to mitigate GHG emissions include: contour buffer strips, riparian forest buffers, vegetative buffers and shelterbelt renovation. A longer, more detailed assessment of cropland BMP effects on GHG emission can be found at NRCS, *et al*., "COMET-Planner: Carbon and GHG Evaluation for NRDC Conservation Practice Planning http://comet-planner.nrel.colostate.edu/COMET-Planner_Report_Final.pdf.

Table 14. Priority Subwatershed Goals, Strategies and Interim 10-year Milestone Adoption Level.

Priority Subwatershed	Goals/Targets and Estimated % Reduction	Strategy Type	Units	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level
Watershed-wide	Nutrient Reduction Strategy Targets 45% reduction in P (12% by 2025) 45% reduction in N (20% by 2025)	See Table 12			
		See “Other sediment reduction BMPs” below			
Pine Creek Headwaters	Maintain or improve existing water quality	ACPF modeled ponds (or other water storage BMPs) (existing % treated = 20%)	% of suitable (upland) acres treated	30%	48%
		Riparian shading/buffer compliance	Linear miles	75% (4.1 miles)	100% (5.5 miles)
		Forest protection/land conservation	% of suitable acres treated	50%	75%
		Feedlot compliance	# feedlots inspected	50% (13)	100% (26)
Pine Creek	No greater than 10% of TSS samples collected April-September exceeding 10 mg/L (10-76% reduction at mid to very high flows);	ACPF modeled ponds (or other water storage BMPs) (existing % treated = 11%)	% of suitable (upland) acres treated	22%	44%
		Other sediment reduction BMPs (grassed waterways, ponds, contour farming, terraces, no-till, crop residue, cover crops)	# of projects installed	1 – 5 projects annually	100% of identified projects implemented
		N & P practices (see Table 12)			
		Bank stabilizations and full channel restorations	Linear feet	Identify sections for restoration	100% implementation of planned projects
		Riparian shading/buffer compliance	Linear miles	75% (3.6 miles)	100% (4.8 miles)

Priority Subwatershed	Goals/Targets and Estimated % Reduction	Strategy Type	Units	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level
		Forest protection/land conservation	% of suitable acres treated	50%	75%
		Continued implementation of stormwater program	Number of joint projects implemented with help from Green Steps program, DOT, City of La Crescent.	Plan projects according to MS4 program needs	100% implementation of projects
	April-October monthly geometric mean *E. coli* <126 cfu/100mL (88-93% reduction at low to high flows)	Animal feedlot compliance	# feedlots inspected	50% (13)	100% (26)
		Address SSTS noncompliance through point of sale	# of ITPHS systems corrected	100%	100%
		Pasture management plans	Meet pasture management plan goals in Local Water Plan	See Houston & Winona County local water plans.	**Houston Co:** 25 sensitive area acres **Winona Co:** 10 rotational grazing plans (2011-2023)
		Restricting cattle access to stream	#of cattle water access projects	Identify critical areas for cattle restriction	Implement voluntary cattle restrictions
	Average water temperatures < 19°C	Protect spring sources	# ponded springs	Evaluate locations of ponded springs for re-connection to stream	Restore 100% spring discharge; volunteer implementation
		See riparian shading strategy above			
	Average MSHA score > 66	Bank stabilizations and full channel restorations	Linear feet	Identify sections for restoration	100% implementation of planned projects

Priority Subwatershed	Goals/Targets and Estimated % Reduction	Strategy Type	Units	Interim 10-year Milestone Adoption Level	Suggested Goal Adoption Level
Dakota Creek	Maintain or improve existing water quality	Forest protection/land conservation	% of suitable acres treated	50%	75%
		Stormwater management	% of required I-90 improvements	50%	100%
Rose Valley Creek	Maintain or improve existing water quality	Forest protection/land conservation	% of suitable acres treated	50%	75%

