PINE CREEK WATERSHED
9-KEY ELEMENT PLAN

Calvin Creek at County LS

2019

Prepared by:

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Acknowledgements

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Pine Creek Watershed 9-Key Element Plan

Executive Summary

Pine Creek watershed is located in Northeast Wisconsin, in Manitowoc County, just south of the city of Manitowoc. Pine and Calvin Creeks and an unnamed intermittent stream transport water from approximately 21 square miles, or 13,409 acres of land into Lake Michigan. There are also eight lakes within the watershed including: Carstens. Gass, Glomski, Grosshuesch, Hartlaub, Kasbaum, Waack and Weyers. Historically, most of the Pine Creek watershed was forested. Today, land within the watershed is primarily used for agriculture.

Many conservation practices were implemented through past and current programs in the watershed that have significantly reduced phosphorus and sediment loading. However, both Pine and Calvin Creeks, and four lakes, Carstens, Gass, Hartlaub, and Weyers, are listed as 303d Impaired waters for Total Phosphorus.

The Pine Creek Watershed 9-Key Element Plan provides a framework to accomplish the following goals:

Goal 1: Improve surface water quality to achieve DNR/EPA water quality standards.
Goal 2: Improve streambank stability and reduce amount of streambank degradation.
Goal 3: Increase public awareness of water quality issues and increase participation in watershed conservation activities.

Watershed Implementation Plan:
In order to meet the goals for the watershed, this 10 year implementation plan was developed. The action plan recommends best management practices for cropland, farmsteads and streambanks, as well as information and education activities to achieve the goals of the watershed. The plan includes estimated cost, potential funding sources, agencies responsible for implementation, and a measure of success.
Recommended Management Practices:

- Nutrient Management Planning and Implementation Verification
- Low Rate/Low Disturbance Manure Injection
- Grassed Waterways
- Cover Crops
- Reduced Tillage/ No Tillage
- Wetland Restoration
- Stream Buffers
- Barnyard and Feed Storage Runoff Management

Education and Information Recommendations:

- Create public awareness of the watershed, existing conditions of water quality, and additional BMP's that, if applied, will improve water quality.
- Increase landowner involvement in watershed stewardship.
- Increase communication and coordination among government agencies, educational institutions, environmental organizations, and the agricultural community.
- Create an advisory team made up of stakeholders living in the watershed.
- Demonstrate good conservation practices.

Conclusion:

Meeting goals for the Pine Creek Watershed will be challenging. The majority of the agricultural land is in compliance with current program requirements. Watershed planning and implementation will be primarily a voluntary effort that will need to be supported by focused technical and financial assistance. It will require widespread cooperation and commitment of the watershed community to improve water quality and condition in the watershed. This plan needs to be adaptable to the many challenges, changes, and lessons that will be found in this watershed area.

1.0 Introduction

Purpose

The purpose of this project is to develop an implementation plan (9-Key Element Plan) for the Pine Creek watershed to reduce phosphorus and sediment loads from point and nonpoint sources in order to meet Wisconsin's surface water quality standards. Nutrient and Sediment reductions in the project area, and the larger Manitowoc River basin, are crucial to the local economy, lifestyles and recreational opportunities in the region, and will benefit the habitat dependent on water quality and near shore health.

US EPA Requirements for 9-Key Element Watershed Plans

In 1987, Congress enacted the Section 319 of the Clean Water Act which established a national program to control nonpoint sources of water pollution. Section 319 grant funding is available to states, tribes, and territories for the restoration of impaired waters and to protect unimpaired/high quality waters. Watershed plans funded by Clean Water Act section 319 funds must address nine key elements that the EPA has identified as critical for achieving improvements in water quality (USEPA 2008). The nine elements from the USEPA Nonpoint Source Program and Grants Guidelines for States and Territories are as follows:

1. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed

2. An estimate of the load reductions expected from management measures.

3. A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in element 2, and a description of the critical areas in which those measures will be needed to implement this plan.

4. Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

5. An information and education component used to enhance public understanding of the plan and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.

6. Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

7. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element 8.

9-Key Element Plan is needed for TMDL Implementation:

In 2015, the Wisconsin Department of Natural Resources (WDNR) identified the Manitowoc River basin as a priority for Total Maximum Daily Load (TMDL) development as part of Wisconsin's Water Quality Restoration and Protection Prioritization Framework. The TMDL project, entitled the NE Lakeshore TMDL, will be multi-jurisdictional and will address sources of total phosphorus (TP) and total suspended solids (TSS) being delivered to Lake Michigan.

Since 2015, the WDNR has met with stakeholders in the Manitowoc River basin to explore opportunities for improving water quality in the Manitowoc River Watersheds. During this time, representative stakeholders came together and agreed that developing and implementing a TMDL could be the best opportunity to bring water quality improvements together with consensus-based outcomes. The stakeholders involved represent key community sectors throughout the watershed including: farmers, agribusinesses, community organizations, and City, County, and State agencies. Strategically, the Manitowoc Basin area stakeholders ultimately plan to develop, implement and evaluate a TMDL that is guided by federal, state, and county management plans, and 9 Key Element Watershed Plans. Creating a 9 Key Element Plan for the Pine Creek Watershed will provide a strong foundation for guiding implementation of best management practices to reduce sediment and nutrient loads and implement the NE Lakeshore TMDL.

Jurisdictional Roles and Responsibilities

Natural resources in the United States are protected to some extent under federal, state, and local law. The Clean Water Act is the strongest regulating tool at the national level. In Wisconsin, the Department of Natural Resources has the authority to administer the provisions of the Clean Water Act. The U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers work with the WDNR to protect natural areas, wetlands, and threatened and endangered species. The Safe Drinking Water Act also protects surface and groundwater resources. The Manitowoc County Soil & Water Conservation Dept. is responsible for implementing ordinances and numerous State conservation programs.

State Surface Water Quality Standards and Agricultural Performance Standards and Prohibitions:

The following state standards have been established to protect surface water: Water Quality Standards for Surface Water Chapter NR 102, Water Quality Standards for Wetlands Chapter NR 103, uses and Designated Standards Chapter NR 104, and Surface Water Quality Criteria and Secondary Values for Toxic Substances Chapter NR 105. **S**tandards dealing with Agriculture and other nonpoint sources include: Chapter NR 151 Runoff Management, Chapter, NR 243 Animal Feeding Operations, Soil and Water Resource Management Program ATCP 50, and Facility Siting ATCP 51.

Local County Ordinances:

In addition to federal and state mandates are local county ordinances which were established to regulate development, provide public health and safety, and protect water quality in Manitowoc County. In instances where various state regulations overlap Manitowoc County ordinances, the enforcement is coordinated with the state agency representatives. Manitowoc County Ordinances include:

Manitowoc County Chapter 9 Shoreland Zoning- The purpose of this ordinance is to further the maintenance of safe and healthful conditions and prevent and control water pollution, protect spawning grounds, fish and aquatic life, control building sites, placement of structures, and land uses, preserve and restore shoreland vegetation and natural scenic beauty.

Manitowoc County Chapter 13 Private Sewage Systems- The purpose of this Private Sewage Systems ordinance is to insure the safe and proper use of land and water resources and to promote the public health, safety, and general welfare by regulating the location, design, installation, alteration, inspection, management, and use of all private sewage systems thereby insuring the protection and security of the general health of the public from disease and pestilence.

Manitowoc County Chapter 14 Parks- The purpose of this ordinance is to enhance the use and enjoyment of the County Parks by establishing rules and regulations to govern the conduct of visitors to County Parks and provide for the protection of the Parks' natural resources.

Manitowoc County Chapter 19 Animal Waste Management – Animal waste and land application related activities other than storage are covered by Chapter 19 of the Manitowoc County Ordinance. The ordinance cites specific manure management restrictions and requirements outside the structure of the 590 nutrient management plan. Restrictions include manure spreading activities in proximity to lakes, streams, wells, sinkholes and tile surface inlets along with winter manure spreading criteria relative to manure type and land slope. Livestock are not permitted to access an intermittent stream, perennial stream, or lake except as authorized in a grazing permit issued by the Manitowoc County Land Conservation Committee.

Manitowoc County Chapter 21 Nonmetallic Mining Operations- The purpose of this chapter is to establish a local program to ensure effective reclamation of nonmetallic mining sites in Manitowoc County on which nonmetallic mining takes place in Manitowoc County and to adopt and implement the uniform statewide standards for nonmetallic mining reclamation required by Wis. Stat. § 295.12(1)(a) and contained in Wis. Admin. Code Ch. NR 135.

Manitowoc County Chapter 26 Animal Waste Storage – Permits to construct manure storage structures greater than 500 cubic feet are required to meet Natural Resource Conservation Service Standard 313 Waste Storage Facility and 634 Waste Transfer Criteria. Permits are required for all new construction, substantial alteration of existing structures, and manure transfer systems. Permittees are required to develop and maintain annual nutrient management plans that meet NRCS 590 Nutrient Management Standard, including soil erosion management criteria utilizing RUSLE II. The Soil and Water Conservation Department requires a manure storage facility abandonment permit prior to closing an animal waste storage facility.

Manitowoc County Chapter 27 Agricultural Shoreland Management – Runoff of manure bearing water from barnyards, manure storage, or field application is prohibited from reaching the agricultural shoreline corridor.

Manitowoc County Chapter 28 Livestock Siting License – Chapter 28 adopts ATCP51 livestock siting criteria for livestock farms. Siting is administered by Manitowoc County Soil and Water Conservation Department using licensing. A license is required for any new livestock facility with 750 or more animal units. A license is also required for an expanded livestock facility if the number of animal units at the expanded livestock facility will exceed 750 and the number of animal units will exceed the maximum number of previously approved or, if no maximum number was previously approved, will exceed a number that is 20% higher than the number kept on January 1, 2007.

Municipal Regulations:

In addition to county-level ordinances, the town of Newton has its own zoning and comprehensive plan.

2.0 Pine Creek Watershed Setting

Pine Creek watershed is located in Northeast Wisconsin, in Manitowoc County, just south of the city of Manitowoc (Figures 1 and 2). The Pine Creek Watershed is a Hydrologic Unit Code (HUC) 12 (040301010702) nested within the Sevenmile and Silver Creeks Frontal Lake Michigan Watershed HUC 10 (0403010107) which is in the WDNR- Northeast Lakeshore Total Maximum Daily Load (TMDL) basin (Figure 3). Pine and Calvin Creeks and an unnamed intermittent stream, located in the watershed transports water from approximately 21 square miles, or 13,409 acres of land into Lake Michigan.

Pine Creek (Water Body Identification Code (WBIC) 66300)

Pine Creek is an eight-mile stream located in the mid and southern portion of the watershed. It starts at Carstens Lake and flows southeast, emptying into Lake Michigan, just south of County Highway U.

The stream's potential to support a balanced biologic community is affected by low flow. During spring runoff, Lake Michigan fish species use the mouth areas of Pine Creek for spawning. Phosphorus results confirm impairment due to exceedance of water quality standards.

Calvin Creek (WBIC 66900)

Calvin Creek is approximately six miles long and is located in the northern portion of the watershed. It starts at Hartlaub Lake and flows south then east, emptying into Lake Michigan, just east of the intersection of Clover Road and County Highway LS.

Calvin Creek supports a forage fishery. Migration of salmonid species from Lake Michigan is limited because of low flow and impassable culverts. Calvin Creek has extremely low flow during the summer and fall. Calvin Creek supports native gamefish during high water years and high water periods. Phosphorus results confirm impairment due to exceedance of the water quality standard.

Unnamed Intermittent Stream (WBIC 5024772)

There is a 1.2 mile intermittent stream located between Calvin and Pine Creeks that starts just north of County Highway C and west of Northeim Road that flows southeast to Lake Michigan.

Water quality assessment for these streams can be found in Chapter 4, Soil and Water Quality Assessment.

Lakes in Pine Creek Watershed

The Pine Creek Watershed has eight lakes including: Carstens, Gass, Glomski, Grosshuesch, Hartlaub, Kasbaum, Waack and Weyers (Figure 2). Detailed information about lake characteristics and quality can be found in Chapter 4, Soil and Water Quality Assessment.

Wisconsin Ecoregion

Ecoregions are a way to geographically identify areas with similar biotic and abiotic characteristics such as climate, soils, land use, geology, vegetation, wildlife, and hydrology. Mapping ecoregions is beneficial to holistically manage ecosystems and has been derived from the work of James M. Omerik of the USGS. The

Pine Creek watershed is located in the Southeastern Wisconsin Till Plains ecoregion and is within the Lake Michigan Lacustrine clay sub ecoregion (Figure 4). This region is characterized by:

> *Red calcareous clay soil, lacustrine and till deposits, and a flat plain. The topography of this ecoregion is much flatter than ecoregions to the south, and there are fewer lakes, but the lakes have generally higher trophic states, than in adjacent level IV ecoregions in (50) and (51). Soils are generally silty and loamy over calcareous loamy till, with muck and loamy lacustrine soils in low–lying areas. Ecoregion 53d has prime farmland with a longer growing season and more fertile soils than surrounding ecoregions. Agriculture has a different mosaic of crops, with more fruit and vegetable crops, than that of ecoregion 53c. The PNV of this region is beech/sugar maple/basswood/red and white oak forests with a greater concentration of beech than other ecoregions in 53" (Omernik, J.M., S.S. Chapman, R.A. Lillie, and R.T. Dumke. 2000. Ecoregions of Wisconsin. Transactions of the Wisconsin Academy of Sciences, Arts, and Letters88:77-103).*

PINE CREEK WATERSHED
PROJECT LOCATION

FIGURE 1: PINE CREEK WATERSHED PROJECT LOCATION

PINE CREEK WATERSHED

FIGURE 2: PINE CREEK WATERSHED SETTING

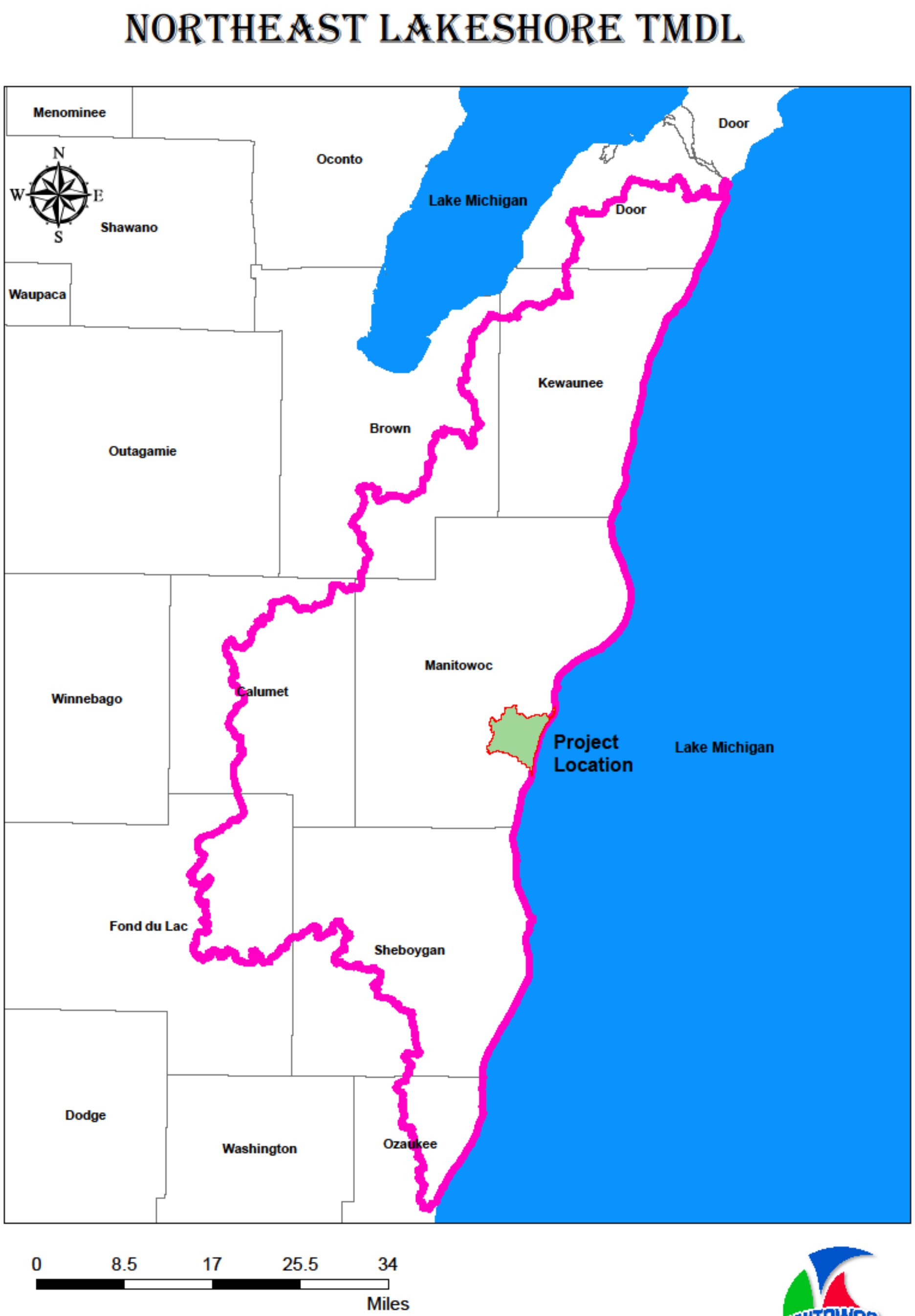


FIGURE 3: NORTHEAST LAKESHORE TMDL PROJECT AREA

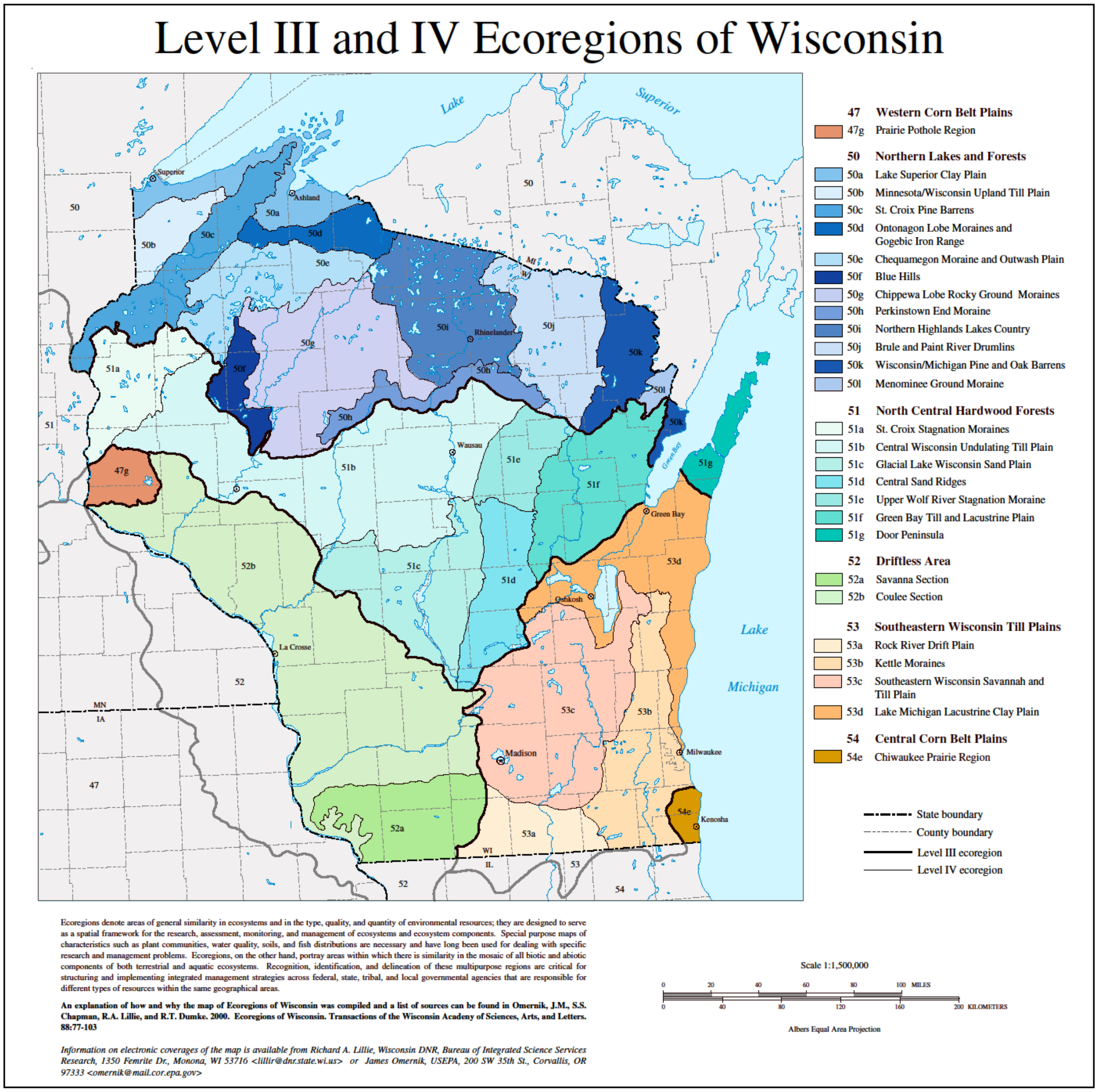


FIGURE 4: ECOREGIONS OF WISCONSIN

Topology and Geology

The Pine Creek Watershed lies in the Eastern Ridges and Lowlands geographical province of Wisconsin. The lowland is formed by limestone ridges and shallow lowlands in between. It is generally characterized by flat plains and gently rolling hills, making the area exceptional for agriculture. Glaciers have greatly impacted the geology of the area. The dolomite Niagara Escarpment is the major bedrock feature.

Surface elevations in the watershed range from 580 feet on the shore of Lake Michigan, to 830 feet on the western extent (figure 5).

FIGURE 5: DIGITAL ELEVATION MODEL OF PINE CREEK WATERSHED

Weather and Climate

The climate of Manitowoc County is continental, characterized by the marked changes in weather common to the latitude. A narrow belt adjacent to Lake Michigan has a modified continental climate. Lake Michigan's influence is strongest during spring, summer and fall. The lag in lake water temperature delays the coming of spring and extends mild temperatures into late fall. Residents of this narrow belt enjoy relatively cool summers compared to the hot summer temperatures further inland.

The current growing season of Manitowoc County varies from east to west reflecting the climatic influences of Lake Michigan. Along the lakeshore, the average growing season is approximately 160 days while it decreases to 140-160 days near the western border of the County. In the east, the last killing spring frost is likely to occur in late April and the first killing fall frost in mid-October. In the west, early May and early October are probable dates of the first and last killing frosts.

Current precipitation trends vary from 31 inches near Lake Michigan to 27 inches in the northwest part of the County. June is the rainiest month, with the five months from May through September averaging about 55 percent of the annual normal. Most of the winter precipitation falls as snow with February on the average being the driest. Precipitation is normally adequate for agricultural purposes, although some degree of soil moisture deficiency occurs in July and August. National Oceanic and Atmospheric Administration (NOAA).

Land Use

Land use assessment of the watershed was based off of an inventory completed by Bay-Lakes Regional Planning Commission (BLRPC) in 2007-2009. BLRPC staff used aerial photography and maps to delineate and note information on land uses.

Agriculture is the dominant land use in the watershed area at 63 %. Natural areas encompass the second greatest area at 22%. The majority of the coastline is residential, whereas the majority of the landscape inland is agricultural (Table 1; Figure 6; and Figure 7).

Land Use	Acres	Percent in Watershed
Residential	1,035	7.8
Commercial	56	0.4
Industrial	45	0.3
Transportation	728	5.4
Institutional/Government/Utilities	16	0.1
Outdoor Recreation	80	0.6
Agriculture	8,469	63.2
Natural Areas	2,977	22.2

Table 1: Land Use Percentage

The major roads that run through the Pine Creek watershed includes County Highway CR, LS and Interstate Highway 43, running north-south. County roads F, C, U, are also throughways, running East-West, in the watershed.

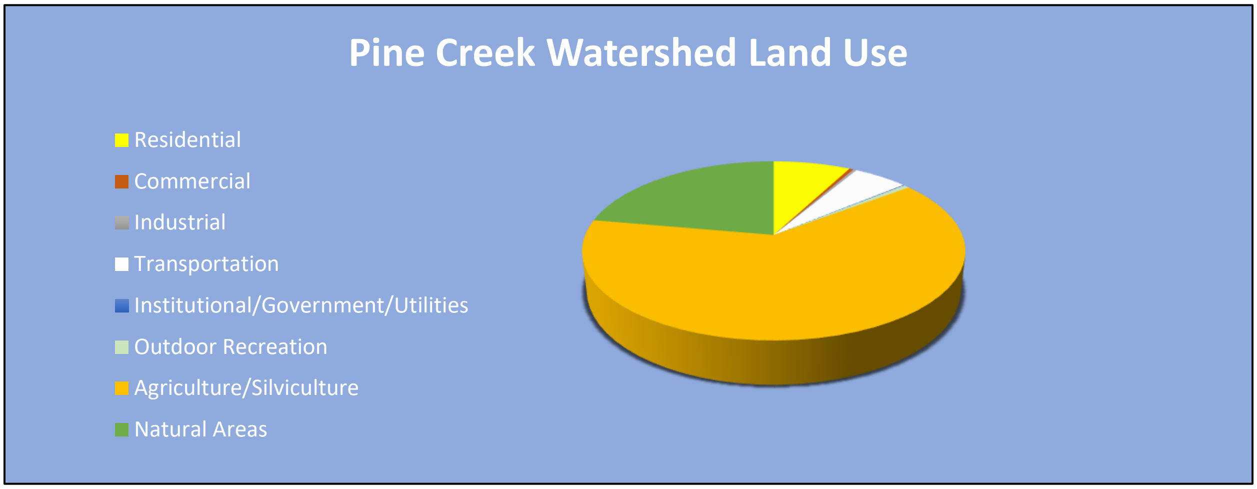


Figure 6: Pine Creek Watershed Land Use

LAND USE

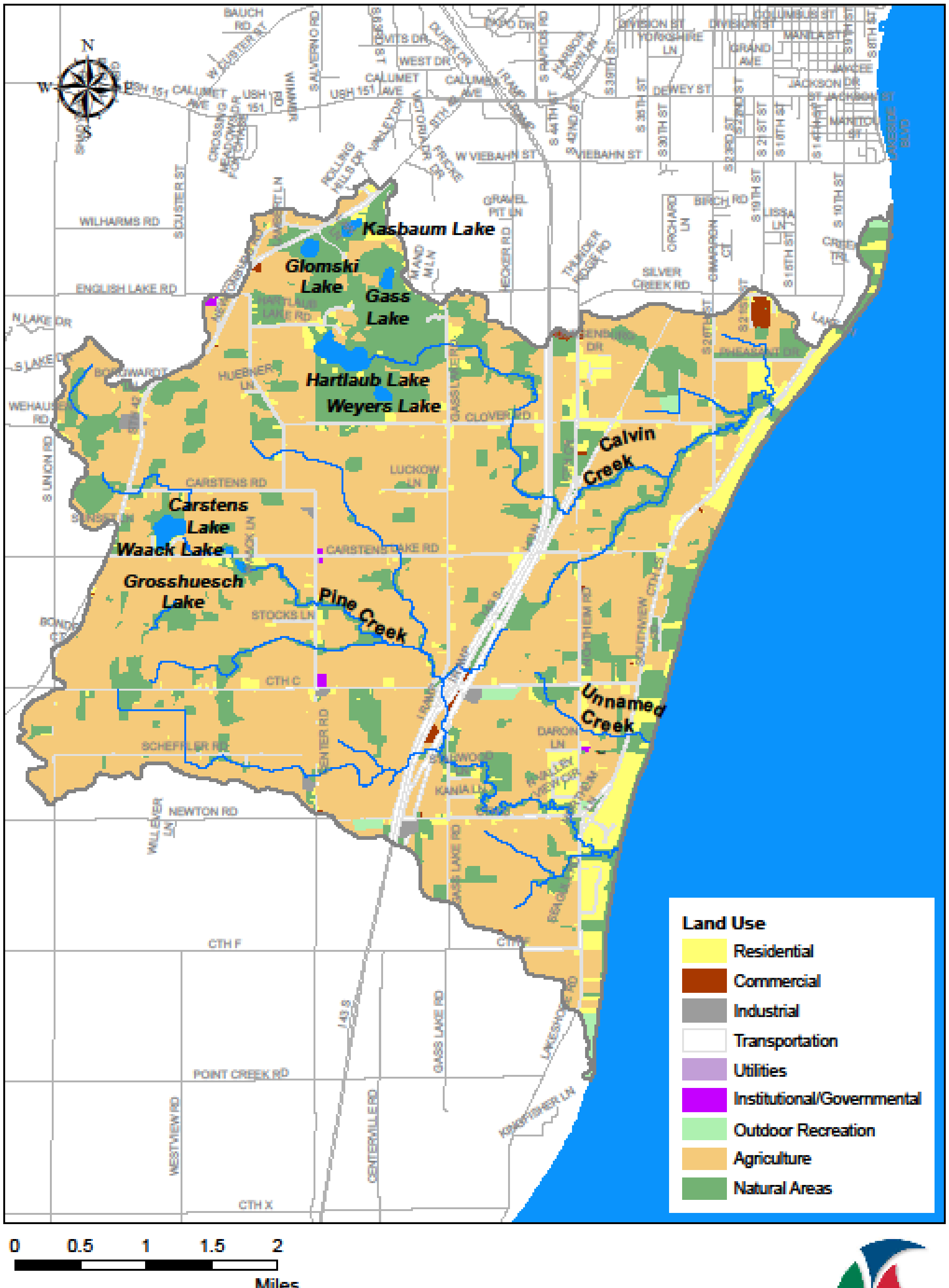


FIGURE 7: LAND USE MAP OF PINE CREEK WATERSHED

3.0 Past and Present Conservation Programming in the Watershed

Nonpoint Source Pollution Control Program for the Sevenmile- Silver Creek Watershed

The Sevenmile - Silver Creek Watershed was selected as a priority watershed in 1986 under the Nonpoint Source Water Pollution Abatement Program. The Sevenmile - Silver Creek (SMSC) Watershed was selected because of: 1) the severity of water quality problems in the watershed, 2) the importance of controlling nonpoint sources of pollution in order to attain water quality improvement or protection, and 3) the capability and willingness of the local government agencies to carry out the planning and implementation of the project. $1.3 million was allocated for the installation of Best Management Practices for this project. There was an exceptionally high level of participation from landowners.

The project, which began in 1986 and ended in 1996, was administered and implemented locally by Manitowoc and Sheboygan Counties. The SMSC Watershed extends approximately 6 miles inland from Lake Michigan between the Cities of Manitowoc and Sheboygan encompasses 112 square miles, with agriculture being the predominant land use.

Project Goal: The project goal was to reduce manure and sediment runoff from the cropland and farmsteads. The water quality objectives of the project were to protect the near-shore zone of Lake Michigan, protect and improve the inland lake fishery and aesthetics, and to protect and improve stream habitat and fishery. Landowners were encouraged to construct manure storages to reduce winter-spread manure, install barnyard runoff control systems, reduce cropland erosion, restore wetlands and establish stream-side buffers.

Project Success: Installation of conservation practices was successful. 171 cost-share agreements contributed to a 64 percent reduction of manure spread in winter, a 72 percent reduction of manure or phosphorus runoff from barnyards, and a 35 percent reduction of cropland erosion. A minimal amount of water quality monitoring was done during the project.

Concentrated Animal Feeding Operations (CAFO) Permits:

State and federal laws also require that Concentrated Animal Feeding Operations (CAFO) have water quality protection permits. An animal feeding operation is considered a CAFO if it has 1,000 animal units or more. A smaller animal feeding operation may be designated a CAFO by the DNR if it discharges pollutants to navigable waters or groundwater. Point source of pollution from a CAFO includes the production area and feedlots. Nonpoint sources of pollution include crop fields. There are four CAFO permitted operators that manage land in the

Pine Creek Watershed (figure 24), however their production areas are located outside the watershed boundary.

Farmland Preservation Program (FPP):

The Farmland Preservation Program is designed to promote farmland conservation practices by providing tax credits to farmers who maintain a robust conservation plan and meet zoning and state conservation performance standards. The Manitowoc County Soil & Water Conservation Dept. provides compliance checks on farms claiming tax credits for FPP every four years. Participants are also required to have and follow an annual nutrient management plan.

Landowners who are Wisconsin residents, produce at least $6,000.00 in gross annual farm revenue, and own tax parcels with Farmland Preservation Zoning (figure 8) are eligible for the tax credit.

There are a total of 60 landowners in the Pine Creek Watershed that are claiming the Farmland Preservation tax credit on approximately 6,900 acres of cropland (Table 2).

The Soil & Water Conservation Dept. conducted compliance determinations on all farms participating in the Farmland Preservation Program in

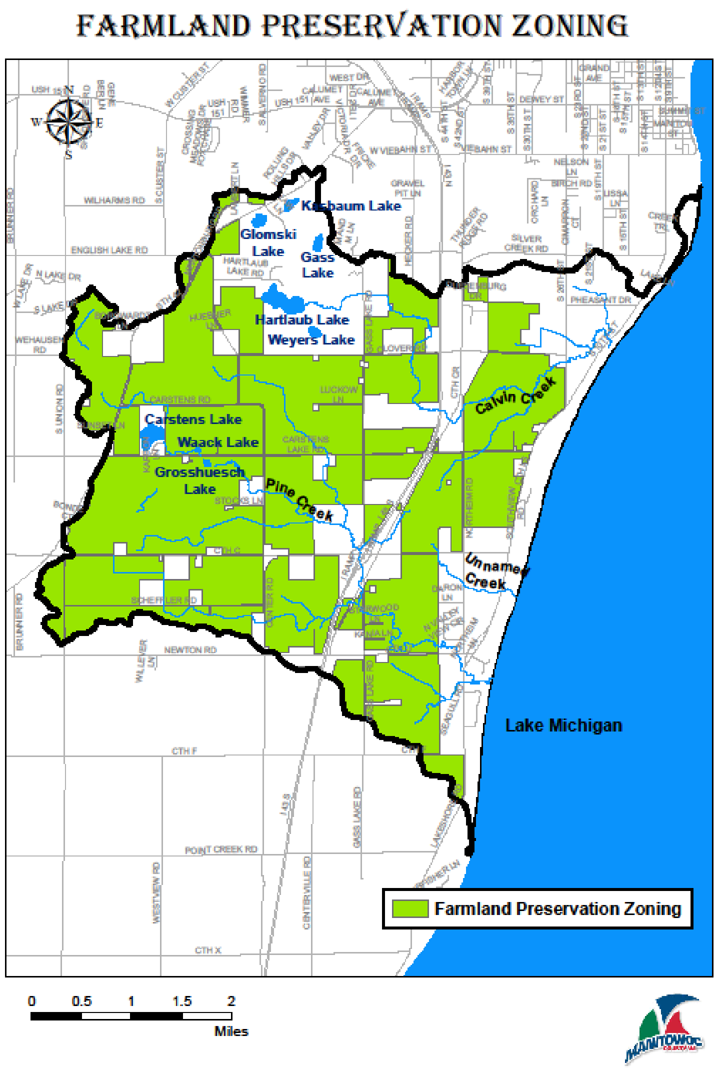


FIGURE 8: FARMLAND PRESERVATION ZONING

Manitowoc County. All Farmland Preservation landowners in the Pine Creek Watershed have been determined to be in compliance and have received certificates of compliance with Wisconsin Agricultural Performance Standards and NR 151.

Farmland Preservation Certificates within Pine Creek Watershed			
36-00013	36-00218	36-00472	36-00749
36-00031	36-00220	36-00517	36-00751
36-00047	36-00228	36-00536	36-00752
36-00057	36-00233	36-00549	36-00762
36-00082	36-00236	36-00555	36-00797
36-00083	36-00237	36-00617	36-00799
36-00084	36-00269	36-00656	36-00805
36-00126	36-00271	36-00678	36-00807
36-00131	36-00276	36-00679	36-00850
36-00160	36-00279	36-00694	36-00863
36-00205	36-00282	36-00705	36-00867
36-00207	36-00305	36-00706	36-00875
36-00208	36-00450	36-00710	36-00876
36-00209	36-00456	36-00723	36-00935
36-00210	36-00470	36-00733	36-00940

TABLE 2: PINE CREEK WATERSHED FARMLAND PRESERVATION PROGRAM PARTICIPANTS

NR 151 RUNOFF MANAGEMENT: Wisconsin Chapter NR 151 Runoff Management provides runoff management standards and prohibitions for agriculture. The Manitowoc County Soil & Water Conservation Dept. assists the State with enforcement of this rule. The Farmland Preservation Program has been utilized to provide a high rate of NR 151 compliance. Currently, 90 percent of the agricultural land in the watershed is in compliance with NR 151.

Facility Siting License (Manitowoc County Ordinance): Chapter 28 adopts ATCP51 livestock siting criteria for livestock farms. Siting is administered by Manitowoc County Soil and Water Conservation Department using licensing. A license is required for any new or expanding livestock facility with 750 or more animal units. There are five Facility Siting Licensed operations that manage land within the Pine Creek Watershed.

UW-Discovery Farms

Ongoing, UW-Wisconsin Extension

Discovery Farms performs research regarding quantity and quality of water leaving agricultural watersheds including: streams, edge-of-field, and subsurface tiles. Discovery Farms evidence-based research, conclusions, and results can and should be applied during the watershed assessment, evaluation, and goal setting for the Pine Creek Watershed Plan.

Discovery Farms did a research project on a site about a mile south of the Pine Creek Watershed boundary. The landscape characteristics on this farm is similar to the Pine Creek watershed, so research results are applicable to the Pine Creek Watershed and for development of this 9-Key Element Plan.

UW-Discovery Farms concluded the following:

- In this region of Wisconsin, the establishment and maintenance of grass waterways in areas of concentrated flow cannot be over emphasized. Runoff has the potential to carry significant levels of sediment and nutrients to surface waters. During this research project, a substantial amount of sediment was transported off of the field when the operator accidentally plowed through a grass waterway.
- Sediment losses occurred predominantly during non-frozen ground conditions. This is consistent with data collected on several other Discovery Farms research sites. There are times when soil loss can occur during frozen soil conditions, but those losses are greatly influenced by tillage practices and the number of concentrated flow channels present.
- Sediment losses from a few runoff events can contribute the majority of sediment losses for the year.
- When ground was frozen, phosphorus losses were low, at approximately 10% of the annual loss, and sediment loss was about 1% of the annual total.
- Phosphorus losses in the dissolved, reactive form represents a considerable portion of total phosphorus: 45% in 2005 and 22% in 2006. These losses are similar to what has been found on other Discovery Farms projects.
- Nitrogen losses in the form of nitrate were higher than expected in surface runoff, likely due to the influence of tile drainage in this watershed.
- In many portions of Wisconsin, tile drainage systems play an important role in the potential delivery of nutrients to surface water. Producers and agency personnel should work together to locate and better understand the impact of tile on the water budget. For additional information on locating, maintaining and repairing tile drainage systems, please review the series of tile drainage fact sheets on the UW-Discovery Farms website.

Discovery Farms research has identified critical time periods and conditions when the risk of soil loss and runoff is high. Snowmelt, rain on snow, concrete frost, and non-frozen soils that are close to saturation are all conditions that increase runoff risk.

Edge-of Field Loss: The timing and mechanisms of loss vary greatly not only between farms, but also between years and individual fields on a single farm. Discovery Farms data collected as of 2014 showed average edge-of-field losses of 590 pounds per acre of sediment, 2.0 pounds per acre of phosphorus and 7.5 pounds per acre of nitrogen.

4.0 Soil and Water Quality Assessment

Current soil and water resource quality in the Pine Creek watershed was assessed based off of recent studies and monitoring results; this chapter reviews those findings. To get more comprehensive and detailed assessment of the Pine Creek Watershed, a field and computer inventory was conducted. Results are summarized in Chapter 6, Watershed Inventory Results.

Soil Resources

For successful management of soil, it is important to understand soil type and characteristics within the area of interest. The Natural Resources Conservation Service Web Soil Survey was used to define erodibility and hydrologic soil groups. Understanding these factors allows government agencies and landowners to better manage land and to reduce erosion within the watershed.

Hydrologic Soil Group

Soils are classified into hydrologic soil groups (HSG) based on soil infiltration and transmission rate, or permeability. Hydrologic soil group along with land use, management practices, and hydrologic condition determine a soil's runoff curve number. Runoff curve numbers are used to estimate direct runoff from rainfall.

There are four hydrologic soil groups: A, B, C, and D. Descriptions of Runoff Potential, Infiltration Rate, and Transmission rate of each group are shown in Table 3. Some soils fall into a dual hydrologic soil group (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and water table depth when drained. The first letter applies to the drained condition and the second letter applies to the undrained condition.

HSG	Runoff Potential	Infiltration Rate	Transmission Rate
A	Low	High	High
B	Mod. Low	Moderate	Moderate
C	Mod. High	Low	Low
D	High	Very Low	Very Low

TABLE 3: HYDROLOGIC SOIL GROUP CHARACTERISTICS

The dominant hydrologic soil groups in the watershed are Group D (34%), Group C (27%) and Group C/D (11%). Group D soils have the highest runoff potential followed by group C. Soils with high runoff potentials account for approximately 72% of the soils in the watershed (Table 4 and Figure 9). Note: The USDA Web Soil Survey was used to generate these numbers.

Soil Hydrologic Group	Acres in Watershed	Percent of Watershed
D	4,564	34
C	3,573	27
C/D	1,488	11
B	1,412	10
A	937	7
A/D	614	5
B/D	518	4
Gravel/Sand Pit	264	2

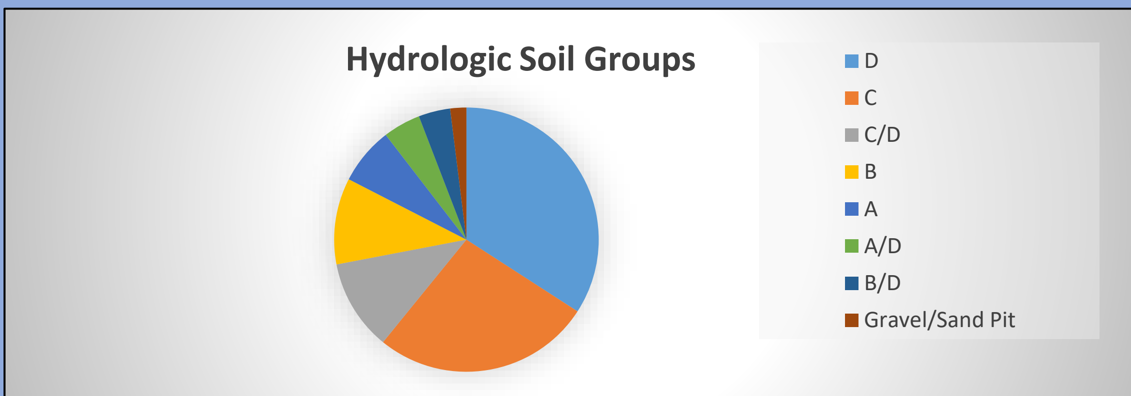


TABLE 4: SOIL HYDROLOGIC GROUPS IN PINE CREEK WATERSHED

HYDROLOGIC SOIL GROUPS

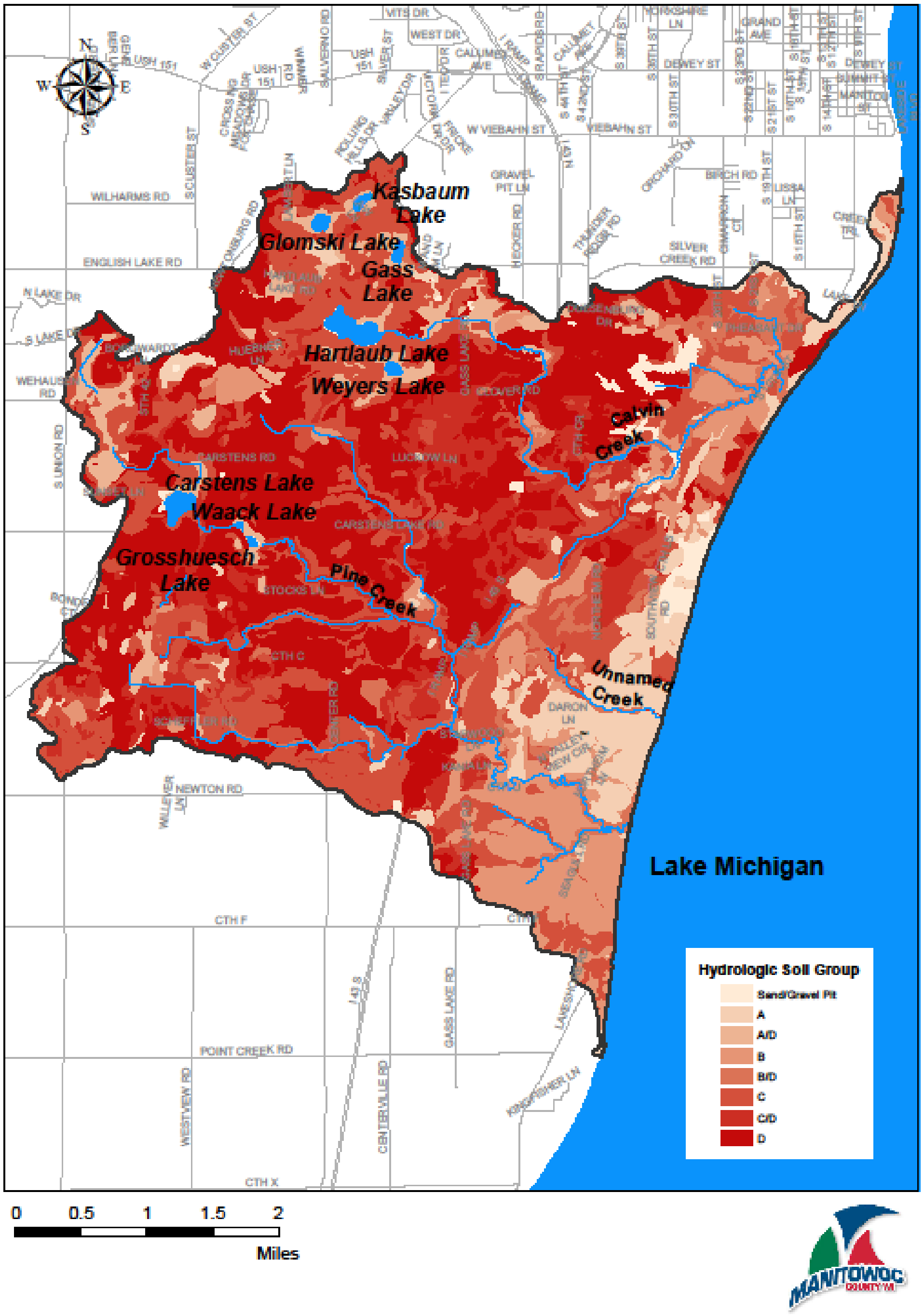


FIGURE 9: HYDROLOGIC SOIL GROUPS FOR PINE CREEK WATERSHED

Slope Ranges

The susceptibility of a soil to wind and water erosion depends on soil type and slope. Course textured soils such as sand are more susceptible to wind erosion, and fine textured soils such as clay are more susceptible to water erosion. Highly erodible and potentially highly erodible soils were mapped using LiDAR data. Soils with a 6-12 % slope were considered potentially highly erodible soils. Soils over 12% slope were considered highly erodible (Table 5 and Figure 10)

Slope	Percent in Watershed
<6%	77.5
6.1-12%	12.7
>12.1%	9.8

TABLE 5: SLOPE GRADES IN PINE CREEK WATERSHED

Based on soil slopes, soil erodibility is relatively low in the Pine Creek watershed. The landscape is generally flat with gentle rolling hills. However, the majority of soils are silts and clays, which have high runoff potential.

SLOPE RANGES

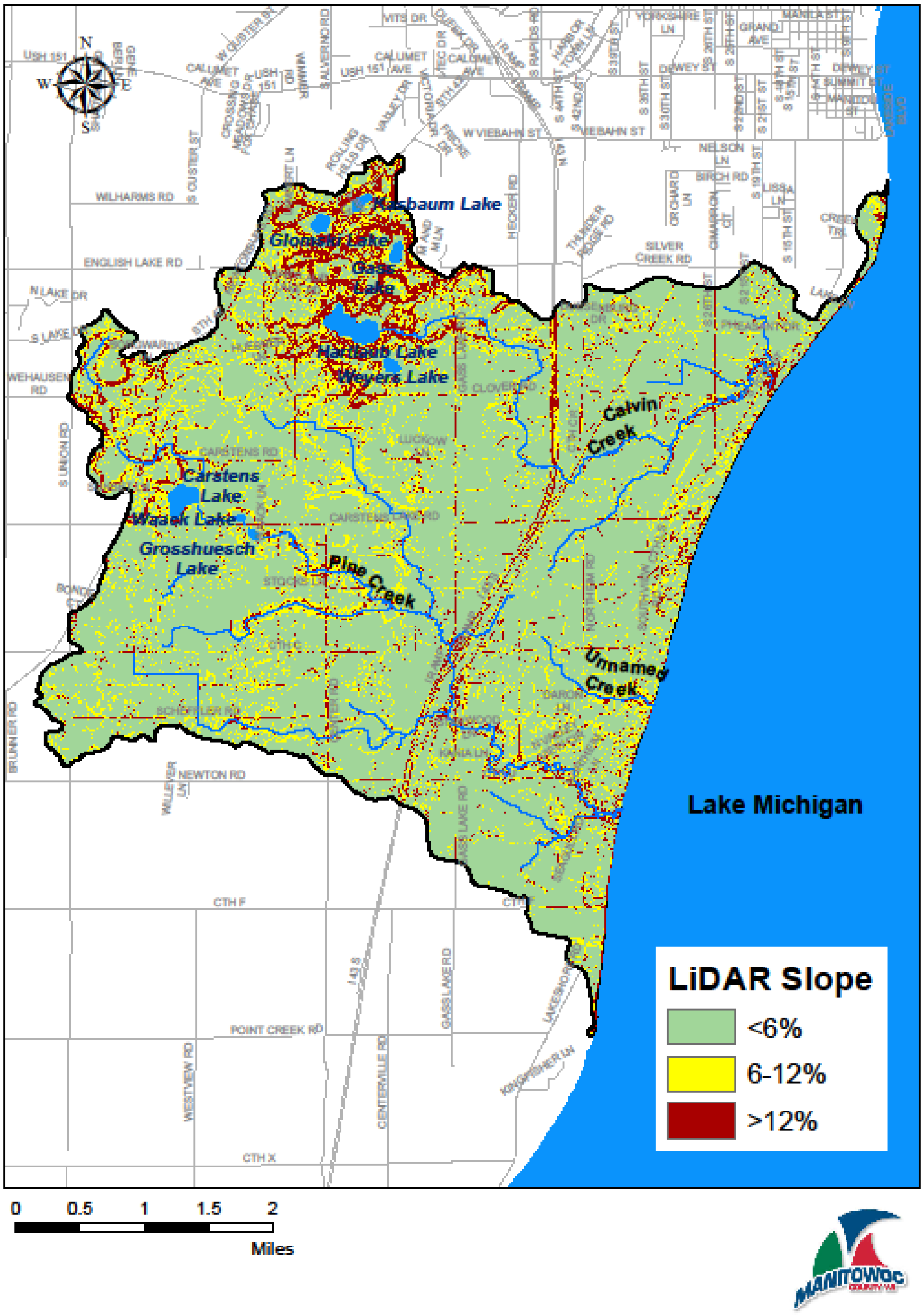


FIGURE 10: SLOPE RANGES FOR PINE CREEK WATERSHED

Water Resources

Impairments for the Pine Creek Watershed:

303D Listings Pollutant: Total Phosphorus
Pine Creek
Calvin Creek
Carstens Lake
Gass Lake
Hartlaub Lake
Weyers Lake

The federal Clean Water Act (CWA) requires states to adopt water quality criteria that the EPA published under 304 (a) of the Clean Water Act. A 303 (d) list is comprised of waters impaired or threatened by a pollutant such as sediment, phosphorus, PCBs, mercury, E.coli, or an unknown source. States submit a separate report on conditions of all waters.

As of 2019, two creeks and four lakes in the Pine Creek Watershed are listed as 303d Impaired for Total Phosphorus. They are: Pine and Calvin Creeks, and Carstens, Gass, Hartlaub, and Weyers Lakes.

Point Sources and Non Point Sources of Pollution

Point sources of pollution are discharges that come from a pipe or point of discharge that can be attributed to a specific source such as septic systems and drain tiles. In Wisconsin, the Wisconsin Pollutant Discharge Elimination System (WPDES) regulates and enforces water pollution control measures. The WI DNR Bureau of Water Quality issues the permits with oversight of the US EPA.