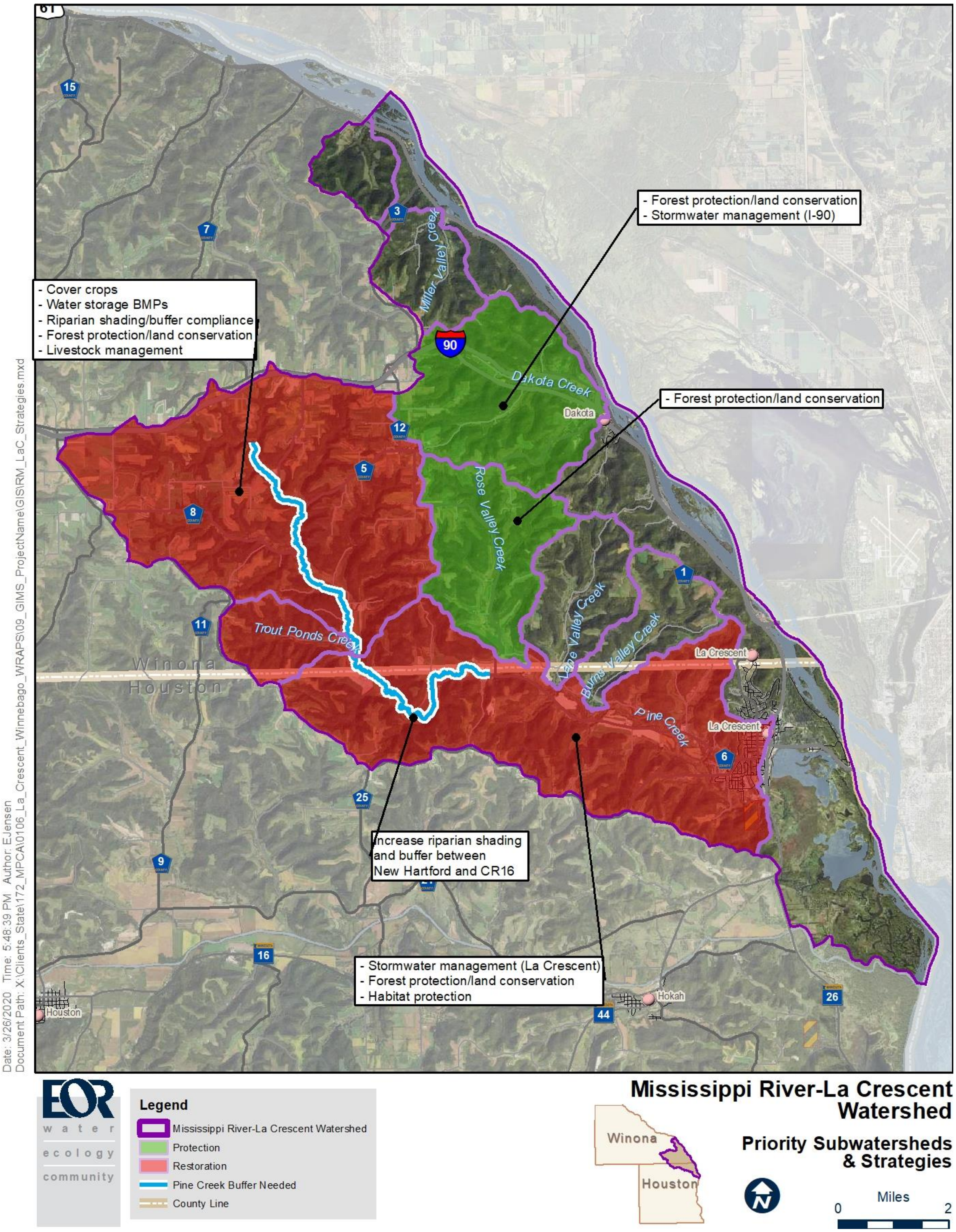


Figure 31. Priority MRLC subwatersheds and strategy examples.

4. Monitoring plan

Monitoring is also a critical component of an adaptive management approach and can be used to help determine when a change in management is needed. This section describes existing and recommended monitoring activities in the watershed.

Future monitoring in the MRLCW will be accomplished according to the watershed approach's IWM. IWM uses a nested watershed design allowing the aggregation of watersheds from a coarse to a fine scale. The foundation of this comprehensive approach is the 80 major watersheds within Minnesota. IWM occurs in each major watershed once every 10 years (MPCA 2011). The MRLCW was monitored in 2015 to 2016 for the first cycle of IWM; second cycle IWM will occur in 2021. The advancement of Cycle 2 IWM prior to 10 years is done to synchronize with the neighboring Mississippi River – Winona Area Watershed. Monitoring stations are proposed for Dakota Creek, Miller Valley Creek, and Pine Creek. It is recommended during Cycle 2 to prioritize filling data gaps for sites that had insufficient information to complete an assessment. Additional sampling is needed throughout the watershed to identify hot spot sources of TSS and *E. coli*, and measure progress from sediment and *E. coli* reduction efforts.

Further monitoring of groundwater and stream flow is needed in the watershed especially because of the correlation between in-stream flow and sediment in southeast Minnesota (Dogwiler and Kumarasamy 2016; Ellison et al. 2014).

As for *E. coli*, more research is needed to fully understand the watershed dynamics behind *E. coli* concentrations in streams. In the revised Regional TMDL Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota Implementation Plan (2007), several research and development needs were identified including:

- Sources of fecal coliform in urban areas
- The effectiveness of structural and nonstructural BMPs in reducing *E. coli* loads
- Models to evaluate loading sources and track fecal coliform load reduction
- Source identification techniques with "DNA fingerprinting" and additional methods to assess pollutant movement through the watershed from source to surface water.

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