The majority of pollutants in the Pine Creek watershed come from nonpoint sources. Nonpoint source (NPS) pollution comes from many diffuse sources and is caused by rainfall or snowmelt moving over and through the ground, picking up natural and manmade pollutants, depositing them into rivers, lakes, wetlands and groundwater. Runoff from agricultural production sites and fields along with urban areas are examples of nonpoint source pollution. Other nonpoint sources in the watershed include erosion and runoff from streambanks, lawns, and impervious surfaces. Given that agriculture is the dominant land use in the Pine Creek watershed, these are common nonpoint sources of pollution.

Industrial Permits: There is one WPDES permit in the Pine Creek Watershed (No. 0042650). The facility is permitted, under the authority of Chapter 283, Wisconsin Statutes, to discharge to Pine Creek via a field drain tile system located in the Seven Mile/Silver Creek Watershed (MA01). The facility pulls groundwater to cool their equipment, and discharges it into Pine Creek. The facility is required to monitor temperature and flow. Accordingly, the discharge does not pose a significant concern for sediment and phosphorus loading because the water is only used as a cooling agent.

Municipal Permits: To meet the requirements of the federal Clean Water Act, the DNR developed a state Storm Water Permit Program under Wisconsin Administrative Coded NR 216. A Municipal Separate Storm Sewer System (MS4) permit is required for a municipality that is either located within a federally designated urbanized area, has a population of 10,000 or more, or the DNR designates the municipality for permit coverage. Municipal permits require storm water management to reduce polluted storm water runoff.

NR 216 also requires certain types of industries in the state to obtain storm water discharge permits from the DNR.

There are no municipal storm water permits or MS4's in the Pine Creek watershed.

Lakes Assessment

Various lake studies have been completed in the Pine Creek Watershed. These studies and results were reviewed to assess the current condition of the lakes in the watershed. This section will summarize the findings.

Citizen Lake Monitoring Network

1977-Present

The Citizen Lake Monitoring Network is a group of volunteers who monitor water clarity, chemistry, temperature, and dissolved oxygen data. They also identify and map plants or watch for the first appearance of invasive plants in the lake. The volunteers have been monitoring four lakes within the Pine Creek Watershed: Weyers, Hartlaub, Carstens, and Gass Lakes.

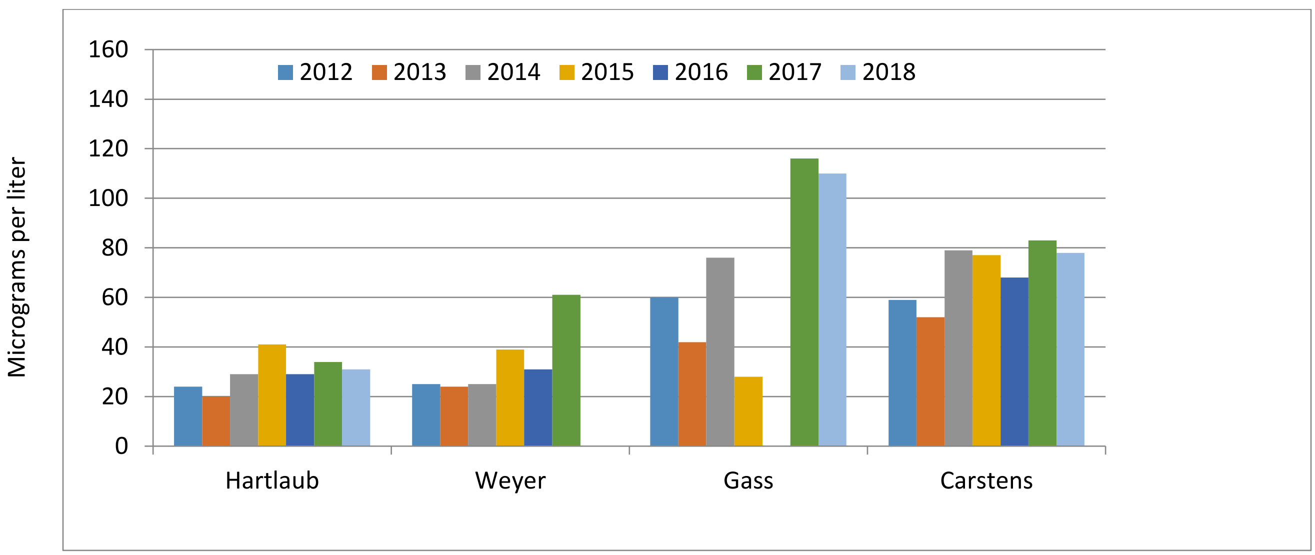


FIGURE 11: SUMMERTIME TOTAL PHOSPHORUS (UG/L)

Assessment of Lake Watershed Cropland

Manitowoc County Soil and Water Conservation Department, 2015

An assessment on watershed size and cropland acres was completed as part of the Manitowoc County 10-Year Land and Water Resource Management Plan. (Manitowoc County Soil & Water Conservation Department 2016) Results indicate that a high percentage of watershed land-use is cropland (Table 6).

Lake	Watershed Acres	Cropland/Pasture Acres in Watershed	Cropland/Pasture Portion of Watershed
Carstens	758	476	63%
Gass	583	209	36%
Hartlaub	645	322	50%
Weyers	139	30	22%
Kasbaum	35	8	23%
Glomski	199	69	35%
Waack	1,177	812	68%
Grossheusch	1,312	890	68%

TABLE 6: LAKE WATERSHEDS AND CROPLAND/PASTURE ACRES

Carstens Lake Comprehensive Management Plan

2017, Stantec Consulting Services, Inc.

Stantec Consulting revised the Manitowoc County Lakes Association Management Plan completed in 2000. The plan includes the following components: current water quality of the lake, watershed assessment, tributary water quality, habitat and plants, aquatic invasive species, fisheries, shorelines, education and outreach, management objectives, climate change implications, and potential funding sources. (Stantec Consulting Services, Inc., 2017)

Lake Management Planning Grant Report: Hartlaub Lake 2000

WDNR Project number LPL-411

The report looked at land use around Hartlaub Lake and its impact on water quality; describing specific best management practices to reduce phosphorus entering the lake.

Descriptions of Lakes within the Watershed

Carstens Lake (WBIC 66800)

Carstens Lake, near the headwaters of Pine Creek and just east of highway 42, and north of Carstens Lake Road, is a hard water seepage lake in a ground moraine, with a surface area of 20 acres, a maximum depth of 30 feet, and a mean depth of 12 feet. The total shoreline length is 0.77 miles, with 0.3 miles in public ownership. Six acres of wetlands adjoin the lake. This lake was assessed in 2017 and found to be exceeding the phosphorus standard, and is listed on the 303d of impaired waters. The mean phosphorus value in the assessment was 67 ug/l, and the threshold for this type of lake (hard water Seepage Lake) is 20 ug/l.

There is a fish barrier located approximately 1.5 miles downstream to reduce the number of rough fish entering the lake.

Hartlaub Lake (WBIC 67200)

Hartlaub Lake, a seepage lake forming the headwaters of Calvin Creek, has an area of 38.4 acres, a maximum depth of approximately 60 feet, and a mean depth of 20 feet. The total shoreline length is 1.2 miles, of which 0.01 miles are publicly owned. There are six acres of adjoining woody wetlands. Northern pike are present, while largemouth bass and pan fish are common. Monitoring data show high phosphorus concentrations, which add to its eutrophic or nutrient-rich condition. Hartlaub Lake is currently on the impaired waters list for phosphorus.

The Hartlaub Lake Association, along with the Manitowoc County Soil and Water Conservation Department and WDNR staff have documented water quality problems associated with runoff from agricultural practices and their impacts on the lake. When controllable phosphorus sources are addressed, the option of a lake rehabilitation plan may be feasible. The Hartlaub Lake Association would like to apply for a Lake Planning Grant to fund the rehabilitation plan process. Hartlaub Lake was assessed during the 2016 listing cycle; total phosphorus sample data exceed 2016 WisCALM listing thresholds for the Recreation use, however, chlorophyll data do not exceed REC thresholds. Total phosphorus and chlorophyll data did not exceed Fish and Aquatic Life thresholds at that time. There is a fish barrier located on the outlet of the lake.

Gass Lake (WBIC 67100)

Gass Lake is a small, six acre seepage lake and is a hard water landlocked lake in terminal moraine about three miles southwest of Manitowoc with a depth of 24 feet. The lake is fed by seepage and drainage. The bottom is mostly mucky with some gravelly areas. It is managed for largemouth bass, pan fish, and northern pike. Approximately 80% of the ten acres of adjacent wetland is wooded. Ducks make limited use of the lake, but there is a significant muskrat population. Hunting is permitted. Public access is possible. There is one boat dock on the lake. Gass Lake was assessed during the 2016 listing cycle; total phosphorus and chlorophyll sample data exceeded 2016 WisCALM thresholds for Recreation use, but did not exceed Fish and Aquatic Life thresholds. Gass Lake is currently on the impaired waters list for phosphorus.

Glomski Lake (WBIC 45400)
This is a small, eight acre hard water landlocked lake in terminal moraine about three miles southwest of Manitowoc. The lake is seepage fed and has clear water. Littoral material consists of muck. Historically, the lake has been managed for largemouth bass and pan fish. Ducks make limited use of the area and hunting is permitted. There is no public access or frontage to Glomski Lake. This lake is managed for fishing and swimming and is currently not considered impaired.

Kasbaum Lake (WBIC 45800)
Kasbaum Lake outlets into Glomski Lake, and is managed for fishing and swimming. It is currently not considered impaired.

This is a small, six acre hard water landlocked lake in terminal moraine about three miles southwest of Manitowoc. The lake is fed by seepage and has clear alkaline water. Littoral material is muck. Historically it has been managed for largemouth bass and pan fish. Kasbaum Lake was assessed during the 2016 listing cycle; chlorophyll sample data were clearly below 2016 WisCALM listing thresholds for Recreation use and Fish and Aquatic Life use. Total phosphorus sample data were clearly below FAL use listing thresholds and did not exceed REC listing thresholds. This water is meeting designated uses and is not considered impaired.

Weyers Lake (WBIC 49400)
Weyers Lake is a small, six acre seepage lake located north of Clover Road and west of Gass Lake Road; having a maximum depth of 32 feet. A public boat ramp provides public access. Fish include pan fish and largemouth bass. Weyers Lake is currently on the impaired waters list for phosphorus.

Waack Lake (WBIC 66700)
Waack Lake is located north of Carstens Lake Road and east of Highway 42. It was not included in the TWA WQM 2017 report but, information on the lake can be found on the DNR website. The lake's hydrologic type is considered seepage. It is one acre in size, with a maximum depth of 18 feet. Pan fish, Largemouth Bass and Northern Pike can be found in this lake.

Grosshuesch Lake (WBIC 66600)
Grosshuesch Lake is located near the outlet of Waack Lake. It was not included in the TWA WQM 2017 report, but information on the lake can be found on the DNR website. Grosshuesch Lake is a three acre lake located in Manitowoc County. It has a maximum depth of 33 feet. Fish include Pan fish, Largemouth Bass and Northern Pike.

Invasive Species
WDNR has identified various invasive species in the Pine Creek Watershed including, but not limited to: curly-leaf pondweed, Hybrid Eurasian/Northern Water Milfoil, VHS, and zebra mussels (Table 7).

Waterbody Name	Waterbody ID Code (WBIC)	Invasive Species
Calvin Creek	66900	Curly-Leaf Pondweed, Hybrid Eurasian / Northern Water-Milfoil
Carstens Lake	66800	Curly-Leaf Pondweed, Eurasian Water-Milfoil, Hybrid Eurasian / Northern Water-Milfoil
Gass Lake	67100	Curly-Leaf Pondweed
Hartlaub Lake	67200	Curly-Leaf Pondweed, Eurasian Water-Milfoil, Hybrid Eurasian / Northern Water-Milfoil
Lake Michigan	20	Eurasian Water-Milfoil, Viral Hemorrhagic Septicemia, Zebra Mussel

TABLE 7: WDNR, AQUATIC INVASIVE SPECIES

Prevention from transporting invasive species is key to protecting the Pine Creek watershed from the spread of invasive species. Boaters should follow regulations to reduce the risk of spreading invasive species. Boaters can do the following to prevent the spread of aquatic invasive species:

- Inspect and remove aquatic plants, animals, and mud from the boat and equipment before leaving the boat launch.
- Drain water from the boat and equipment before leaving the boat launch.
- Throw away unwanted bait.
- Remove all plant materials from boats and trailers.
- Spray or rinse boat and equipment with high pressure or hot tap water.

Control Methods as described by Manitowoc County Lakes Association:
Curly Leaf Pondweed: Mechanical harvesting in early spring and chemical application by licensed individuals. Diquat, endothall, and floridone can be effective.

Eurasian Water-Milfoil: Mechanical harvesting, raising or lowering water levels to drown or dehydrate plants, and chemical application by licensed individuals.

Zebra Mussel: Once zebra mussels are established in a water body, very little can be done to control them.

Streams Assessment

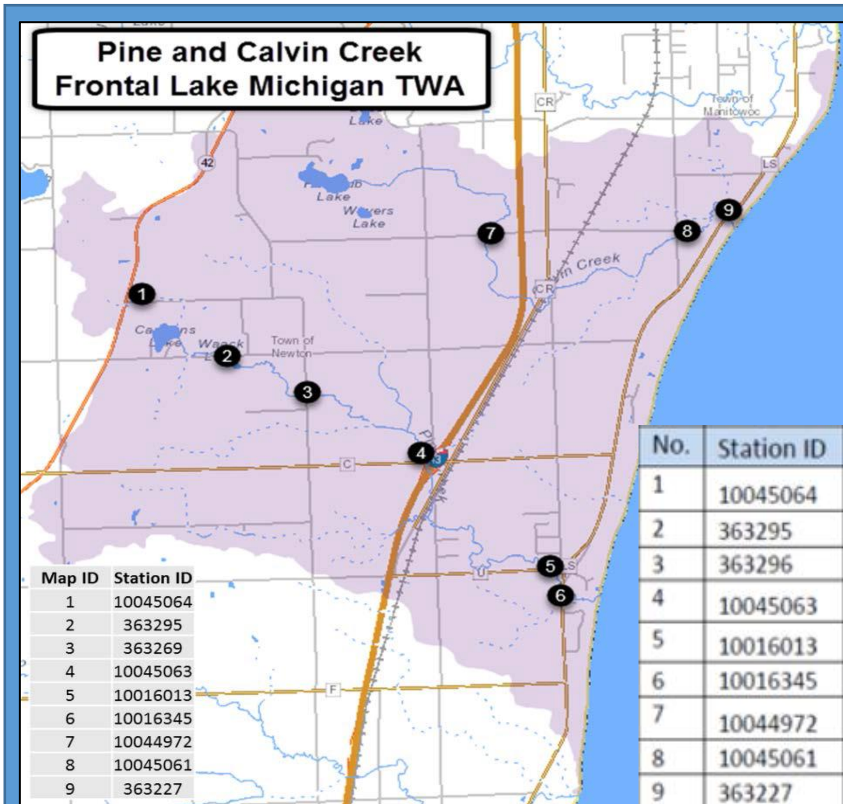
Numerous streams studies have been completed in the Pine Creek Watershed. These studies and results were reviewed to assess the current condition of the streams in the watershed.

Pine and Calvin Creek Frontal Lake Michigan TWA WQM 2017

July 1, 2017, Mary Gansberg, Water Resources Biologist & Investigator, Eastern District, Wisconsin DNR; Victoria Ziegler, Program Support, Water Quality Bureau, Wisconsin DNR; Lisa Helmuth, Program Coordinator, Water Quality Bureau, Wisconsin DNR
https://dnr.wi.gov/water/TwaPlanDetail.aspx?key=126593405

The study of the Pine Creek and Calvin Creek sub watersheds was initiated as a planning project to assess the overall chemical, physical and biological condition of waters that discharge directly to Lake Michigan. While the report focused on the monitoring results for this smaller sub watershed, the document covered assessment data for the larger Sevenmile and Silver Creek Watershed.

Three sites in Pine Creek and two sites in Calvin Creek were assessed for fish, physical habitat and macroinvertebrates. In addition to fish, physical habitat, and macroinvertebrates, data was collected on sites 6 and 9 for diatom samples, six monthly water chemistry samples, and long-term temperature. (Figure 12).



No.	Station ID	Station Name
1	10045064	Pine Creek 120 Meters DS Carstens Road
2	363295	Pine Creek at Carstens Lake Rd
3	363296	Pine Creek at Center Road
4	10045063	Pine Creek 25 Meters US Gass Lake Road
5	10016013	Pine Creek Above Cth U
6	10016345	Pine Creek Above And Under Ls Bridge
7	10044972	Calvin Creek 15 meters US Clover Road
8	10045061	Calvin Creek 200 meters DS South 26th Street
9	363227	Calvin Creek at Cth Ls (Bi Sur)

FIGURE 12: MAP OF MONITORING STATIONS IN PINE AND CALVIN CREEK FRONTAL LAKE MICHIGAN TWA

Fish Index:

An Index of Biological Integrity (IBI) is a scientific tool used to identify and classify water pollution problems. An IBI associates anthropogenic influences on a water body with biological activity in the water and is formulated using data developed from biosurveys. In Wisconsin, Fish IBIs are created for each type of natural community in the state’s stream system.

Station ID	Station Name	M-Natural Community	Natural Community	FIBI USED	fIBI Value Condition	Habitat Values	Notes
10045061	Calvin Creek 200 meters DS South 26th Street	WARM HEADWATER	Cool Warm Headwater	INTERMITTENT IBI	(40) Fair	Quantitative Good	fish assessment and quantitative habitat surveys Sampled Riffle
10044972	Calvin Creek 15 meters US Clover Road	WARM HEADWATER	Cool Warm Headwater	INTERMITTENT IBI	(60) Good	Qualitative Excellent	fish assessment and qualitative habitat surveys Sampled Riffle
10045063	Pine Creek 25 Meters US Gass Lake Road	WARM HEADWATER	Cool Warm Headwater	INTERMITTENT IBI	(40) Fair	Qualitative Good	fish assessment and qualitative habitat surveys Sampled Riffle
10016013	Pine Creek Above Cth U	WARM HEADWATER	Cool Cold Headwater	INTERMITTENT IBI	(70) Good	Quantitative Fair	fish assessment and quantitative habitat surveys Sampled Riffle.

TABLE 8: LIST OF FISH AND HABITAT DATA

Macroinvertebrate IBI: In Wisconsin, the mIBI, or macroinvertebrate Index of biological integrity, was developed specifically to assess Wisconsin's macroinvertebrate community (see also Fish IBI).

The macroinvertebrate IBI study concluded that the combination of watershed land cover and local riparian and instream conditions strongly influence one another (Weigel, 2003). Results indicated that mIBI values were fair for all sites sampled with the exception of Calvin Creek downstream of South 26th Street with a Poor value.

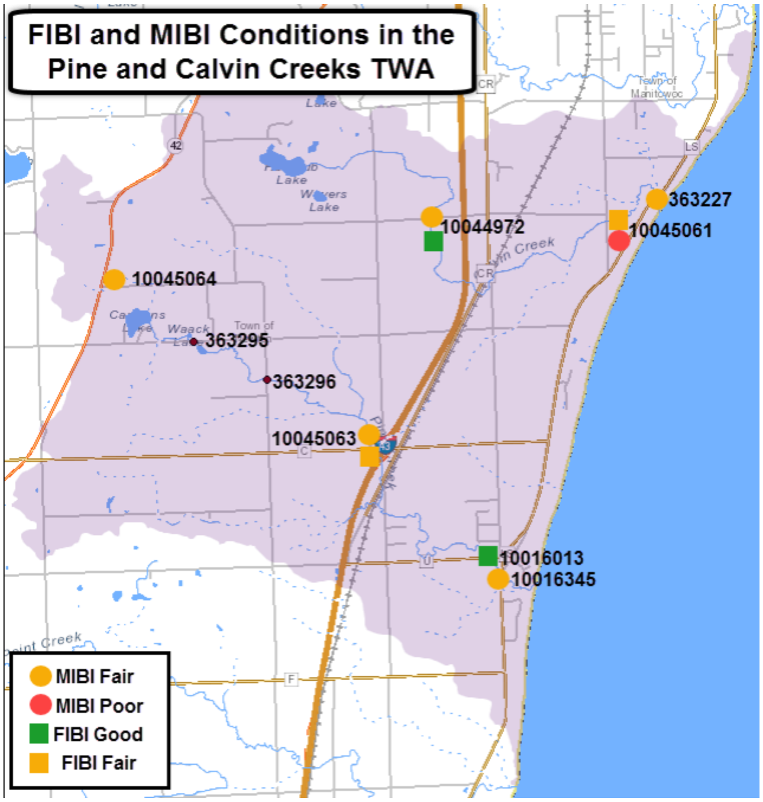


FIGURE 13: FISH IBI AND MIBI CONDITION IN THE PINE AND CALVIN CREEKS TWA

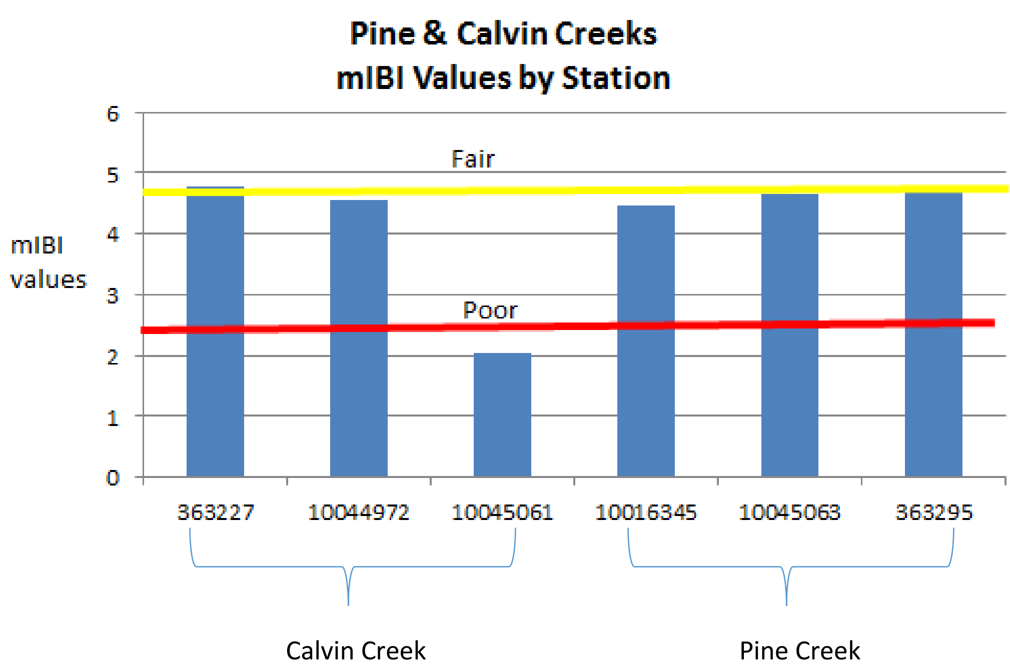


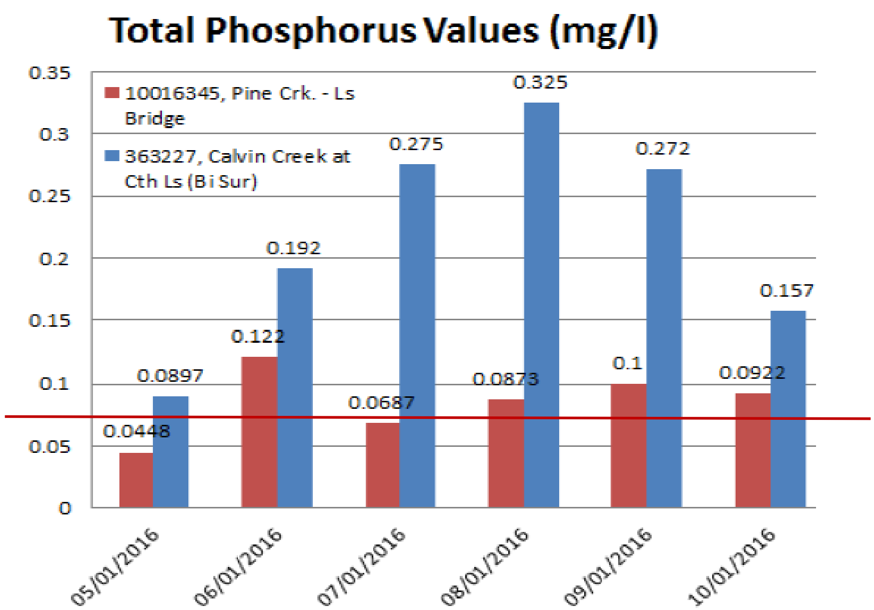
FIGURE 14: PINE & CALVIN CREEKS MIBI VALUES BY STATION

Chemistry Results

For phosphorus, the department's listing methodology for impaired waters (WDNR, 2017) lists waters where the median concentration exceeds 0.075 mg/l on wadable streams and 0.1 mg/l on rivers. The impairment listing protocol uses a 95% confidence interval about the median for listing streams and rivers.

The samples from Calvin Creek exceeded the phosphorus standard showing a mean value of .232 mg/l (includes data from 2007 to 2016), far exceeding the listing standard of .075 mg/L, while fewer results exceed the standard on Pine Creek which is already listed as impaired for phosphorus. Pine Creek is listed from mile 2 to 6 for phosphorus (Category 5P) with the pollutant "unknown"; biological data from the study for both creeks supports impairments for excess nutrients and the recent values for phosphorus support the listing (Figure 15).

WQ Standard = 0.075 mg/l



Note: WDNR 2016 Phosphorous Monitoring – Pine Creek Average = .218, Calvin Creek Average = .086

FIGURE 15: TOTAL PHOSPHORUS FOR PINE AND CALVIN CREEKS – WDNR 2016 SAMPLES

Total Suspended Solids: Total suspended solids are particles that are larger than 2 microns found in the water column. Particles include sediment, silt, clay, algae, and plankton. TSS reduces water clarity and quality.

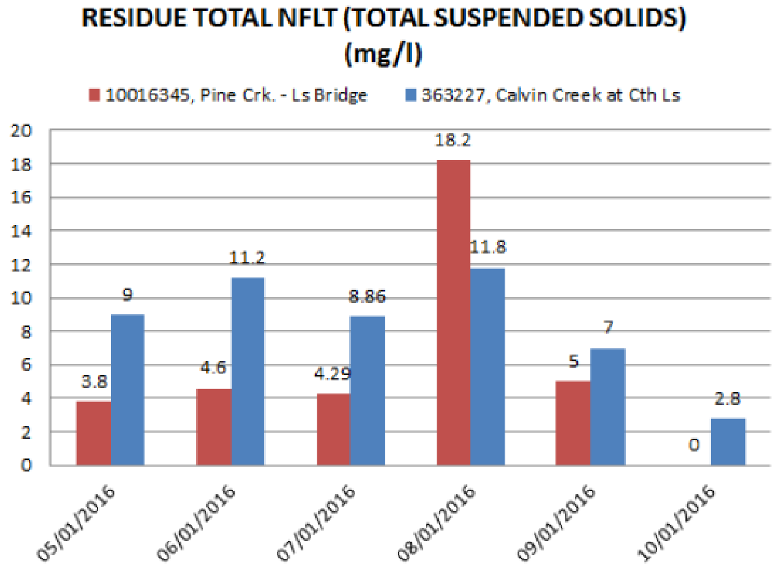


FIGURE 16: TOTAL SUSPENDED SOLIDS

Management Actions

Management Priorities

• A priority issue for this watershed is to work with landowners to decrease the amount of agricultural runoff reaching surface and groundwater.

Management Goals

Water quality goals for the Pine and Calvin Creek subwatershed are:

• Minimize agricultural runoff from rural areas.
• Restore key wetlands and forest lands for water quality improvements and protections.
• Establish riparian buffers to protect water quality.
• Monitor and control non-native invasive species.
• Minimize fish passage barriers.
• Increase citizens' watershed awareness, understanding, and stewardship.
• Restore the water quality of Pine Creek and Calvin Creek through listing for total phosphorus, best management practices, and watershed management activities.

Monitoring and Assessment Recommendations

• Calvin Creek should be added to the state's 303d List of impaired waters due to the total phosphorus concentrations exceeding the WisCALM guidance.

• Assess the condition of all the lakes within the Pine and Calvin Creeks Subwatershed since this study only focused on streams.

• Natural Community validation or recommended changes or updates based on analysis of fish species found in recent surveys: ○ Station 10045061, Calvin Creek 200 meters DS South 26th Street was modeled as a WARM HEADWATER but is recommended as a Cool Warm Headwater based on the 2017 Natural Community temperature evaluation analysis tool.

• Station 10044972, Calvin Creek 15 meters US Clover Road was modeled as WARM HEADWATER but is recommended as a Cool Warm Headwater based on the 2017 Natural Community temperature evaluation analysis tool.

• Station 10045063, Pine Creek 25 Meters US Gass Lake Road was modeled as a WARM HEADWATER but is recommended as a Cool Warm Headwater based on the 2017 Natural Community temperature evaluation analysis tool.

• Station 10016013, Pine Creek above Cth U was modeled as a WARM HEADWATER but is recommended as a Cool Cold Headwater based on the 2017 Natural Community temperature evaluation analysis tool.

Management Recommendations for DNR

• Pine Creek is currently listed for phosphorus. This study provides additional biological data showing impacts from the phosphorus listing.

• Calvin Creek should be listed as impaired for phosphorus as it is found to be clearly exceeding listing values for the 2018 WisCALM guidance.

Management Recommendations for External Partners

• DNR should work with partners to reduce phosphorus runoff and engage local units of government and watershed residents in stream restoration.

• DNR encourages local governments and nonprofit organizations to apply for runoff management grants to reduce phosphorus delivery in the larger watershed (MA01).

Lakeshore Water Institute

UW-Green Bay, Manitowoc Campus and Lakeshore Natural Resources Partnership

Student interns from UW-Green Bay collected and analyzed phosphate levels on four locations on Calvin and Pine Creeks. Year-to-year comparisons are made in an effort to determine the trends in water quality.

Lakeshore Water Institute monitoring locations are on Calvin Creek at the intersection of South 26th street and Northeim Road and on Pine Creek at Hwy U and South Gass Lake Road.

The screen shot below, from the Lakeshore Water Institute, shows monitoring locations and phosphate results from 2014-2018. (University of Wisconsin Green Bay-Manitwoc Campus Lakeshore Water Institute)

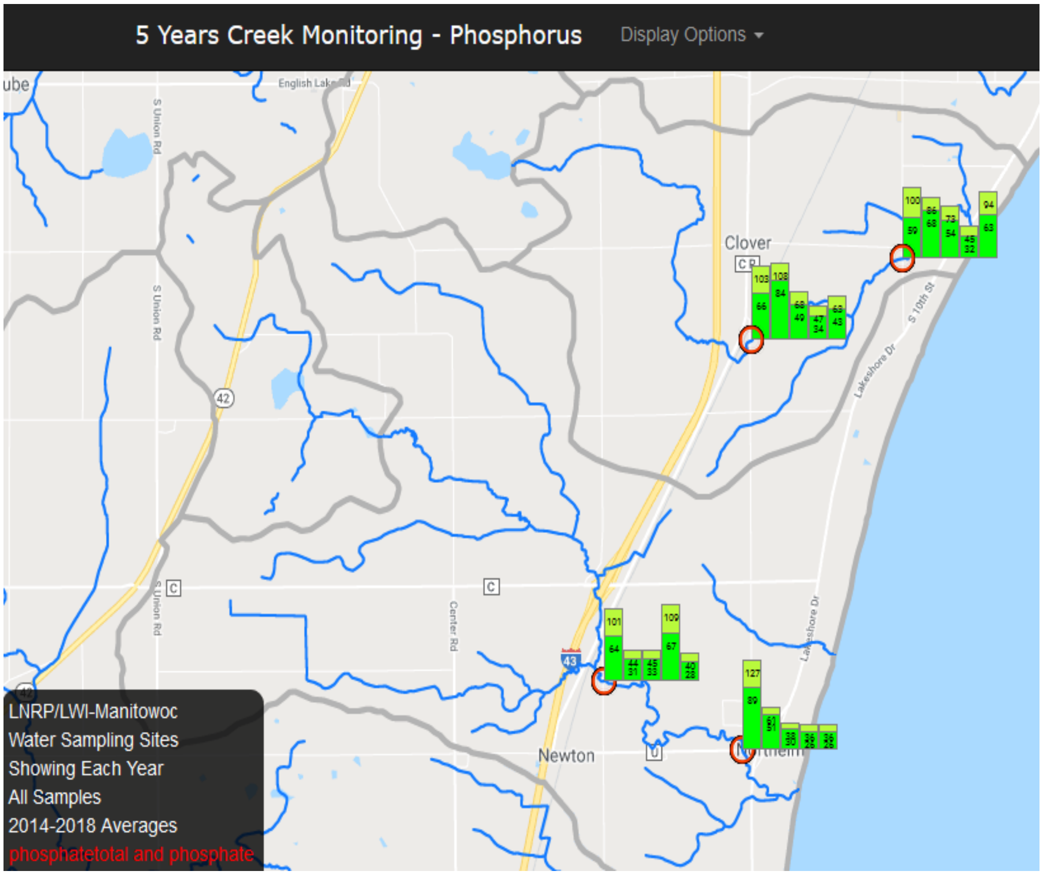


FIGURE 17: 5 YEARS CREEK MONITORING – LAKESHORE WATER INSTITUTE

Phosphate results reported by the Lakeshore Water Institute were converted to phosphorus in order to compare the results to WDNR phosphorus monitoring values for the Pine Creek 9-Key Element Plan. The Lakeshore Water Institute collected samples during the summer months every Monday morning, and after rain events of more than 0.5 inch. The red line, on the bar graphs below, indicates the impaired water quality standard of .075 mg/l.

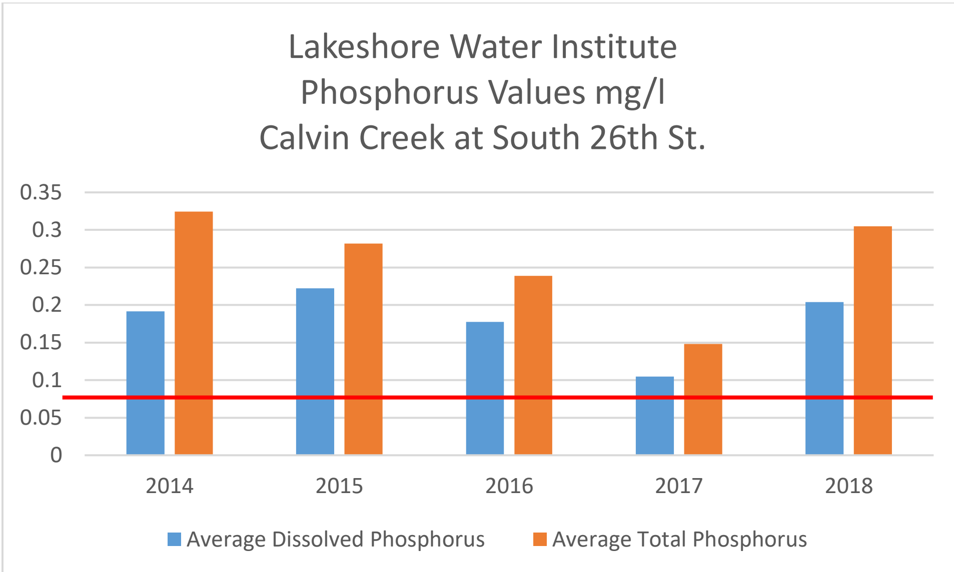


FIGURE 18: LWI PHOSPHORUS VALUES MG/L CALVIN CREEK AT SOUTH 26TH ST.

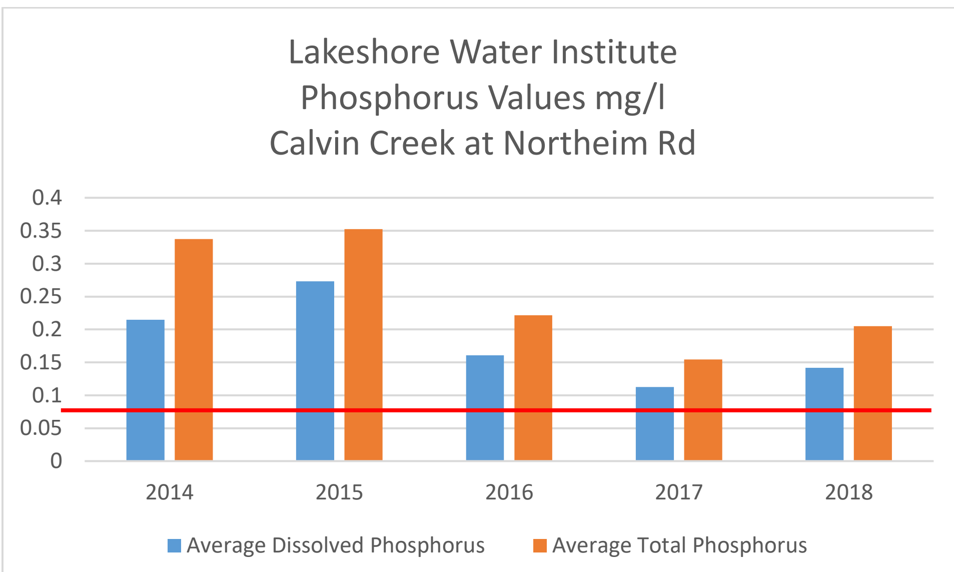


FIGURE 19: LWI VALUES MG/L CALVIN CREEK AT NORTHEIM RD

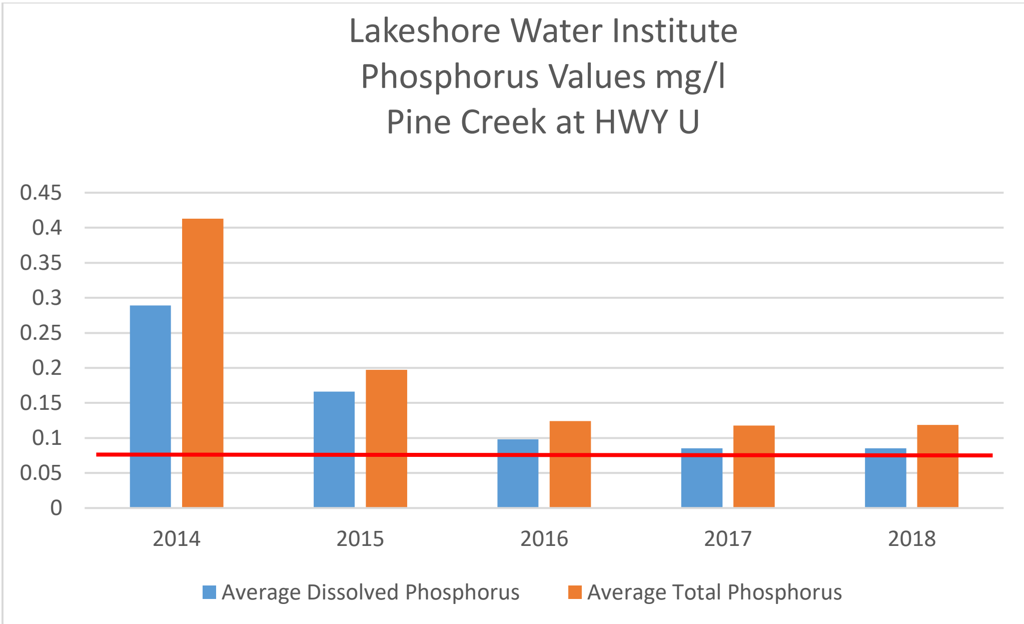


FIGURE 20: LWI PHOSPHORUS VALUES MG/L PINE CREEK AT HWY U

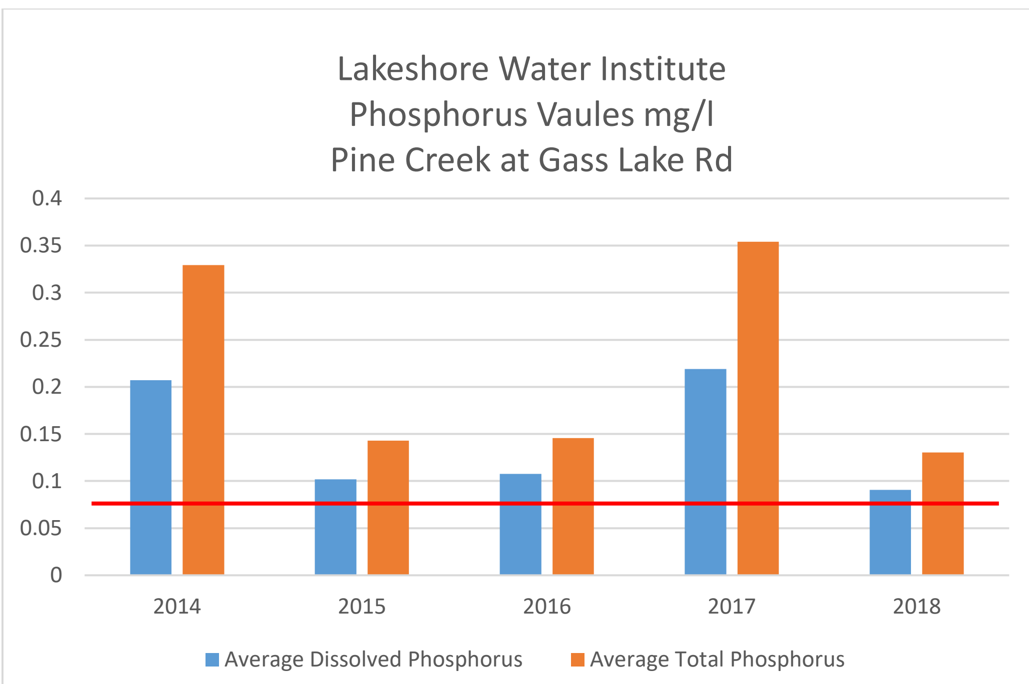


FIGURE 21: LWI PHOSPHORUS VALUES MG/L PINE CREEK AT GASS LAKE RD

5.0 Pollutants that Impact Surface Water in the Pine Creek Watershed:

Pollutants that impact surface water in the Pine Creek Watershed include: Phosphorus, sediment from soil erosion, animal manure, nutrients from commercial fertilizer, milking center waste, runoff from barnyards, feed storages, septic systems, streambanks, and tile line discharge.

Phosphorus

Phosphorus has long been recognized as the controlling factor in plant and algae growth in Wisconsin lakes and streams. Small increases in phosphorus can fuel substantial increases in aquatic plant and algae growth, which in turn can reduce recreational use, property values, and public health.

Phosphorus also comes from "nonpoint" or "runoff" pollution. Such pollution occurs when heavy rains and melting snow wash over farm fields and feedlots and carry fertilizer, manure and soil into lakes and streams, or carry phosphorus-containing contaminants from urban streets and parking lots.

Particulate phosphorus is attached to sediment and are delivered to waterbodies from eroding sites. Dissolved phosphorus from agricultural land is found in drain tile water, barnyard runoff and manure spreading runoff.

Sediment

Sediment entering water bodies degrades the quality of water and effects the land surrounding the streams in the following ways:

- Increases potential for flooding.
- Water becomes cloudy, preventing animals from seeing food.
- Murky water prevents natural vegetation from growing in water.
- Sediment in stream beds disrupts the natural food chain by destroying the habitat where the smallest stream organisms live causing declines in fish populations.
- Increases the cost of treating drinking water and can result in odor and taste problems
- Sediment can clog fish gills, reducing resistance to disease, reducing growth rates, and also affects fish egg and larvae development.
- Nutrients transported by sediment can activate blue-green algae that release toxins and can make swimmers sick.
- Sediment deposits in rivers can alter the flow of water and reduce water depth, which makes navigation and recreational use more difficult.

Sediment is also a primary carrier of phosphorus. Phosphorus readily attaches to soil particles and is transported to the water body through the erosion process. Excess phosphorus can cause nutrient enrichment, as defined below.

In rapidly flowing rivers and streams, the sediment remains suspended. When the water velocity decreases, such as in a pool in the stream or when it reaches a lake, the sediment is often deposited in the stream or lake bed. This deposited sediment can kill aquatic organisms and create a bottom unsuitable for spawning fish.

Animal Waste and Nutrient Enrichment

Nutrient enrichment of lakes and streams, primarily from animal manure and commercial fertilizer, is detrimental to surface and groundwater quality. Surface water and groundwater contaminated by animal manure can cause serious illnesses if consumed by humans. Animal manure can also be hazardous to aquatic life. When manure enters a water system, the breakdown of organic matter results in a depletion of the oxygen in the water which fish require to live. Furthermore, ammonia in manure is toxic and can kill aquatic life.

A major source of phosphorus loading to lakes and streams is runoff from dissolved nutrients transported by rainwater and snowmelt. Phosphorus in manure and commercial fertilizer causes eutrophication in lakes and streams. Eutrophication is the enrichment of an ecosystem with nutrients, causing excessive plant growth and decay. As plants decomposes, oxygen is depleted and water quality is severely degraded. Eutrophication often causes fish kills.

Manure Spreading on Frozen and Non-frozen Ground

In Manitowoc County, the ground usually freezes in early December and can stay frozen until the end of March. UW-Discovery Farms research indicated the highest runoff potential is in the months of February and March, accounting for over 50% of the annual runoff. UW-Discovery Farms data indicates that the early frozen ground period will often have a low potential for nutrient loss from manure if there is adequate contact to the soil surface and sufficient pore space in the surface of the soil for nutrients to infiltrate (UW-Discovery Farms, 2012).

UW-Discovery Farms research also indicated that another critical runoff period occurs on non-frozen ground when a rain event occurs when soils are already high in moisture content. This critical period typically occurs in April, May, and June. Approximately 30% of the annual runoff occurs during this time when soils are characteristically high in moisture contents from snowmelt and spring rains. Large volume and/or intense precipitation from one or two annual events can result in the majority of sediment and nutrient loss (UW-Discovery Farms, 2012).

Milking Center Waste

The wastewater from washing dairy milking equipment and the milking parlor after each milking contains milk waste, animal waste and cleaning products. This water can be a problem for dairy farmers without a suitable method of disposal. Large amounts of nutrients, fats, and detergents from milking center waste can pose risks to humans, animals, and to the environment. Collection and treatment systems need to be adequate to handle the amount of wastewater being processed and treated (Cortland SWCD).

Barnyard Runoff
A barnyard is an outdoor facility where livestock are concentrated for feeding or other purposes. This area can be a significant source of sediment and phosphorus runoff. An inventory of barnyards in Pine Creek Watershed is detailed in Chapter 6.

Feed Storage Runoff
Feed storage runoff can be a significant source of pollution entering streams. When compared to liquid manure, runoff from feed storage areas contain higher levels of biochemical oxygen demand, phosphorous, and ammonia. An inventory of feed storages in Pine Creek Watershed is detailed in Chapter 6.

Septic Systems
Nationwide, onsite wastewater treatment systems (septic systems, private sewage systems, onsite sewage disposal systems) collect, treat, and release about four billion gallons of effluent per day from an estimated 26 million homes and businesses, according to U.S. Census Bureau estimates as reported in the U.S. Environmental Protection Agency.

Half of the septic systems in operation today were installed more than 30 years ago when rules were nonexistent, substandard, or poorly enforced. EPA estimates that anywhere from 10 to 30 percent of onsite systems fail annually.

Failing onsite wastewater treatment systems can degrade surface water with increased bacteria, nitrates, cleaning chemicals and pharmaceuticals.

Streambanks
As storm water increases in volume and velocity, it can uproot vegetation and cause streambanks to collapse. Roads, parking lots, and buildings create impervious surfaces that prevent water from draining naturally. Compacted/bare/low organic matter soil, increases water volume and velocity in streams.

Streambank erosion negatively impacts water quality by increasing the amount of suspended sediment in the stream water. When suspended sediment levels in streams are high, aquatic life suffers as the amount of suitable habitat is reduced. Excessive sediment fills the spaces between the rocks and gravel in streambeds smothering fish eggs and bottom – dwelling animals. As sediment builds up in slow-moving waterways, excessive sediment destroys fish habitat and increases flooding. Sediments may carry contaminants such as organic waste, phosphorus, nitrogen, chemicals and pesticides. These contaminants cling to sediment particles and are transported downstream and eventually to Lake Michigan.

Tile Line Discharge
Subsurface draining is used for agricultural purposes to remove excess water from poorly drained land. Tile drained agricultural land must be well managed to reduce the loss of nutrients to surface waters.

Repairing tile blowouts, locating surface inlets, and monitoring tile outlets after manure application on subsurface drained crop fields are essential components to properly manage tile drainage systems.

UW Discovery Farms is currently monitoring agricultural tile drainage systems in northeastern Wisconsin to better understand the timing and mechanisms for soil and nutrient loss through tile systems. See pages 22-23 for additional UW Discovery Farm research information.

6.0 Watershed Inventory Results

Staff from the Manitowoc County Soil and Water Conservation Department collected inventory data on agricultural land in the Pine Creek Watershed. Watershed inventory included: erosion vulnerability assessment for agricultural land, animal units, crop rotations, nutrient management plans including soil test phosphorus and phosphorus index, cropland average annual soil loss, cropland concentrated flow and gullies, barnyards and feed storage structures, pastures, stream and wetland buffers, wetlands, erosion from streambanks, and septic systems. Assessment of current and potential best management practices (BMPs) was also completed. The inventory was completed during May to September of 2018. A summary of results are included in this chapter.

Pine Creek Watershed Inventory Fast Facts

Cropland Acres	8,192
Nutrient Management Plans	6,881
Acres with soil test above 35 ppm	3,742
Average soil loss tons/acre/year	1.7
Cropland Operators	29
Livestock Facilities	12
Animal Units contributing manure	5,527
Potential new stream buffer acres	431

TABLE 9: FAST FACTS

Critical Areas:

The maps in this plan are all spatial utilizing ArcGIS software and will be combined and compared during the first two years of the plan schedule to further define critical areas in the watershed for adoption of new/additional cropland practices to make progress towards meeting the plan’s phosphorus and sediment reductions.

Erosion Vulnerability Assessment for Agricultural Land:

The Wisconsin Department of Natural Resources, Bureau of Water Quality has developed EVAAL, the Erosion Vulnerability Assessment for Agricultural lands to assist watershed managers in prioritizing area within the watershed which may be vulnerable erosion (and associated nutrient export) and which may contribute to downstream water quality problems. It evaluates locations of relative vulnerability to sheet, rill and gully erosion using information about topography, soils, rainfall and land cover. EVAAL inputs include LIDAR digital elevation models, USDA-NRCS Soils Survey data, culvert locations, local precipitation data, cropping history from the National Agricultural Statistics Service, field boundaries and conservation practice locations. This tool does not predict erosion rates, but estimates the probability of a field to have more erosion problems than its neighboring fields. The data sets will be used to help determine priority areas for installation of best management practices in the watershed. One of the output options of EVAAL is the Stream Power Index. The index is used to estimate areas that are susceptible to gully erosion.

THE EVAAL EROSION VULNERABILITY INDEX CAN BE AGGREGATED USING A ZONAL BOUNDARY LAYER. THE MEAN EROSION INDEX VALUE WAS GENERATED USING CROPLAND BOUNDARIES IN THE PINE CREEK WATERSHED (FIGURE 22). THE CROPLAND EROSION VULNERABILITY MAP AND UNDERLYING GIS DATASET WILL BE USED TO TARGET HIGH PRIORITY CROPLAND FIELDS IN THE WATERSHED. THE EVAAL EROSION VULNERABILITY INDEX IS AN IMPORTANT TOOL IN INDICATING WHICH FIELDS ARE CONTRIBUTING THE MOST SEDIMENT AND PHOSPHORUS IN COMPARISON TO OTHER FIELDS IN THE WATERSHED, INDICATING WHERE BEST MANAGEMENT PRACTICES ARE GOING TO BENEFIT THE MOST IN THE WATERSHED.

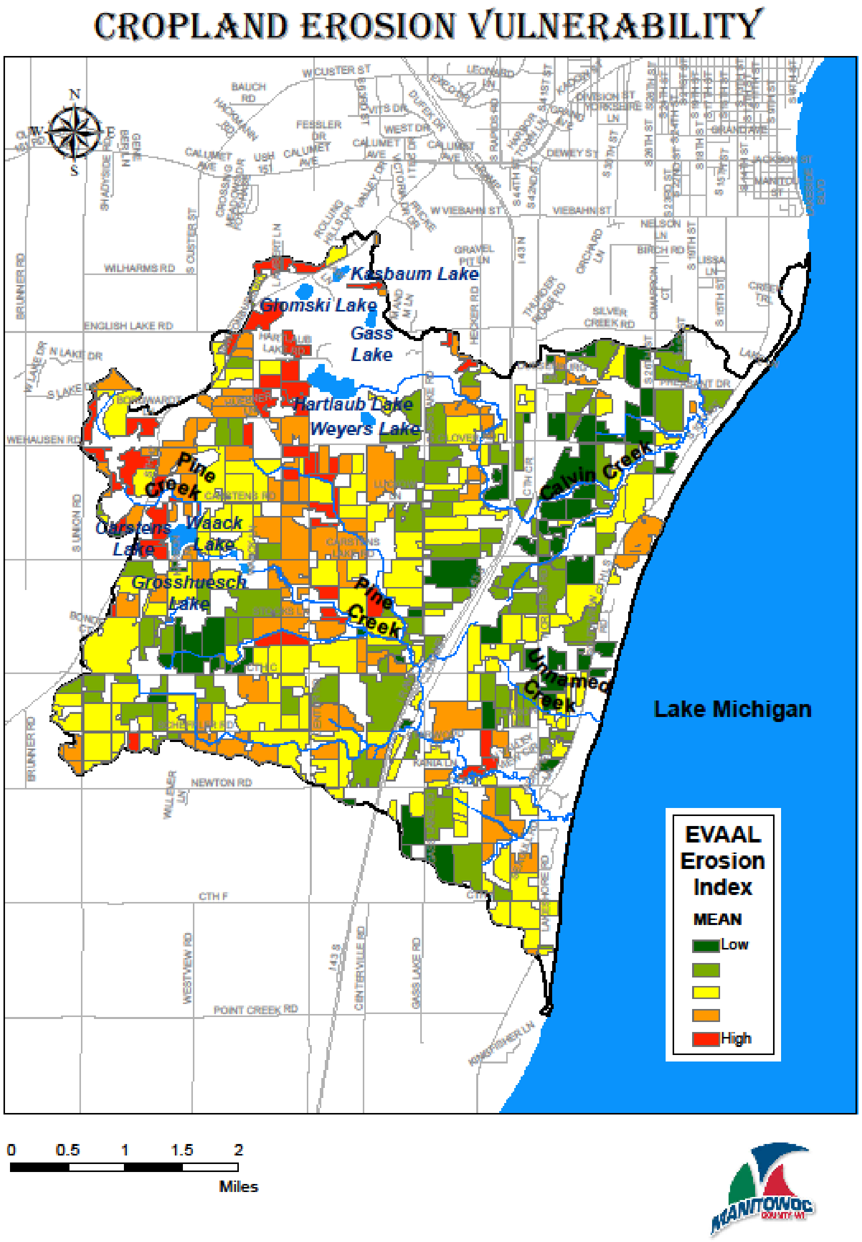


FIGURE 22: CROPLAND EROSION VULNERABILITY

Animal Units: The total number of animal units` within the watershed was also inventoried using Nutrient Management Plans (NMPs). According to available NMPs data, manure from 5,527 animal units apply manure to cropland and pasture in the watershed, or 0.8 animal units per cropland acre.

Crop Rotations: A crop rotation is a systematic planting of different crops in a particular order over several years in the same crop field. Crop rotations have a significant impact on conservation management. The type of rotation that is used on a field can affect nutrient levels within soil, erosion vulnerability, biodiversity, pest and disease vulnerabilities and more. The USDA CropScape Cropland Data Layer (CDL) was used to identify crops within the watershed. The CDL is a raster, geo-referenced, crop-specific land cover data layer created annually for the continental United States using moderate resolution satellite imagery and extensive agricultural ground truth. The CDL map for Pine Creek was created and then compared with 2013-2017 NMPs in the Pine Creek Watershed to confirm accuracy.

Approximately 81% of the following crop rotations were accurately represented: grain/vegetable rotation, dairy rotation (corn and alfalfa), continuous corn and cash grain. Inventory on pasture/hay/grassland rotation was misrepresented on many acres in the watershed, commonly appearing over wooded areas and residential property.

Crop rotations for dairy are dominant in the watershed, making up 67.4% of all rotations. Rotating crops can affect the amount of erosion and runoff that is likely to occur on a field over the period of the rotation. Changing intensive row crop rotations to a conservation crop rotation will decrease the amount of soil and nutrients lost from a field. Increasing the conservation level of crop rotation can be done by adding years of grass and/or legumes, add diversity of crops grown, or add annual crops with cover crops.

Rotation	Percentage of Watershed
Pasture/Hay/Grasslands	25.3
Cash Grain	4.3
Potato/Grain/Vegetable	2.9
Continuous Corn	0.1
Dairy Rotation (corn and alfalfa)	67.4

TABLE 10: CROP ROTATIONS

In the Manitowoc County 10-Year Land and Water Management Plan, a trend of increasing corn silage acres was identified. This practice leaves soil exposed for long periods of time with no residue and subjects fields to greater soil erosion/particulate and dissolved phosphorus loss to surface waters.

Planned crop rotations reviewed from individual nutrient management plans, on record from the years 2016-2018, within the watershed, ranged from 2 to 8 years in length. The most common planned crop rotation length was 6 years.

CROP ROTATIONS

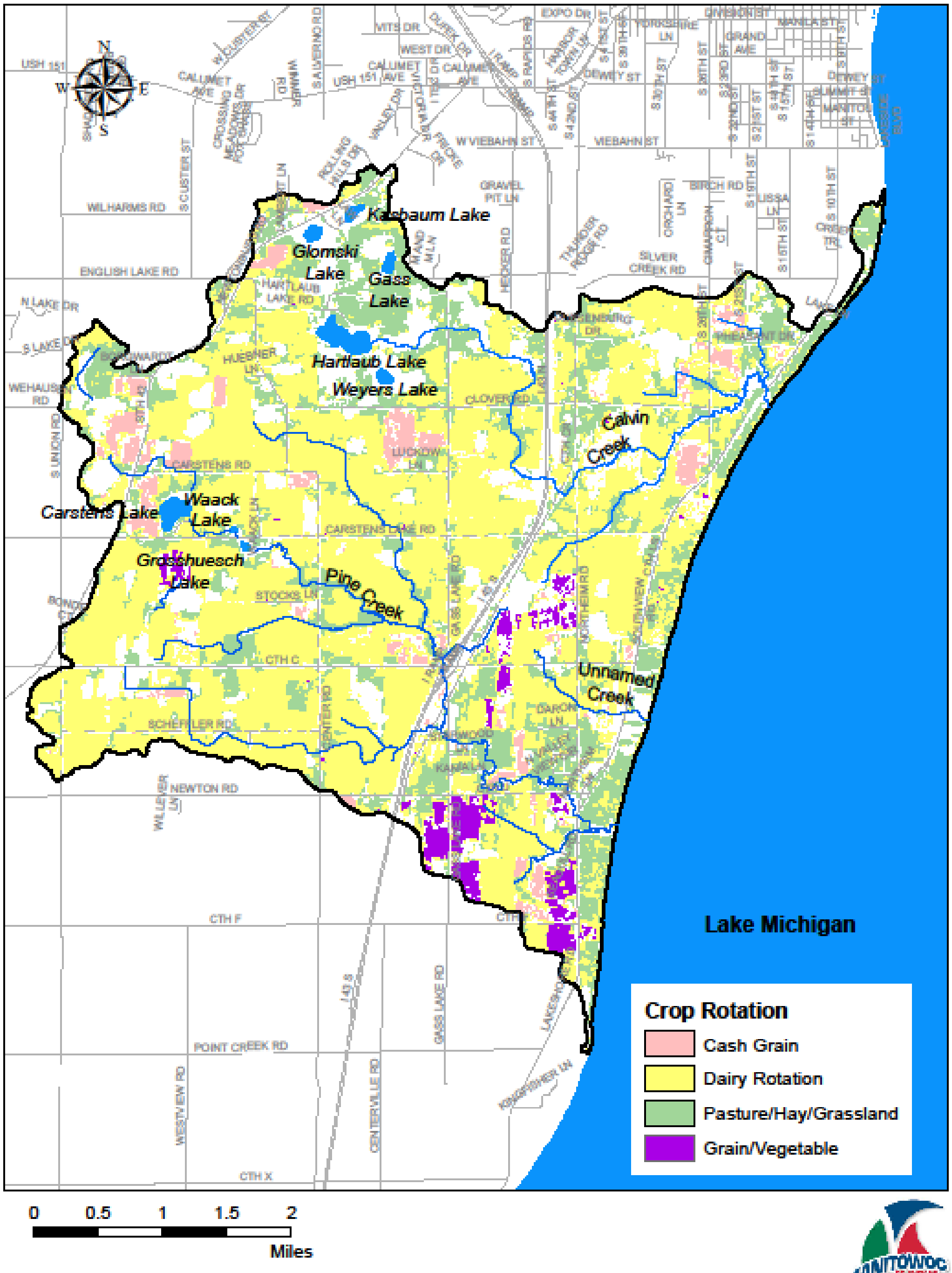


FIGURE 23: CROP ROTATIONS IN THE PINE CREEK WATERSHED

Nutrient Management Plans:

The definition of a Nutrient Management Plan is: Managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments. The purpose of a nutrient management plan is to supply and conserve nutrients for plant production, minimize the risk of agricultural nonpoint source pollution of surface and groundwater resources, properly utilize manure or organic by-products as a plant nutrient source, protect air quality by reducing odors and reactive nitrogen emissions (ammonia, inorganic oxidized forms, and organic compounds,) and maintain or improve the physical, chemical, and biological condition of the soil.

To inventory nutrient management in the Pine Creek Watershed, staff reviewed 25 Nutrient Management Plans submitted from 2016-2018. Numerous NMP attributes were identified and mapped including: field boundaries, operators' names, animal units on each farm, animal units per acre, soil test phosphorus, phosphorus index, tolerable soil loss and average annual soil loss. Fields operated by concentrated animal feeding farm operations (CAFO) were also identified (figure 24).

NUTRIENT MANAGEMENT PLANS

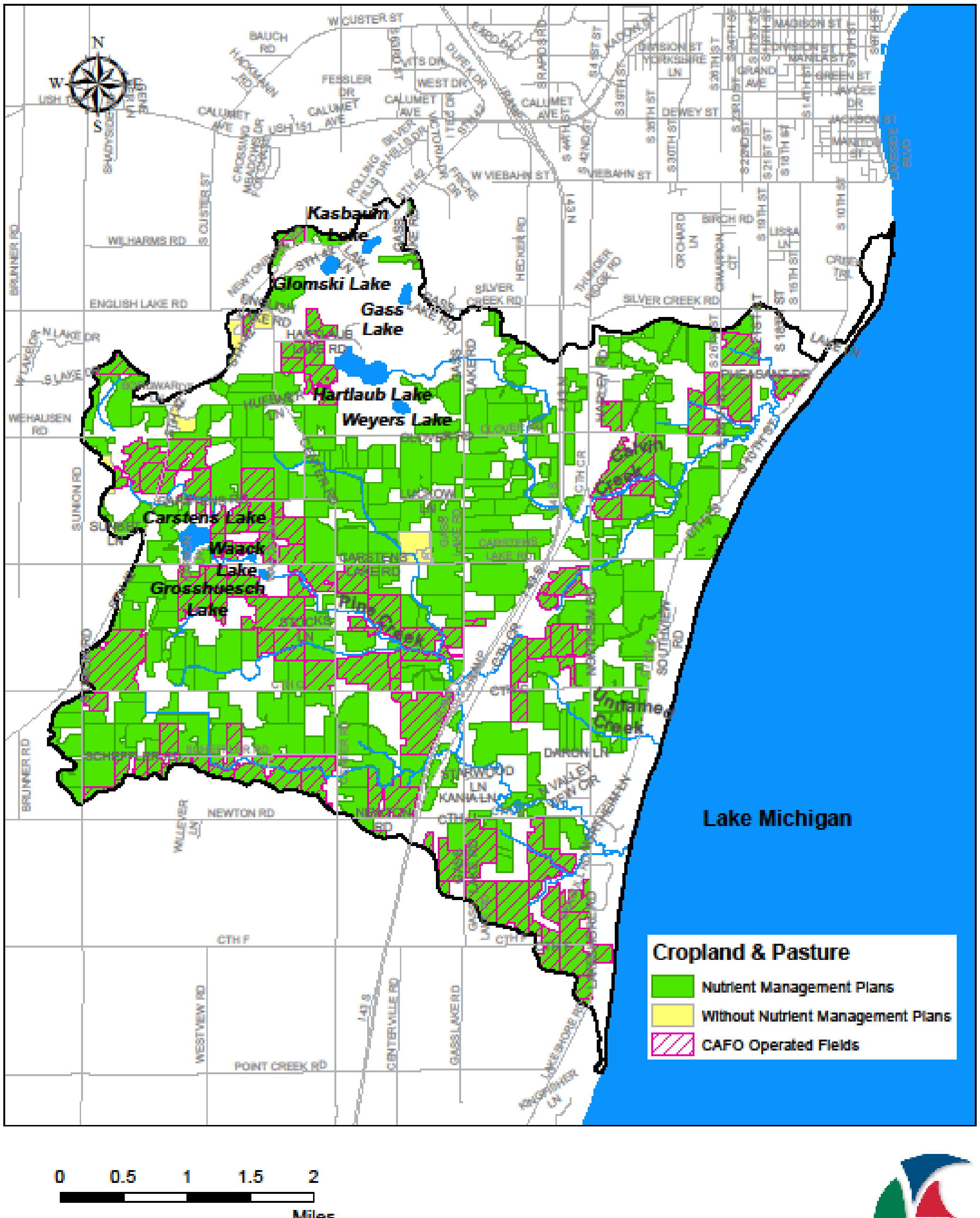


FIGURE 24: PARCELS WITH NUTRIENT MANAGEMENT PLANS IN THE PINE CREEK WATERSHED

Nutrient Management Plan Coverage:
There are 8,192 acres of cropland and pastureland in the watershed. Eighty-four percent, or 6,881 acres, of the cropland and pastureland in the Pine Creek Watershed is covered by a NMP. Currently 25 of the known 29 land operators have a nutrient management plan on file with the Soil and Water Conservation Department. (Figure 24)

For purposes of the STEPL Model, we assumed 80% of CAFO NMP acres (2,300 acres) and 68% of other farm NMP acres (4,400 acres) are consistently implementing their NMP. This is an assumption based on Soil and Water Department staff experience. A goal of the Pine Creek Watershed project is to verify the degree of implementation and work with landowners to consistently implement their plans.

Soil Test Phosphorus:
Soil test phosphorus levels were mapped using data from all 25 NMPs dated from 2016-2018. Soil test phosphorus concentrations may be used to help identify fields that are high priority for additional pollution reducing conservation measures. For example, cropland with soil test phosphorus concentrations greater than 35 ppm should be given higher priority (NR151). 3,742 acres, or 46% of crop fields are above 35 ppm. (Figure 26).

Phosphorus:
Phosphorus is a plant nutrient that is applied to the landscape and often times, is a major source of pollution in the watershed. Phosphorus nonpoint pollution has two forms: dissolved plant available phosphorus and sediment attached phosphorus. Nutrient management plans are designed to reduce loss of phosphorus from cropland by addressing both plant available and sediment attached phosphorus. NMPs include soil testing, using existing nutrients within the soil to the extent practical, and accounting for application of fertilizer in the form of animal wastes, industrial wastes and commercial fertilizer in a manner that will meet the crop needs while minimizing risk of over-application of those nutrients.

Sediment containing phosphorus accumulates within water corridors and depression areas. Over years, the accumulated sediment may "leak" phosphorus in both sediment attached forms and by releasing dissolved plant available phosphorus. Understanding that corridors and depression areas can be a source of phosphorus is important when addressing reduction strategies. Closed depressions determined from 2015 LiDAR data are displayed in Figure 25. Phosphorus corridors consist of concentrated flow and gully areas on Figure 29.

CLOSED DEPRESSIONS

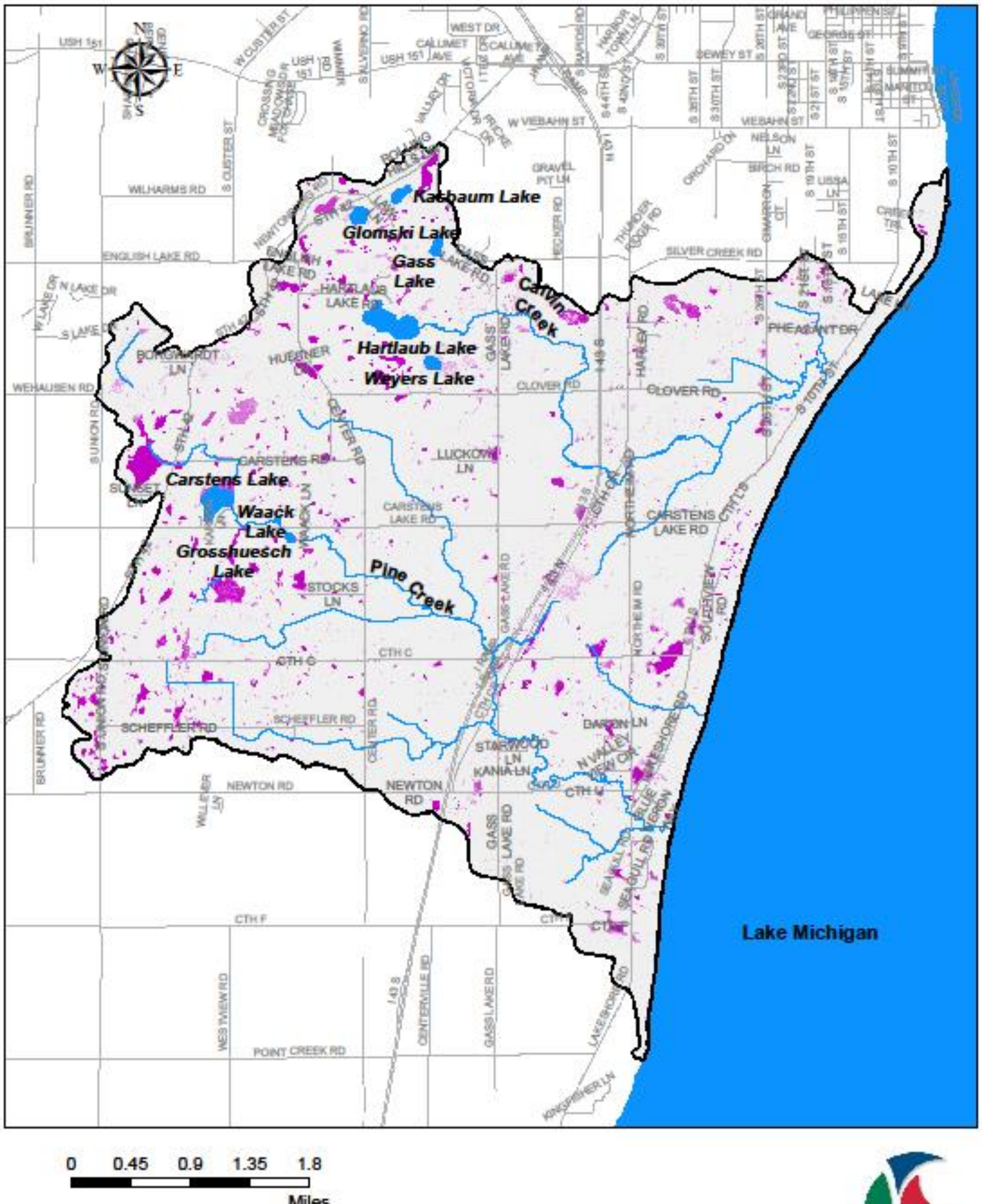


FIGURE 25: CLOSED DEPRESSIONS

SOIL TEST PHOSPHORUS

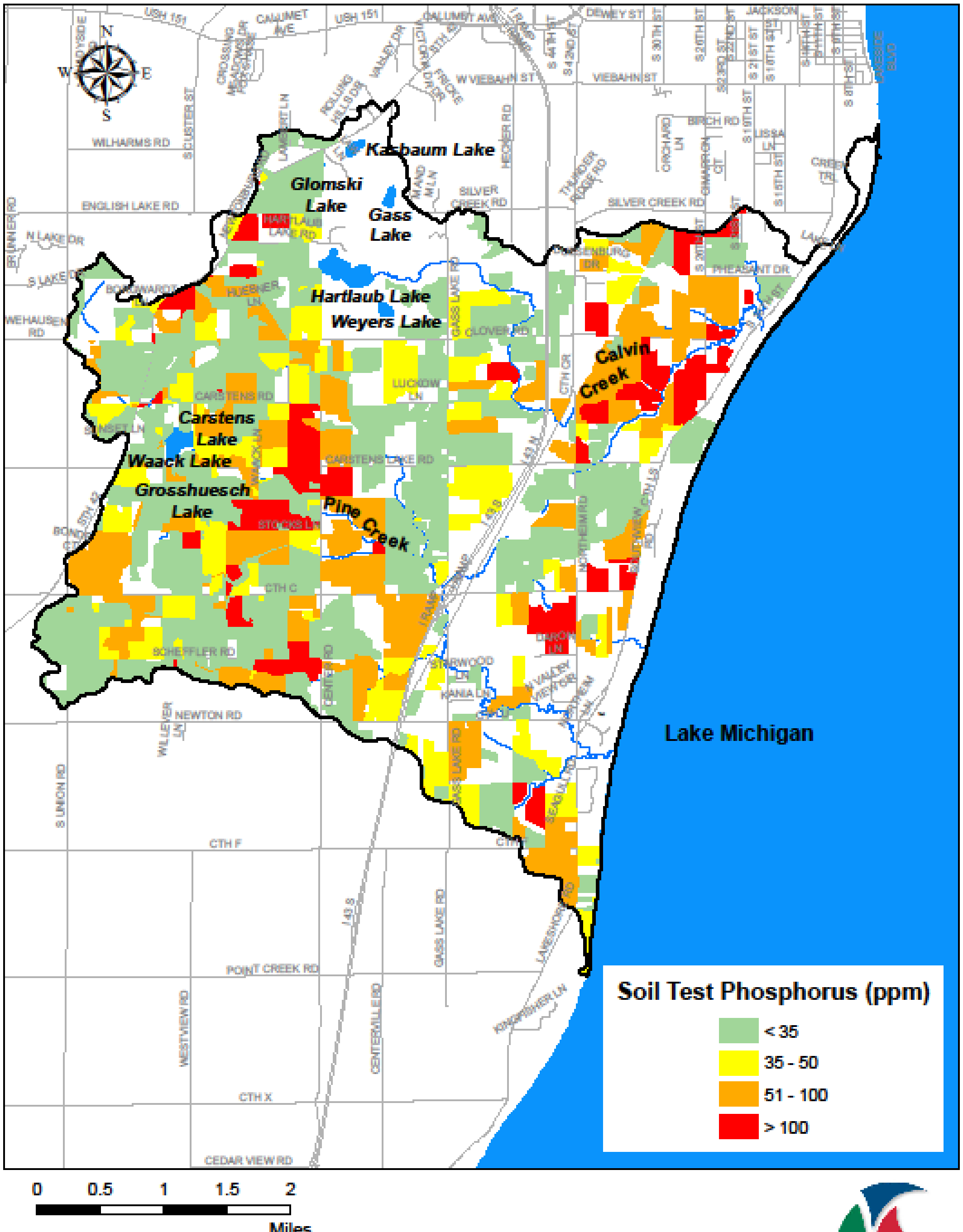


FIGURE 26: SOIL TEST PHOSPHORUS

Phosphorus Index: Phosphorus Index (PI) is Wisconsin's agricultural land management planning tool for assessing the potential of a cropped or grazed field to contribute phosphorus to the surface water. Components of PI include particulate and soluble phosphorus. In Wisconsin, croplands, pastures, and winter grazing areas shall average a phosphorus index of 6 or less over the accounting period, and may not exceed a phosphorus index of 12, in any individual year within the accounting period.

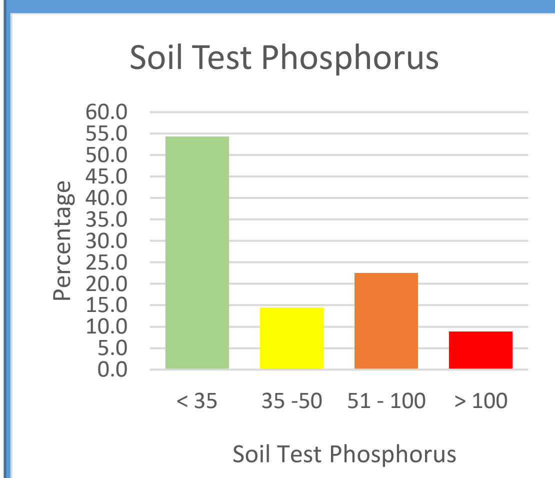
The accounting period begins when the NMP is completed. Historic and planned crop management data can be used to compute the phosphorus index for the first eight years of the NR151 standard implementation.

The majority of fields having a nutrient management plan in the Pine Creek watershed are below the state standard of 6 and 12 (Table 11 and Figure 27). The average PI in the watershed is 2. Although the agricultural fields in the watershed are meeting the state standard, water impairments still exist.

Cropland & Pasture Phosphorus Inventory

Soil Test Phosphorus		
Soil Test P	**Acres**	**Percent**
< 35	4,450.4	54.3
35 - 50	1,177.0	14.4
51 -100	1,846.4	22.5
>100	718.3	8.8

Phosphorus Index		
PI	**Acres**	**Percent**
<3	6,923.4	84.5
3 - 6	1,215.0	14.8
> 6	53.7	0.7



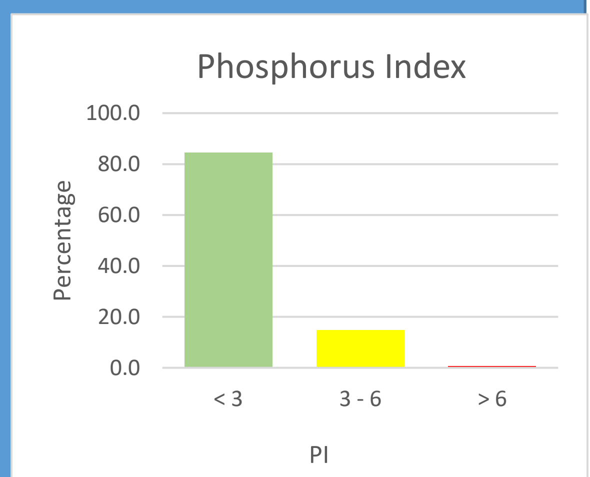


TABLE 11: PHOSPHORUS INVENTORY FOR PINE CREEK WATERSHED

PHOSPHORUS INDEX

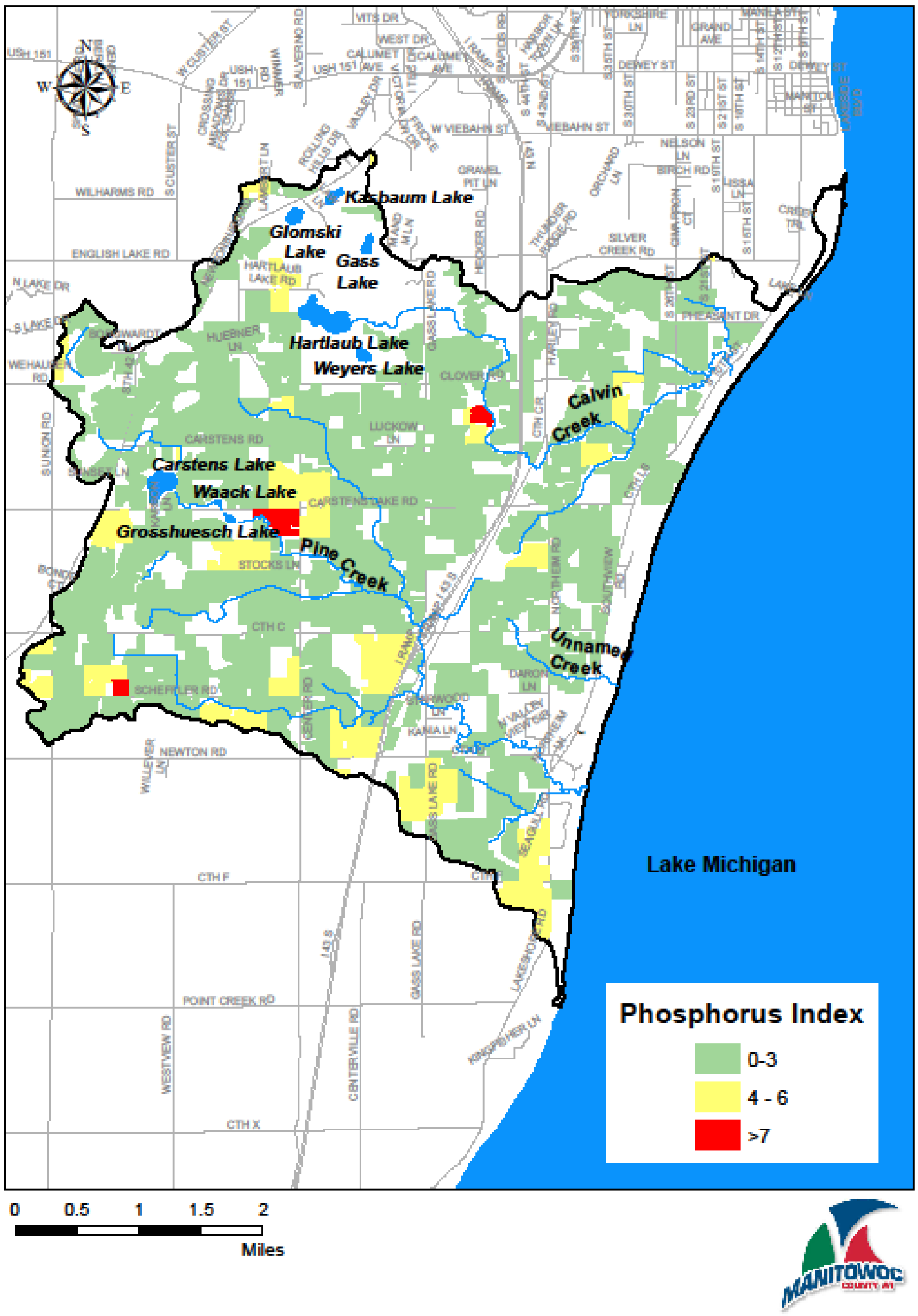


FIGURE 27: PHOSPHORUS INDEX OF FIELDS IN THE PINE CREEK WATERSHED

Cropland Average Annual Soil Loss: Average annual soil loss (A) refers to the calculated soil loss that is occurring or what is forecast to occur over the crop rotation. Average annual soil loss values ranged from 1-8 tons/acre/year (Figure 28). The average annual soil loss for the entire watershed was 1.7 tons/acre/year.

Soil Loss Tolerance (T) for a specific soil is the maximum average annual soil loss expressed in tons per acre per year that will maintain current production levels economically and indefinitely. T values in the watershed range from 3-5 tons per acre per year.

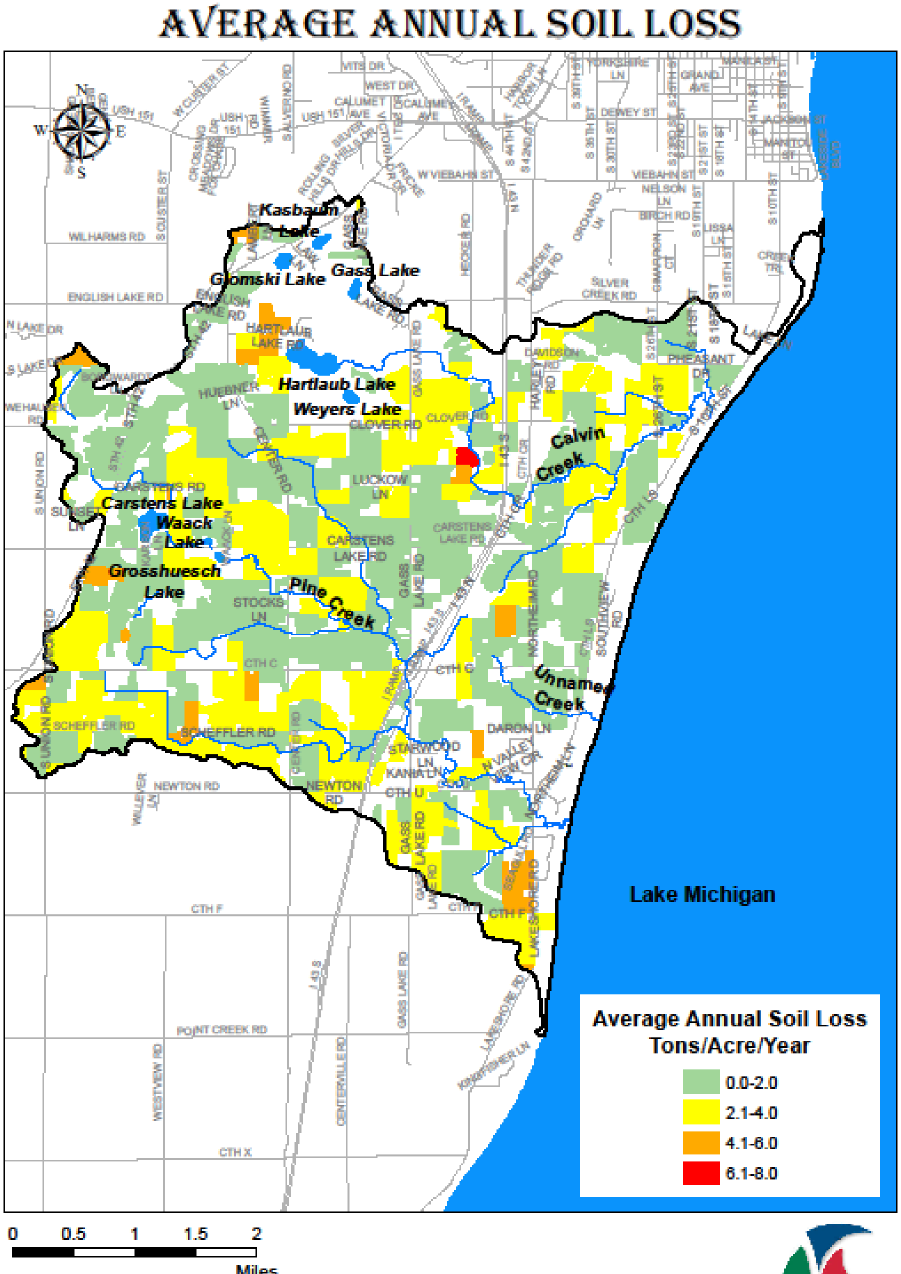


FIGURE 28: AVERAGE ANNUAL SOIL LOSS FOR FIELDS IN PINE CREEK WATERSHED

Cropland Concentrated Flow and Gullies: Concentrated flow refers to runoff water flowing through a confined feature such as a channel, ditch, or swale. When there is not enough ground cover to keep the soil in place, concentrated flow paths can turn into gullies.

A combination of LiDAR data, EVAAL, 2017 aerial photographs, and field verification was used to identify concentrated flow paths and gullies in the Pine Creek watershed. LiDAR data included slope intensity, flow accumulation, hillshade, channel grade, and ponding. Elevations and flow direction data were used to develop a stream power index (SPI) for the EVAAL tool. This map can be used to identify sheet and rill erosion, as well as locations of concentrated flows that may include gullies (Figure 29). Identified concentrated flow and gully locations in cropland are shown in Figure 29. Gully locations displayed with orange line symbols are critical areas in the watershed where flow channels need to be repaired during implementation.

Gully Inventory Results: Nearly all concentrated flow channels are maintained as stable grassed waterways. A minor amount of gully erosion is occurring in the Pine Creek watershed. The watershed had 17 small gullies and 7 medium gullies, totaling 4,449 feet.

Size Category	Measurement (Ft.)	Number Identified	Time to Form (yrs.)	Total Length (Ft.)
Small	0.5 X 0.5	17	1	2,892
Medium	1 X 1	7	3	1,557

TABLE 12: PINE CREEK WATERSHED GULLY INVENTORY RESULTS

CONCENTRATED FLOW AND GULLIES

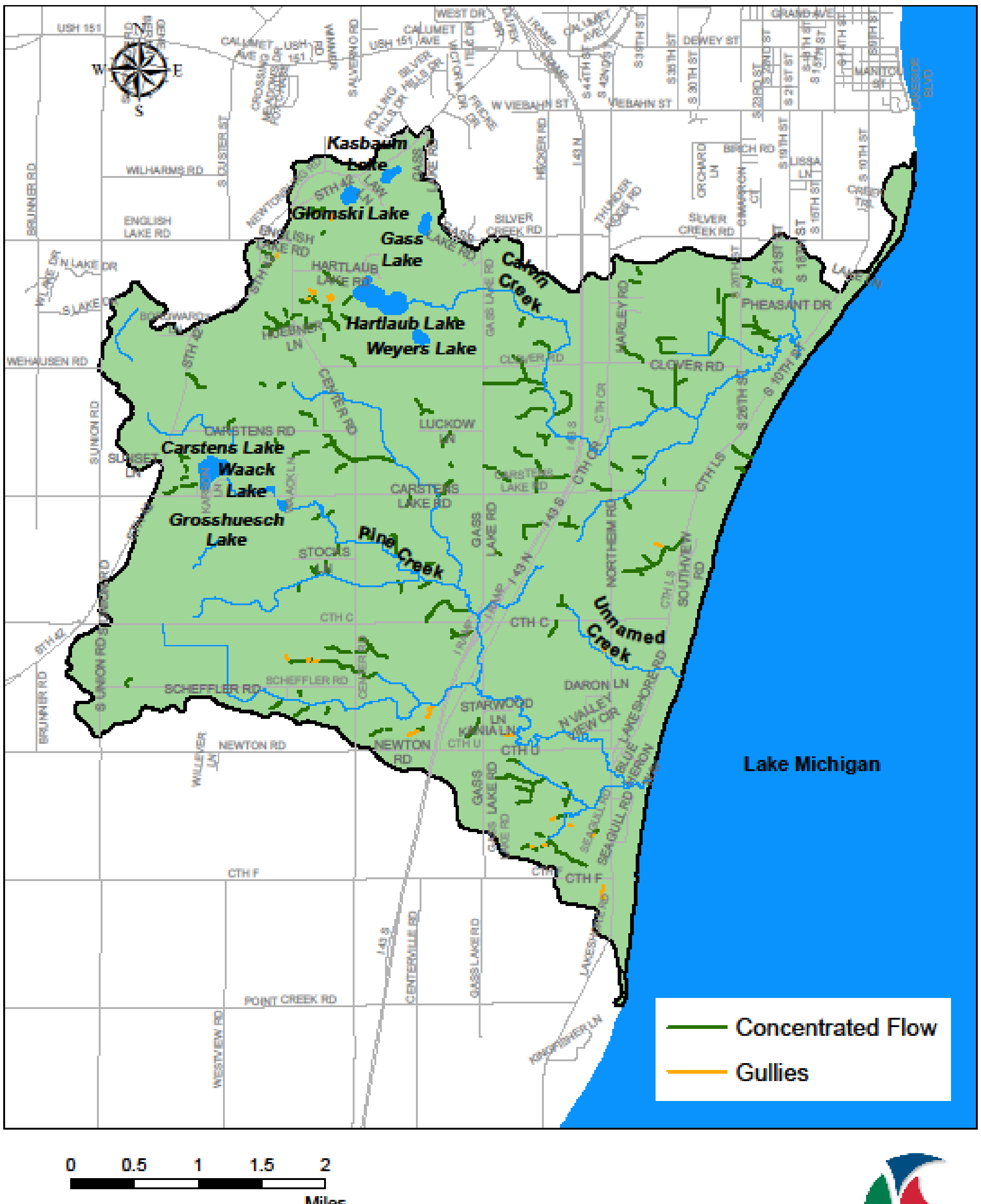
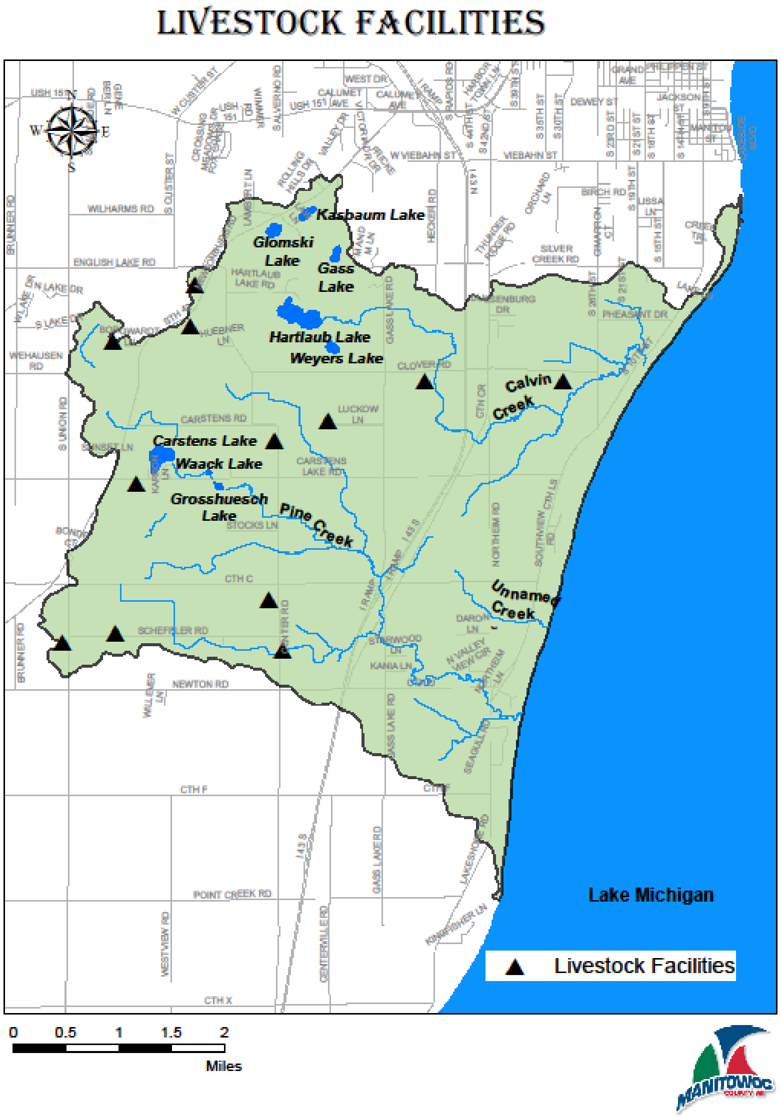


FIGURE 29: CONCENTRATED FLOW AND GULLIES

Barnyard and Feed Storage Structures: Location of current livestock operations was compiled through existing Soil and Water Conservation Department data and air photo interpretation. There are a total of 12 known active livestock operations with an estimated 2,500 animal units housed in the Pine Creek watershed. Locations of livestock operations in the watershed are shown in (Figure 30.)



Barnyard and feed storage data was entered in to the STEPL spreadsheet tool to estimate phosphorus loading. According to the STEPL calculations, an estimated 4,056 lbs. of phosphorus per year can be attributed to barnyard and feed storage runoff in the Pine Creek watershed. Barnyard and feed storage runoff accounts for 21.5 % of the total phosphorus loading in the watershed.

FIGURE 30: LIVESTOCK FACILITIES

Pastures: Pasture is defined as "land on which livestock graze or otherwise seek feed in a manner that maintains the vegetative cover over the grazing area. Pasture may include limited areas of bare soil such as cattle lanes and supplemental feeding areas provided the bare soil areas are not significant sources of pollution to waters of the state" (NR 151). Pine Creek Watershed has approximately 91 acres that are pastured.

Stream and Wetland Buffers

Riparian buffers filter out sediment and nutrients from water before reaching a stream channel or wetland. Buffers also reduce the amount of runoff volume, provide wildlife habitat, and help regulate stream temperature.

Conservation Reserve Enhancement Program **(**CREP) is a part of the Conservation Reserve Program (CRP), the country's largest private-land conservation program. In exchange for removing environmentally sensitive land from production, and establishing grass or trees, landowners are paid an annual rental rate, along with other upfront federal and state incentives. Participation is voluntary, and the contract period is typically 15 years.

There are a total of 17 acres in the Pine Creek Watershed that are currently enrolled in CREP. Pine Creek watershed landowners have the potential to enroll 431 acres in CREP for buffers along streams and another 776 acres for buffers around wetlands. This calculation is based on the maximum program width allowable (150 ft. from the edge of the stream or wetland). Approximately 14% of the agricultural land is eligible for this program, totaling 1,207 acres.

There are seven conservation easements, totaling 100 acres in the Pine Creek watershed, and include a combination of stream buffers and wetland restorations with buffers. The state-owned perpetual conservation easements were primarily established during the Seven Mile Silver Creek Priority Watershed project in the early 90's. Figure 31 displays existing CREP buffers, existing conservation easements and potential CREP stream and wetland buffers.

Wetlands

Wisconsin State Statutes define a wetland as "an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions. Wetlands are an important feature of a watershed. Wetlands provide a number of benefits such as water quality improvement, wildlife habitat, and flood control. Restoring wetlands and constructing designed wetlands in the watershed area will provide water storage and reduce sediment and phosphorus loading to streams and lakes. Inventory of existing, restored, and restorable wetlands was completed using the Wisconsin Department of Natural Resources' Potential Restorable Wetlands GIS layer, and the Manitowoc County Wetland Restoration Inventory. (Figure 32)

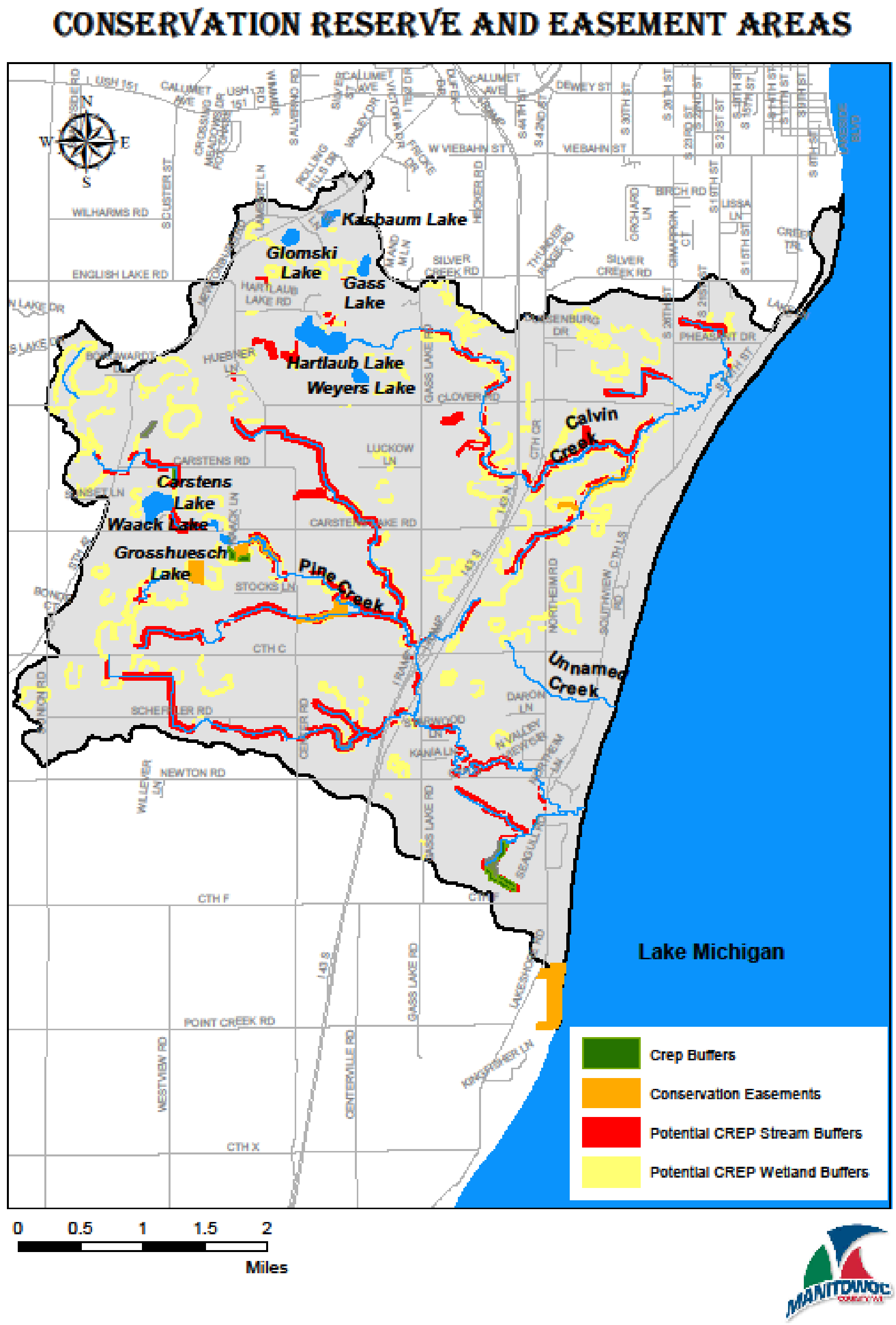


FIGURE 31: CONSERVATION RESERVE AND EASEMENT AREAS IN THE PINE CREEK WATERSHED

WETLANDS

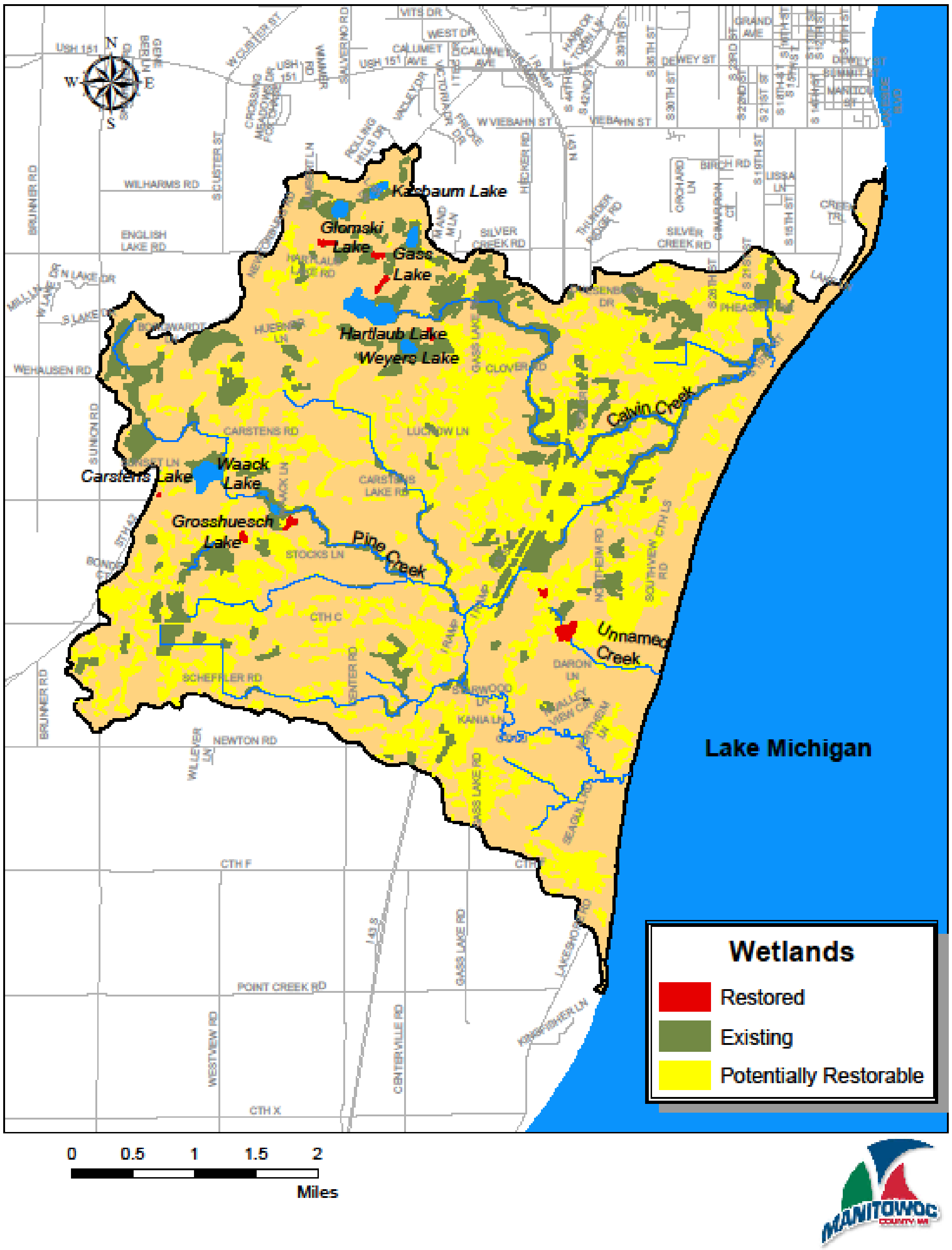


FIGURE 32: EXISTING, RESTORED, AND POTENTIALLY RESTORABLE WETLANDS IN THE PINE CREEK WATERSHED

Streambank Erosion:

Streambank assessment was completed using a combination of LiDAR, field inventory, and WDNR Wadable Stream Assessment.

Assessing Steep Slopes: LiDAR data was used to determine the location of streambank slopes that were 45 degrees or greater. These areas are expected to have erosion problems. In May of 2018, SWCD staff performed a field verification of accessible sites that were identified. Upon field verification, SWCD determined that areas identified having slopes greater than 45 degrees had severe erosion potential. Figure 33 is an example of one of these sites. The total length of streambanks that are over 45 degree slope is 2,729 feet. The sites were classified under NRCS category very severe, meaning the bank is bare, with vegetative overhang.

SWCD and WDNR staff compared LiDAR mapping to the WDNR Streambank surveys of June, 2016.

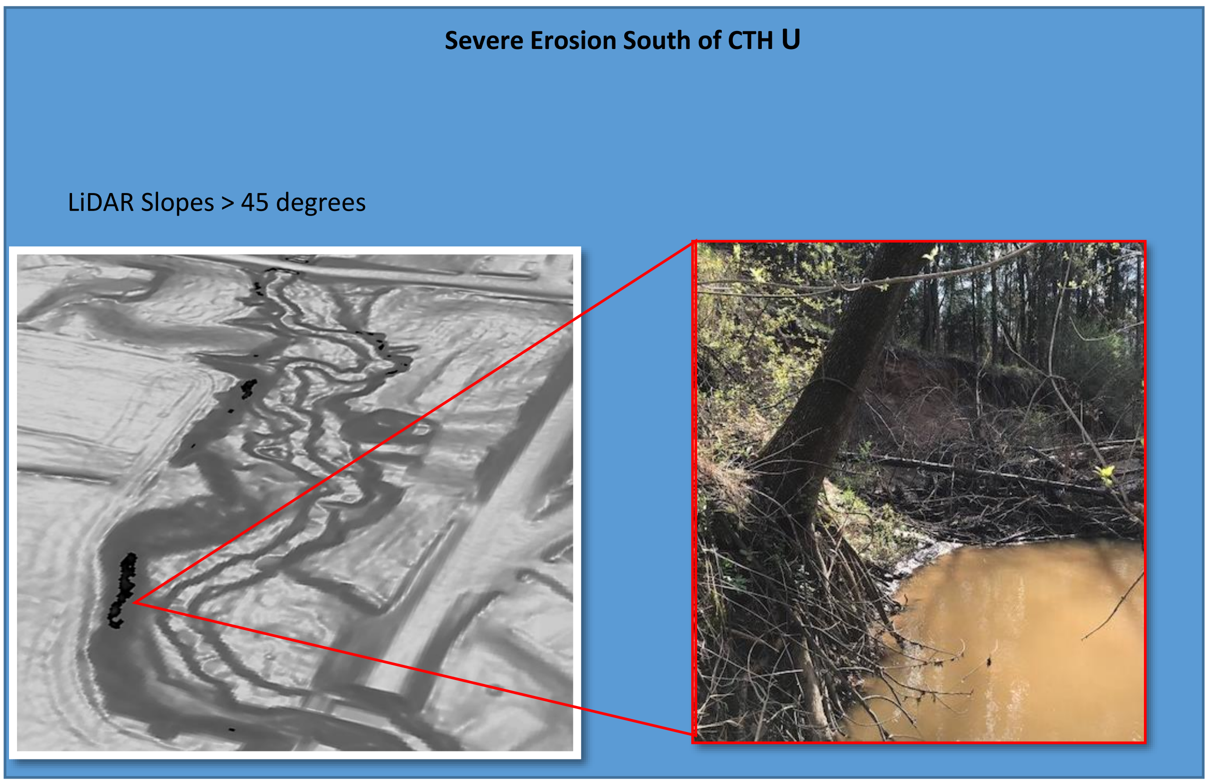


FIGURE 33: FIELD VERIFICATION OF CRITICAL SITES (45 DEGREE SLOPE LIDAR)

The WDNR Stream Surveys included three sites on Pine Creek and three sites on Calvin Creek. The sites that appeared to be actively eroding were measured for length and given a DNR-erosion rating of moderate to extensive, based on the length of bare soil at the site.

The WDNR erosion classifications for all inventoried sites were reviewed and compared with the NRCS description criteria. After categorizing the sites to match NRCS descriptions, a lateral recession rate for the sites was identified.

The WDNR assessment provided the length of each inventoried site and SWCD used LiDAR data to measure a surface area at those sites. The total surface area of all sites classified as "Very Severe" was 18,019 sq. ft. (approximately 0.4 of an acre). The total area of sites classified as "Severe" was 8,145.61 sq. ft. (approximately 0.2 of an acre).

DNR Streambank Survey 2016

Location	**Direction**	**Category (DNR)**	**Category (NRCS)**	**Length (feet)**
Pine Creek at U	Upstream	Extensive erosion (> 1 m of bank is bare soil)	Very Severe	460
Pine Creek Gass Lake Rd. and 43	Upstream	Moderate erosion (0.5-1 m bare soil)	Severe	345
Pine Creek at Carstens Road	Downstream (north of Carstens Lake)	Limited erosion (0.2-0.5 m of bank is bare soil	moderate	345
Calvin Creek at Clover Road	Upstream	No significant erosion (<0.2 m of bank is bare soil)	Slight	345
Calvin Creek at S. 26th Street	Downstream	Moderate erosion (0.5-1 m of bank is bare soil)	Severe	460

Table 13: DNR Streambank Survey 2016

Septic Systems

Manitowoc County Planning and Zoning Department does not have readily available septic system inventory for the Pine Creek Watershed. To get septic systems inventory, parcel information from Manitowoc County Tax Parcel layer was obtained. Data was filtered by Total Improvement Value (TOTIV). Any record above $20,000 was considered a building that would have at least one septic system in place. Pine Creek watershed had 566 parcels with improvement values above $20,000. So it is estimated that Pine Creek Watershed has 566 septic systems.

In 2017, Manitowoc County had a total of 145 systems out of 10,420 (1.4%) that failed and needed replacement. SWCD applied the 1.4% failure rate per year to the Pine Creek Watershed to estimate how many failures can be expected each year:

566 septic systems X 1.4% failure rate = 8 failures/year

7.0 Watershed Goals and Management Objectives

The main focus of the watershed project is to reduce pollutant loading in the Pine Creek Watershed to meet water quality standards. Goals address critical issues in the watershed area based on watershed inventory results. Management objectives indicate recommended actions to meet the watershed goals.

Goal	Indicators	Cause or Source of Impact	Management Objectives
Improve surface water quality to achieve DNR/EPA water quality standards.	Total phosphorus, Total Suspended Sediment	High phosphorus levels causing algal growth and decreased dissolved oxygen. Cropland and farmstead runoff.	Reduce pollutant loading by applying BMPs to cropland and livestock production sites.
Improve streambank stability and reduce amount of streambank degradation.	Severe erosion characterized by undercutting, vertical banks, and slumping.	High peak flows to streams, inadequate riparian vegetation and tile drainage.	Stabilize degraded streambanks and reduce phosphorus and sediment loading to streams.
Increase public awareness of water quality issues and increase participation in watershed conservation activities.	Event participation, evaluation and attendance.	Lack of awareness of environmental issues and their impact.	Provide information and education to stakeholders.

Table 14: Watershed Goals and Management Objectives

8.0 Management Measures Implementation

The Pine Creek Watershed plan presents a recommended plan of actions needed over the next 10 years in order to achieve water quality targets and watershed goals. The plan implementation matrix provides a guideline to what kinds of practices are needed in the watershed and to what extent they are needed to achieve the watershed goals. The plan matrix provides a timeline for which practices should be completed, possible funding sources, and agencies responsible for implementation.

TABLE 15: 10 YEAR MANAGEMENT MEASURES

Recommended Actions	*Indicators*	*Milestones*			*Timeline*	*Additional Funding Sources*	*Agency*
		0-3 years	*3-7 years*	*7-10 years*			
1) Management Objective: Reduce pollutant loading by applying BMPs to cropland and livestock production sites.							
Increase nutrient management plans from 84% to 94%: 655 new acres	# of acres with additional nutrient management plans	219 acres	218 acres	218 acres	0-10 years	EQIP, TRM, SWRM, MDV,	NRCS, SWCD, DATCP, DNR
Review/Field Verify NMP implementation	# of verified NMPs	10	10	9	0-10 years	SWRM	SWCD
apply 800 acres of low rate/low disturbance manure injection	# of acres applied	267	267	266	0-10 years	EQIP, TRM, SWRM, MDV,	NRCS, SWCD, DATCP, DNR

Recommended Actions	*Indicators*	*Milestones*			*Timeline*	*Additional Funding Sources*	*Agency*
		0-3 years	*3-7 years*	*7-10 years*			
Install 4,500 ft. of grassed waterways in active gully areas	# of ft. installed	1500	1500	1500	0-10 years	EQIP, TRM, SWRM, MDV,	NRCS, SWCD, DATCP, DNR
Implement use of cover crops by 1700 acres	# of acres additional cover crops	567 acres	567 acres	566 acres	0-10 years	EQIP, TRM, SWRM, MDV,	NRCS, SWCD, DATCP, DNR
Apply 700 acres of reduced tillage or no-till. Fields must meet 30% residue	# of cropland acres with applied practice	234	233	233	0-10 years	EQIP, TRM, SWRM, MDV,	NRCS, SWCD, DATCP, DNR
Install 5 acres of wetland restorations	# of acres of wetlands restored	2	2	1	0-10 years	EQIP, CREP, MDV, USFW	NRCS, SWCD, DATCP, DNR, USFW
Reduce sediment and phosphorus loading by installing 200 acres of stream buffers.	# acres of streambank buffers	50 acres	100 acres	50 acres	0-10 years	EQIP, CREP, MDV,	NRCS, SWCD, DATCP

Recommended Actions	*Indicators*	*Milestones*			*Timeline*	*Additional Funding Sources*	*Agency*
		0-3 years	*3-7 years*	*7-10 years*			
Install 1 barnyard runoff and 1 feed storage runoff control systems	# of new installations		1	1	0-10 years	EQIP, TRM, SWRM, MDV, NOD	NRCS, SWCD, DATCP, DNR
Management Objective: Stabilize degraded streambanks to reduce phosphorus and sediment loading to streams.							
Restore 200 acres of eroded stream banks by use of stream buffers.	# acres of streambank buffers	50 Acres	100 Acres	50 Acres	0-10 years	EQIP, CREP, MDV	NRCS, SWCD, DATCP
Annually meet with WDNR Nonpoint Source and TMDL staff to review and discuss NR 151 implementation efforts in the watershed. Items for review will include, but not be limited to, 1-6 below.	# of annual meetings	3	3	4	0-10 Years	N/A	SWCD, WDNR

1. Do plan implementation efforts for agricultural cropland/operations in the watershed reflect the following priority:
    - Priority 1 - Achieve compliance with NR 151 performance standards on a majority (>70%) of agricultural acres/operations in the watershed*
    - Priority 2 – After a majority of agricultural cropland or operations in the watershed* are found in compliance with existing NR 151 standards, then adoption of additional practices on agricultural acres/operations already in compliance with NR 151 is completed to further reduce pollutant loads from agricultural sources in watershed.

* = NR 151 Implementation/Compliance rates may vary within the watershed and require dividing the watershed into sub-basins.

2. If item 1 is not met, then how and when can plan implementation efforts change to meet item 1?
3. Complete annual watershed inventory to determine current number agricultural cropland acres/farms - out of total number of cropland acres/farms in watershed - that are complying with NR151.
4. Identify how many cropland acres/farms in watershed have received/been documented in compliance with NR 151 via letter.
5. Share/Review copies of NR 151 compliance letters with WDNR staff.
6. Summarize NR 151 priorities, compliance inventory and documentation efforts within annual 9 element plan progress reports.

9.0 Estimated Load Reductions

Load reductions for upland best management practices were estimated using STEPL (Spreadsheet Tool for Estimating Pollutant Loading) version 4.4. Percent reduction was based on the STEPL model agricultural baseline loading of 15,962 lbs. total phosphorus/yr. and 3,196 tons total suspended solids/year. Expected load reductions from planned activities are shown in Table 16.

Current modeling shows that the needed reduction in suspended sediment from agriculture in the watershed area can be reasonably met with current available conservation practices and cost effectiveness. The estimated reduction in sediment is 11.5%. Current load reduction modeling used for this plan shows that we can achieve a 21.9% reduction in phosphorus from agriculture with the practices installed and followed in the plan recommendations.

Additional evaluation of water quality monitoring data as plan implementation begins will help provide a more accurate prediction of load reductions and current loading rates. STEPL calculations are shown in appendix B.

Management Measure Category	Total Units (size/ length)	Total Cost	Estimated Load Reduction			
			TP (lbs. / yr.)	Percent	TSS (t/yr.)	Percent
Agricultural BMP's						
Barnyard and Feed Storage Runoff Control Systems	2 sites	$300,000	1,825	45	n/a	n/a
Conservation Practices applied to Cropland (Conservation Tillage, No-till, Cover Crops, Nutrient Management, Low rate/ low Disturbance Manure Application, Conservation Crop Rotation, Wetland restorations, Riparian buffers, Grassed waterways)[1]	2,500 ac	$1,323,821	1,667	14.1	369	11.6
Use of new technologies/management measures (gypsum applications, biofilters and water control structures at outlets of tiles, etc.)[2]	N/A	N/A	N/A	N/A	N/A	N/A
Totals		**$1,623,821**	**3,492**		369	

TABLE 16: ESTIMATED LOAD REDUCTIONS FOR MANAGEMENT MEASURES

1. A combination of conservation practices applied to a majority of the cropland in the watershed is necessary to get the desired pollutant load reductions. It is also important to note that not all fields will need to apply more than one practice to meet desired reduction goals. The BMP Efficiency Calculator was used to determined efficiencies of different combinations of practices such as Reduced Tillage & Cover Crops. An average pollutant reduction efficiency was determined for this category. See Appendix B

2. The amount of new technologies and management measures has not been determined as well as expected load reductions and cost. The effectiveness of these technologies can widely vary and need to be tested before watershed wide implementation. If new management measures/technologies prove effective they will be incorporated into the plan with more accurate load reductions, cost, and amount needed.

10.0 Information and Education

An effective Information and Education Plan (I&E) includes the following components as referenced in USEPA's "*Handbook for Developing Watershed Plans to Restore and Protect our Waters*" (USEPA 2008):

- Define I&E goals and objectives
- Identify and analyze the target audiences
- Create the messages for each audience
- Package the message to various audiences
- Distribute the message
- Evaluate the I&E program

Information and Education Plan Goals

Educational efforts will focus on supporting the Pine Creek Watershed 9-Key Element Plan priorities and goals. Manitowoc County Soil and Water Conservation Department will educate stakeholders on the importance of implementing best management practices in the watershed that will improve water quality in lakes and streams.

Objectives

- Create public awareness of the watershed, existing conditions of water quality, and additional BMP's that, if applied, will improve water quality.
- Increase landowner involvement in watershed stewardship.
- Increase communication and coordination among government agencies, educational institutions, environmental organizations, and the agricultural community.
- Create an advisory team made up of stakeholders living in the watershed.
- Demonstrate good conservation practices

Target Audience

Audiences in this watershed include: Agricultural landowners and operators, agribusinesses, Certified Crop Advisors (CCAs), manure haulers, and the general public. Efforts will provide environmental messaging based on specific audiences.

Existing Partnerships

Existing partnerships are important in implementing a successful I&E program. Each organization has a role to play in continuing outreach efforts across Manitowoc County. SWCD will continue to foster the following partnerships, resulting in improved information and education programming:

State:

- UW Extension-Manitowoc
- Wisconsin Department of Natural Resources
- Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP)
- University of Wisconsin Green Bay - Manitowoc Campus

Federal:

- Natural Resource Conservation Service
- Farm Service Agency
- U.S. Fish & Wildlife
- Sea Grant

Local:

- County Executive, County Board and Land Conservation Committee
- Planning and Zoning
- Health Department

Furthermore, many environmental organizations perform valuable services in support of natural resources in the watershed. These groups are largely self-directed. This grass roots hands-on approach will continue to play a major role in protecting and enhancing the natural resources in the Pine Creek Watershed. Some of the groups include:

- Manitowoc County Lakes Association
- Lakeshore Natural Resource Partnership
- Manitowoc County Forage Council- Land and Water Stewardship Committee
- Manitowoc County Fish and Game Association
- Glacial Lakes Conservancy
- Glacier Land RC&D

Education Plan Matrix

The Educational Plan Matrix (Table 17) provides an outline of the Pine Creek Watershed Education Plan. The matrix is organized by: Educational program name, program description, actions or activities, the target audience for each program, staff, and the indicators of success.

TABLE 17: EDUCATION PLAN MATRIX

Programs	Description	Action/Activity	Target Audience	Staff	Indicators of Success
Annual Farmer Watershed Meeting	Annual opportunity for watershed farmers to discuss plan implementation with project staff.	Invite all farm operators and owners to discuss project implementation and progress.	Agricultural landowners/ operators	Resource Conservationist Educator	1 farmer watershed meeting/year.
Annual Farmer-to-Farmer Mentoring Program (Winter)	Local farmers host informal meetings/roundtables to discuss their operation, resource concerns, and BMPs. This program provides an opportunity for farmers to talk to other farmers about what is and is not working on their farm.	Identify and invite farmers in the Pine Creek Watershed to attend discussion. Offer opportunity for a farmer in the watershed to host the roundtable.	Agricultural landowners/ operators	Resource Conservationist Educator	1 watershed farmer host/year.
Annual Soil Health and Cover Crop Forum (Winter)	An annual forum hosted by SWCD, UWEX, and NRCS for the agricultural community to learn about various soil health-related topics such as: cover crops, no-till, grazing and more.	Invite stakeholders in Pine Creek Watershed to event.	Agricultural landowners/operators and agribusiness professionals	Resource Conservationist Educator	10 Owners/Operators from the watershed attend the forum annually
Annual Watershed Project Signs	Local farmers volunteer to display signs of installed BMPs.	Identify and invite farmers in the Pine Creek Watershed to participate in the program.	Agricultural landowners/operators and General Public	Watershed Coordinator Educator	15 signs installed throughout the watershed
[redacted]					

Programs	Description	Action/Activity	Target Audience	Staff	Indicators of Success
Annual Nutrient Management Farmer Education Classes (Winter)	Lecture and computer classes that assist land operators with writing and understanding their NMP.	Invite all landowner/ operators to NMP classes. Present watershed project to participants who own/operate in the Pine Creek Watershed.	Agricultural landowners/operators	Resource Conservationist Educator	5 landowner/ operators in watershed attend the class annually.
Annual Crop Consultant/Manure Hauler Meeting (Winter)	SWCD and UWEX host an annual meeting for CCAs and manure haulers to discuss pertinent topics relating to conservation and their professions: Groundwater, surface water, standards revisions, ordinance updates, new maps…etc.	Provide 9-Key Element Plan annual report summary to CCAs and Haulers.	CCAs and manure haulers	Watershed Coordinator	Annual presentation of updates in Pine Creek watershed.
Annual 10-Year L&W Resource Management Plan Meeting (Winter)	Discuss and review SWCD progress towards meeting resource goals. Determine if changes need to be made to the 10-Year Land and Water Plan. Roundtable discussion among committee.	Provide 9-Key Element Plan annual report summary to the advisory committee.	Local and Technical Advisory Committee	Watershed Coordinator	Annual progress report.
FPP Farm Visits (Once every 4 years per land owner)	Staff conducts farm visit to assure farmers are meeting local and state conservation standards.	Provide packet of watershed-specific information such as: • Cost share opportunities • Site-specific BMP opportunities • Upcoming educational programs	Agricultural landowners/ operators	Resource Conservationist Educator	15 FPP visits in the watershed/year. 60 packets distributed to FPP participants within the first 4 years of plan implementation.

Programs	Description	Action/Activity	Target Audience	Staff	Indicators of Success
Media Releases (Year-round)	Communications of upcoming local conservation-related events and watershed progress via an annual newsletter distributed through email and the SWCD website, press releases, and weekly social media posts.	Invite all target audiences to subscribe. Include an article and link for the Pine Creek Watershed annual report.	General public Landowners/ operators Local officials SWCD partners	Educator	730 landowner/operators invited to subscribe. Watershed report is distributed annually.

11.0 Cost Analysis

Cost estimates were calculated based on current NRCS and DATCP cost-share rates, incentives payments to get necessary participation, and current conservation project installation rates. Landowners will be responsible for maintenance costs associated with installed practices. The total cost to implement the watershed plan is estimated to be $2,766,321.00.

Summary of Cost Analysis

- $1,623,821.00 to implement best management practices.
- $930,000.00 needed for technical assistance
- $64,000.00 needed for operating costs
- $148,500 needed for water quality monitoring

BMP	Quantity	Cost /Unit $	Payment Timeframe	Total Cost
Upland Control				
New Nutrient Management Plans	655 acres	$40/acre	One-time payment	$26,200
Low rate/low disturbance manure injection	800 acres	$70/acre/year	3 years	$168,000
Grassed Waterway without tile	2,250 lin. Ft.	$4.21/lin. Ft.	One-time payment	$9,473.00
Grassed Waterways with tile	2,250 lin. Ft.	$6.31/lin. Ft.	One-time payment	$14,198.00
Cover Crops	1,700 acres	$41/acre/year	3 years	$209,100.00
Reduced Tillage/No Till	700 acres	$18.50/acre/year	3 years	$38,850.00
Wetland Restoration	5 acres	$30,000/acre	One-time payment	$150,000.00
Streambank Erosion Control				
Stream Buffer	200 acres	$236/acre/year	15 years	$708,000.00
Farm Production Site				
Barnyard/Feed Storage Runoff Control System	2	$150,000	One-time payment	$300,000.00
Operating Costs				
Tour/Field Days	10 events	$500		$5,000.00
Mileage	5,000 miles	.58/mile/year	10 years	$29,000.00
Office/Operating/Education Supplies		$3,000/year	10 years	$30,000.00

BMP	Quantity	Cost /Unit $	Payment Timeframe	Total Cost
Technical Assistance				
Resource Conservationist	1,000 hours/year	$60,000.00	10 years	$600,000.00
Education Coordinator	300 hours/year	$18,000.00	10 years	$180,000.00
Engineering		$15,000/year	10 years	$150,000.00

TABLE 18: ESTIMATED COST FOR MANAGEMENT MEASURES AND TECHNICAL ASSISTANCE.

Water Quality Monitoring: UW Green Bay - Manitowoc	**Cost**
Water Monitoring **Includes:** Total Phosphorus and Total Suspended Solids on 4 stream sites: 2 on Calvin Creek and 2 on Pine Creek, 4 Lakes: Carstens, Gass, Hartlaub, and Weyers **Frequency:** 1 time per month for 6 months – May through October for a 10 year period.	$118,500.00 over 10 year period
Equipment	$30,000.00 over 10 year period
Total	$148,500.00

TABLE 19: ESTIMATED COST FOR WATER QUALITY MONITORING

This cost estimate reflects contracting with UW Green Bay-Manitowoc Campus for all services. If follow-up monitoring for the TMDL process or other WDNR monitoring is carried out in the watershed, this cost estimate would be reduced. Cost of new technologies was not included in this estimate since the quantity of these technologies that may be needed is not yet known.

Operation & Maintenance

This plan will require a land owner to agree to a 10 year maintenance period for practices such as vegetated buffers, grassed waterways, wetland restoration, barnyard runoff control, manure storage, streambank stabilization including crossings and fencing, and concentrated flow area seedings. For practices such as conservation tillage, cover crops, and nutrient management landowners are required to maintain the practice for each period that cost sharing is available. Upon completion of the operation and maintenance period, point source dischargers may be able to work with operators and landowners to continue implementation of the BMP's under a pollutant trading agreement (non EPA 319 monies).

Funding Sources

There are many state and federal programs that currently provide funding sources for conservation practices. Recently the option of adaptive management and water quality trading has become another option for funding of practices.

Federal and State Funding Sources

A brief description of current funding programs available and their acronyms are listed below:

Environmental Quality Incentives Program (EQIP) - Program provides financial and technical assistance to implement conservation practices that address resource concerns. Farmers receive flat rate payments for installing and implementing runoff management practices.

Conservation Reserve Program (CRP) - A land conservation program administered by the Farm Service Agency. Farmers enrolled in the program receive a yearly rental payment for environmentally sensitive land that they agree to remove from production. Contracts are 10-15 years in length. Eligible practices include buffers for wildlife habitat, wetland buffers, riparian buffers, wetland restorations, filter strips, grass waterways, shelter belts, living snow fences, contour grass strips, and shallow water areas for wildlife.

Conservation Reserve Enhancement Program (CREP) - Program provides funding for installation, rental payments, and a sign-up incentive payment. A 15 year contract or perpetual contract conservation easement can be entered into. Eligible practices include filter strips, buffer strips, wetland restoration, tall grass prairie and oak savanna restoration, grassed waterway, and permanent native grasses.

ACEP- Agricultural Conservation Easement Program - New program that consolidates three former programs (Wetlands Reserve Program, Grassland Reserve Program, and Farm and Ranchlands Protection Program). Under this program NRCS provides financial assistance to eligible partners for purchasing Agricultural Land Easements that protect the agriculture use and conservation values of eligible land.

Targeted Runoff Management Grant Program (TRM) - Program offers competitive grants for local governments for controlling nonpoint source pollution. Grants reimburse costs for agriculture or urban runoff management practices in critical areas with surface or groundwater quality concerns. The cost-share rate for TRM projects is up to 70% of eligible costs.

Conservation Stewardship Program (CSP) – Program offers funding for participants that take additional steps to improve resource condition. Program provides two types of funding through 5 year contracts; annual payments for installing new practices and maintaining existing practices as well as supplemental payments for adopting a resource conserving crop rotation.

Great Lakes Restoration Initiative (GLRI) - The largest funding program investing in the Great Lakes. The GLRI program was launched in 2010 to accelerate efforts to protect and restore the Great Lakes; the largest system of fresh surface water in the world. The program provides funding to target the biggest threats to the Great Lakes ecosystem.

Farmable Wetlands Program (FWP) - Program designed to restore previously farmed wetlands and wetland buffer to improve both vegetation and water flow. The Farm Service Agency runs the program through the Conservation Reserve Program with assistance from other government agencies and local conservation groups.

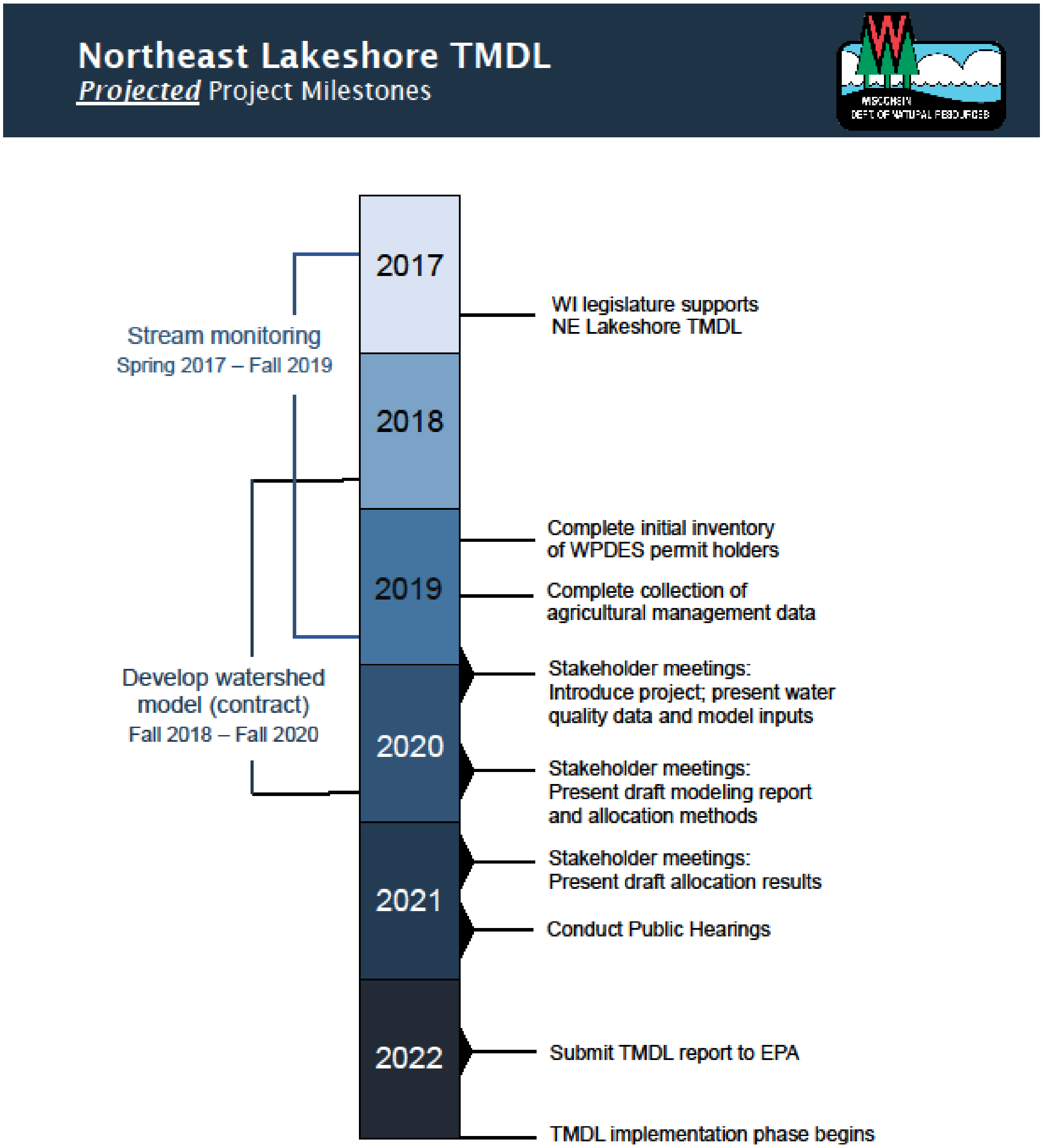
Land Trusts - Landowners also have the option of working with a land trust to preserve land. Land trusts preserve private land through conservation easements, purchase land from owners, and accept donated land.

12.0 Measuring Planned Progress and Success

A combination of state standards, state prohibitions, and local ordinances will be used to implement and enforce conservation practices and compliance. Reference Chapter 1 for jurisdictional roles and local ordinances that apply.

Existing runoff management standards have been established by the State of Wisconsin. Chapter NR 151 Runoff Management provides runoff management standards and prohibitions for agriculture. There has been limited enforcement of the state standards due to lack of funding and staff in this watershed area. This plan recommends enforcement of the state runoff standards when implementing the plan. NR 151.005 (Performance standard for total maximum daily loads) states that a crop producer or livestock producer subject to this chapter shall reduce discharges of pollutants from a livestock facility or cropland to surface waters if necessary to meet a load allocation in a US EPA and state approved TMDL. Local ordinances and regulations will also be used to implement conservation practices and compliance. Manitowoc County Soil and Water Conservation Department will work with landowners to implement conservation practices. Landowners will be educated on programs and funding available to them, as well as current state and local agricultural regulations.

Furthermore, it is recommended that the 9-Key Element Plan for the Pine Creek Watershed adopt the designated limits and load allocations in the Northeast Lakeshore TMDL which is under development and is expected to be completed in approximately 2022. (Figure 34) Once completed, the two plans will be compared and this 9-Key Element Plan will be updated with information/reduction goals for the watershed. When the TMDL is adopted, crop producers and livestock producers will be required to reduce discharges of pollutants to surface water from a livestock facility or cropland if it is deemed necessary to meet a load allocation in a US EPA and state approved TMDL.



For more information on the NE Lakeshore TMDL, contact:
Kim Oldenborg
NE Lakeshore TMDL project coordinator, WDNR - (608)-266-7037 - Kimbery.Oldenborg@Wisconsin.gov
Or visit: https://dnr.wi.gov/topic/TMDLs/NELakeshore.html

FIGURE 34: NORTHEAST LAKESHORE TMDL PROJECTED MILESTONES

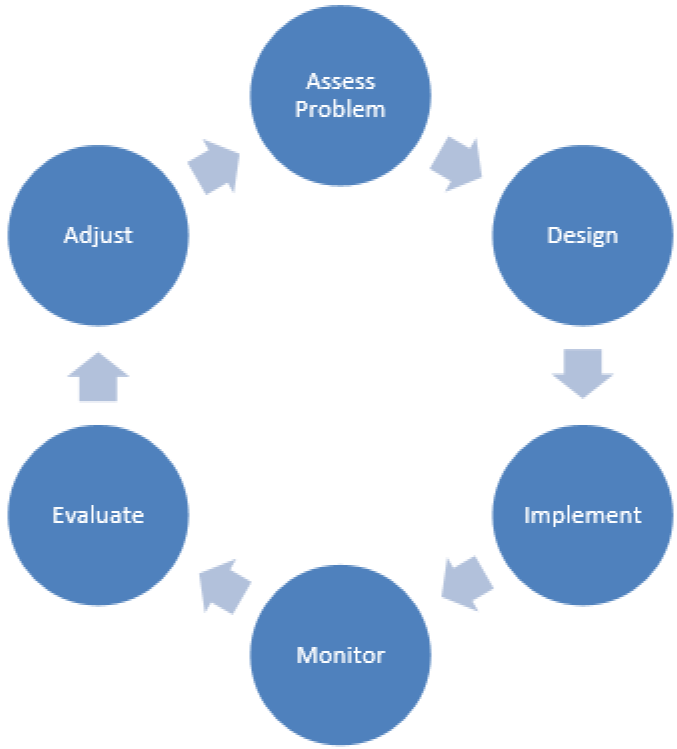


FIGURE 35: PROGRESS EVALUATION MODEL

Water Quality Monitoring Progress Evaluation

This implementation plan recognizes that estimated pollutant load reductions and expected improvement in water quality or aquatic habitat may not occur immediately following implementation of practices due to several factors (described below) that will need to be taken into consideration when evaluating water quality data. These factors can affect or mask progress that plan implementation has made elsewhere. Consultation with the WDNR and Water Quality biologists will be critical when evaluating water quality or aquatic habitat monitoring results. Milestones for pollutant load reductions are shown in Table 20. If the target values/goals for water quality improvement for the milestone period are not being achieved, the water quality targets or timetable for pollutant reduction will need to be evaluated and adjusted as necessary. The following criteria will be evaluated when water quality and aquatic habitat monitoring is completed after implementation of practices:

- Changes in land use or crop rotations within the same watershed where practices are implemented. (Increase in cattle numbers, corn silage acres, and/or urban areas can negatively impact stream quality and water quality efforts)
- Location in watershed where land use changes or crop rotations occur. (Where are these changes occurring in relation to implemented practices?)
- Watershed size, location where practices are implemented and location of monitoring sites.

- Climate, precipitation and soil conditions that occurred before and during monitoring periods. (Climate and weather patterns can significantly affect growing season, soil conditions, and water quality)
- Frequency and timing of monitoring.
- Percent of watershed area (acres) or facilities (number) meeting NR 151 performance standards and prohibitions.
- Percent of watershed area (acres) or facilities (number) that maintain implemented practices over time.
- Extent of gully erosion on crop fields within the watershed over time. How many are maintained in perennial vegetation vs. plowed under each year?
- Stability of bank sediments and how much this sediment may be contributing P and TSS to the stream
- How "Legacy' sediments already within the stream and watershed may be contributing P and sediment loads to stream?
- Presence and extent of drain tiles in watershed area in relation to monitoring locations. Do these drainage systems contribute significant P and sediment loads to receiving streams?
- Do monitored streams meet IBI and habitat criteria but does not meet TMDL water quality criteria?
- Are targets reasonable? Load reductions predicted by models could be overly optimistic.

US EPA Technical Memorandum #1

The methods outlined in the US EPA technical memo, "Adjusting for Depreciation of Land Treatment When Planning Watershed Projects" will be used when evaluating BMP effectiveness and identifying factors that may affect BMP performance levels and implementation in this plan. For additional information on BMP depreciation see Appendix C.

Monitoring Agricultural Fields, Programs, and Practices

The Manitowoc County Soil and Water Conservation Department will continue to use available resources to monitor water quality, cropland, soil health, nutrient management plans, livestock operations, and BMP efficiency.

Furthermore, SWCD will track participation and compliance for the Farmland Preservation Program, Livestock Siting Licenses, the Soil and Water Resource Management Program, the Conservation Reserve Enhancement Program, nutrient management plans, local ordinance complaints and violations, and manure storage permits.

Tillage Practices and Residue Management

Tillage conditions within the Pine Creek and other watersheds change over time. Accordingly, this plan will employ a new method of analyzing Crop residue levels and tillage intensity from readily available satellite imagery. Since tillage takes place at different times, a series of Landsat 8 satellite images -

https://landsat.usgs.gov/landsat-8 -will be selected for analysis in spring and fall months to calculate a minimum Normalized Difference Tillage Index (NDTI) for the Pine Creek watershed. The NDTI estimates crop residue levels based on shortwave infrared wavelengths.

Link to Wisconsin Land & Water Conservation Association NDTI Webinar:
http://wislandwatermedia.org/2018/05/02/webinar-satellite-imagery-used-in-conservation/

The example image below displays the mean minNDTI values per agricultural field in a Lower Fox basin watershed. The mean minNDTI will help to easily identify areas in the Pine Creek watershed that would be good candidates for implementation of reduced tillage practices and cover crops. This analysis of imagery can also be used as a way to track implementation of cropping practices as more years of imagery is collected, since satellites regularly circle the earth.

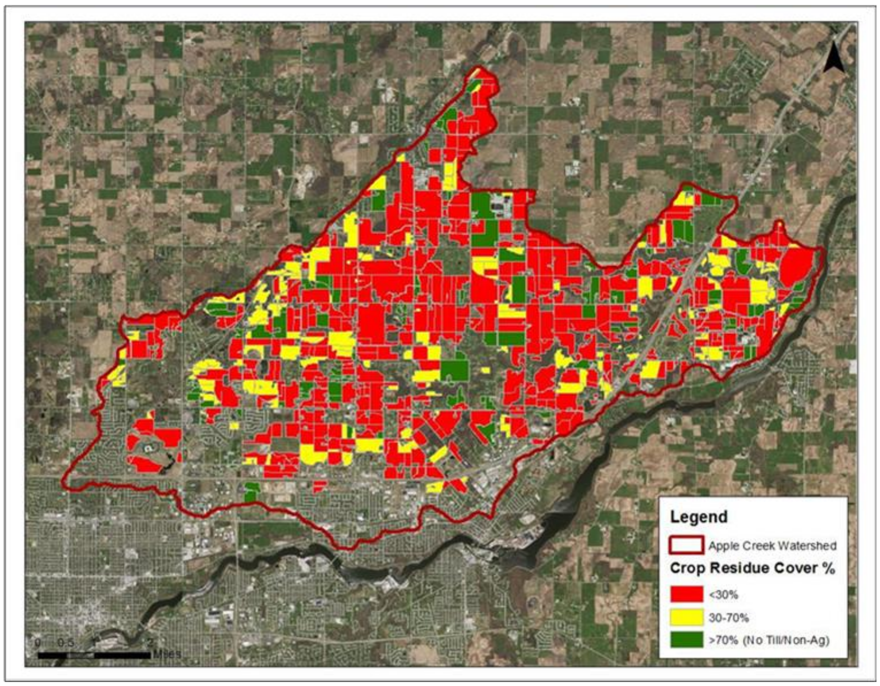


FIGURE 36: CROP RESIDUE COVER ESTIMATES BASED ON NORMALIZE DIFFERENCE TILLAGE INDEX

Manitowoc County SWCD will complete a Normalized Difference Tillage Index (NDTI) analysis for the watershed in the first year of implementation, then repeat the same analysis annually over the plan's ten year schedule to evaluate plan implementation and watershed tillage practices.

Tracking of Progress and Success of Plan

Progress and success of the Pine Creek Watershed Project will be tracked by the following components:

Information and education activities and participation 2) Pollution reduction evaluation based on BMP's installed 3) Water quality monitoring 4) Administrative review

The Manitowoc County Soil and Water Conservation Department will be responsible for tracking progress of the plan.

Reports will be completed annually, and a final report will be prepared at the end of the project.

1) Information and education reports will include: a) Number of landowners/operators in the watershed plan area. b) Number of eligible landowners/operators in the watershed plan area. c) Number of landowners/operators contacted. d) Number of cost-share agreements signed. e) Number and type of information and education activities held, who lead the activity, how many invited, how many attended, and any measurable results of I&E activities. f) Number of informational flyers/brochures distributed per given time period. g) Number of one on one contacts made with landowners in the watershed. h) Number of newspaper articles related to water quality protection. i) Percent change in attendance at information and education activities held. j) Comments or suggestions for future activities.

2) Installed best management practices will be mapped using GIS. Pollution reductions from completed projects will be evaluated using models and spreadsheet tools such as STEPL and SnapPlus for upland practices and the BERT model for barnyard practices. Installation dates, design specifications, operation and maintenance periods, practice inspections, estimated load reductions and cost share sources/amounts will also be tracked in a GIS database.

Report parameters for pollutant reduction evaluation for BMPs installed: a) Planned and completed BMP's. b) Pollutant load reductions and percent of goal planned and achieved. c) Cost-share funding source of planned and installed BMP's. d) Numbers of checks to make sure management plans are being followed by landowners. e) Number of checks to make sure practices are being operated and maintained properly. f) The fields and practices selected and funded by a point source (adaptive management or water quality trading) compliance options will be carefully tracked to assure that Section 319 funds are not being used to implement practices that are part of a point source permit compliance strategy. g) Number of new and alternative technologies and management measures assessed for feasibility, used, and incorporated into plan. h) Changes in land use or land management in watershed that may impact BMP effectiveness. i) Variations in weather that may have influenced implementation of BMPs or effectiveness of installed BMPs.

3) Water Quality Monitoring Reporting Parameters: a) Total phosphorus b) Macroinvertebrate Index of Biotic Integrity.

4) Administrative Review tracking and reporting will include: a) Status of grants relating to project. b) Status of project administration including data management, staff training, and BMP monitoring. c) Status of nutrient management planning, and easement acquisition and development. d) Number of cost-share agreements.

e) Total amount of money on cost-share agreements. f) Total amount of landowner reimbursements made. g) Staff salary and fringe benefits expenditures. h) Staff travel expenditures. i) Information and education expenditures. j) Equipment, materials, and supply expenses. k) Professional services and staff support costs. l) Total expenditures for the county. m) Total amount paid for installation of BMP's and amount encumbered for cost-share agreements. n) Number of Water Quality Trading/Adaptive Management contracts.

SWCD will review/field verify all 29 NMPs to ensure they are being implemented. See the 10 Year Management Measures Table in Chapter 8 for an implementation schedule.

Monitoring Water Quality

In order to measure the progress and effectiveness of the watershed plan, water quality monitoring will need to be conducted throughout the plan term. Chemical data will need to be collected for phosphorus and sediment to determine if pollutant loading is actually being reduced as a result of Best Management Practices being implemented within the watershed. Additionally, it is recommended that streambank erosion be assessed for actively eroding sites.

Stream Water Quality Monitoring

The WDNR collected chemical, biological, and physical data on Pine and Calvin Creek for the Pine & Calvin Creek Frontal Lake Michigan TWA WQM 2017. These results were used in this 9-Key Element Plan as a baseline for water quality in the watershed. As part of the monitoring strategy, it is recommended that the WDNR uses the same methodologies to perform a chemical, biological, and physical assessment to determine water quality changes on a three to five year cycle.

In addition to the WDNR TWA WQM report, volunteer monitoring is conducted on various waterbodies by the Manitowoc County Lakes Association, the University of Wisconsin Green Bay, Manitowoc Campus Lakeshore Water Institute. This data may be used as a secondary source of information if deemed necessary.

Streambank Erosion Monitoring

Further inventory of streambanks is needed to identify actively eroding sites in the Pine Creek Watershed. SWCD staff may partner with UW-Green Bay, Manitowoc Campus Lakeshore Water Institute to track rates of lateral recession in Pine Creek. It is recommended that at least three sites identified with 100% or more slope will be monitored by using erosion pins. Erosion pins are metal rods that are inserted perpendicular into the bank. Pins will be measured annually to determine if the sites are actively eroding. If areas are found to be actively eroding, SWCD will determine stabilization strategies.

Legacy Phosphorus and Sediment

Another challenge that presents itself is legacy phosphorus in the soil, lakes and streams. In recent years scientists and watershed managers are finding that water quality is not responding as well as expected to implemented conservation practices (Sharpley et al 2013). They are attributing this slower and smaller response to legacy phosphorus. Legacy phosphorus is used to describe the accumulated phosphorus that can serve as a long- term source of P to surface waters. Legacy phosphorus in a soil occurs when phosphorus in soils builds up much more rapidly than the decline due to crop uptake. In stream channels and lakes, legacy phosphorus can result from sediment deposition of particulate phosphorus, sorption of dissolved phosphorus onto riverbed sediments or suspended sediments, or by incorporation into the water column (Sharpley et al 2013). Therefore, water quality may not respond to implementation of conservation practices in a watershed as quickly as expected due to remobilization of legacy phosphorus hot spots.

Manitowoc County SWCD will complete a phosphorus waterway corridor and depression assessment on several representative farms in the watershed.   The assessment will include high density soil testing for phosphorus in cropland in and adjacent to concentrated flow channels and in closed depressions.   Precision fertilizing will be used to reduce rates of application in high concentration areas.   Follow-up testing will be conducted to determine the reductions in soil phosphorus levels.

Progress Evaluation

Due to the uncertainty of models and the efficiency of best management practices, an adaptive management approach should be taken with this subwatershed (Figure 35). Milestones are essential when determining if management measures are being implemented and how effective they are at achieving plan goals over a given time period. Milestones are based on the plan implementation schedule with short term (0-3 years), medium term (3-7 years), and long term (7-10 years) milestones. After the implementation of practices and monitoring of water quality, plan progress and success should be evaluated after each milestone period. In addition to the annual report, a progress report should be completed at the end of each milestone period. The progress report will be used to identify and track plan implementation to ensure that progress is being made and to make corrections as necessary. Plan progress will be determined by minimum progress criteria for management practices, water quality monitoring, and information and education activities held. If lack of progress is demonstrated, factors resulting in milestones not being met should be included in the report. Adjustments should be made to the plan based on plan progress and any additional new data and/or watershed tools. If less than 25% of practices are implemented by year 5 of this plan or if the Manitowoc County SWCD loses one staff member for more than a year during the first five years of the plan schedule, the plan milestones need to be reset to reflect minimum progress achieved.

Monitoring Recommendation	Indicators	Current Values	Target Value or Goal [1]	Milestones			Imple-mentation	Funding
				Short Term (3 yrs.)	Medium Term (7 yrs.)	Long Term (10 yrs.)		
WDNR Phosphorus Monitoring on Calvin Creek at CTH LS	Phosphorus Concentration mg/l	.218 2016 average	.170	.202	.186	.170	WDNR	WDNR
WDNR Phosphorus Monitoring on Pine Creek at CTH LS	Phosphorus Concentration mg/l	.086 2016 average	.067	.080	.074	.067	WDNR	WDNR
Lakeshore Water Institute Phosphorus Monitoring on Calvin Creek at South 26th St.	Phosphorus Concentration mg/l	.305 2018 average	.238	.283	.261	.238	Lakeshore Water Institute	WDNR UWGB
Lakeshore Water Institute Phosphorus Monitoring on Pine Creek at HWY U	Phosphorus Concentration mg/l	.119 2018 average	.093	.110	.101	.093	Lakeshore Water Institute	WDNR UWGB
WDNR Macroinvertebrate Index of Biological Integrity monitoring at 6 stations on Calvin & Pine Creeks (see figure 13)	mIBI Values	Poor-Fair	Good	Fair	Fair	Good	WDNR	WDNR

TABLE 20: MONITORING RECOMMENDATIONS

[1] ACHIEVING THE AGRICULTURAL PRACTICE MILESTONES IN THIS PLAN MAY NOT GENERATE ENOUGH TP REDUCTION TO MEET/REFLECT THIS PLAN'S LONG TERM WQ MILESTONES.

13.0 Literature Cited

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Appendix

Appendix A: Glossary of Terms and Acronyms

Baseline –An initial set of observations or data used for comparison or as a control.

Best Management Practice (BMP) – A method that has been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources.

Cost-Sharing- Financial assistance provided to a landowner to install and/or use applicable best management practices.

Ephemeral gully- Voided areas that occur in the same location every year that are crossable with farm equipment and are often partially filled in by tillage.

Erosion Vulnerability Assessment for Agricultural Lands (EVAAL) – Developed by Wisconsin Department of Natural Resources

Geographic Information System (GIS) – A tool that links spatial features commonly seen on maps with information from various sources ranging from demographics to pollutant sources.

Hydrologic Unit Code (HUC) is a sequence of numbers or letters that identify a hydrological feature like a river, reach, lake, or area like a drainage basin (also called watershed (in North America)) or catchment.

Index of Biotic Integrity (IBI) – An indexing procedure commonly used by academia, agencies, and groups to assess watershed condition based on the composition of a biological community in a water body.

Lateral Recession Rate- the thickness of soil eroded from a bank surface (perpendicular to the face) in an average year, given in feet per year.

Macroinvertebrate IBI (MIBI) – Macroinvertebrate index of biological integrity

Natural Resources Conservation Service (NRCS) - Provides technical expertise and conservation planning for farmers, ranchers, and forest landowners wanting to make conservation improvements to their land.

Phosphorus Index (PI) – The phosphorus index is used in nutrient management planning. It is calculated by estimating average runoff phosphorus delivery from each field to the nearest surface water in a year given the field's soil conditions, crops, tillage, manure and fertilizer applications, and long term weather patterns. The higher the number the greater the likely hood that the field is contributing phosphorus to local water bodies.

Riparian – Relating to or located on the bank of a natural watercourse such as a river or sometimes of a lake or tidewater

Soil Nutrient Application Manager (SNAP) – Wisconsin's nutrient management planning software.

Spreadsheet Tool for Estimating Pollutant Load (STEPL) - Model that calculates nutrient loads (Phosphorus, Nitrogen, and Biological Oxygen Demand) by land use type and aggregated by watershed.

Soil and Water Assessment Tool (SWAT) – A small watershed to river basin-scale model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. Model is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds.

Stream Power Index (SPI) – Measures the erosive power of overland flow as a function of local slope and upstream drainage area.

Total Suspended Sediment (TSS) - The organic and inorganic material suspended in the water column and greater than 0.45 micron in size.

Total Maximum Daily Load (TMDL) - A calculation of the maximum amount of pollutant that a water body can receive and still meet water quality standards.

United States Geological Survey (USGS) – Science organization that collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems.

United States Environmental Protection Agency (USEPA) – Government agency to protect human health and the environment.

University of Wisconsin Extension (UWEX) – UW-Extension works with UW- System campuses, Wisconsin counties, tribal governments, and other public and private organizations to help address economic, social, and environmental issues.

WisCALM – Wisconsin Consolidated Assessment and Listing Methodology for water quality

Wisconsin Department of Natural Resources (WDNR) – State organization that works with citizens and businesses to preserve and enhance the natural resources of Wisconsin.

APPENDIX B STEPL MODEL RESULTS & BMP COMBINED EFFICIENCIES

A	B	C	D	E	F	G	H
Estimate an area-weighted combined efficiency of multiple BMPs (in parallel) across a watershed							
Enter total treated land use area (acre)	6122.00	Cropland	Update BMP List				
Enter the subarea treated by each selected BMP type (upto 20 varying frequency of treatment allowed)							
Treatment	**Area (ac)**	**Select a BMP Type**	**N**	**P**	**BOD**	**Sediment**	**E. coli**
1- WetlandRestore	22.00	Land Retirement	0.898	0.808	0.000	0.950	0.000
2 - NMP2+CT1+Cover	300.00	Combined BMPs-Calculated	0.490	0.740	0.000	0.460	0.000
3	0.00	0 No BMP	0.000	0.000	0.000	0.000	0.000
ied Buffers - 100 ac CREP/easmts - 10 to	1000.00	Buffer - Grass (35ft wide)	0.338	0.435	0.000	0.533	0.000
5 - CAFO NMPs - 2300ac total	1800.00	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.560	0.000	0.000	0.000
6 - Other farm NMPs - 4400ac total	3000.00	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.560	0.000	0.000	0.000
7- Natural/Exist Grass Setbacks	0.00	Buffer - Grass (35ft wide)	0.338	0.435	0.000	0.533	0.000
8		0 No BMP	0.000	0.000	0.000	0.000	0.000
9		0 No BMP	0.000	0.000	0.000	0.000	0.000
10		0 No BMP	0.000	0.000	0.000	0.000	0.000
11		0 No BMP	0.000	0.000	0.000	0.000	0.000
12		0 No BMP	0.000	0.000	0.000	0.000	0.000
13		0 No BMP	0.000	0.000	0.000	0.000	0.000
14		0 No BMP	0.000	0.000	0.000	0.000	0.000
15		0 No BMP	0.000	0.000	0.000	0.000	0.000
16		0 No BMP	0.000	0.000	0.000	0.000	0.000
17		0 No BMP	0.000	0.000	0.000	0.000	0.000
18		0 No BMP	0.000	0.000	0.000	0.000	0.000
19		0 No BMP	0.000	0.000	0.000	0.000	0.000
20		0 No BMP	0.000	0.000	0.000	0.000	0.000
Total Land Use Area	6122.00	nter the calculated value in Table 7. located in "BMPs" tab, under the appropriate watershed -->	**0.276**	**0.549**	**0.000**	**0.113**	**0.000**
Total Area check:	OK						
Total Cropland Acres	8061.00						
Total Cropland Acres with BMPs	6122.00	76%					
Assumed 80% of CAFO NMP acres consistently implemented							
Assumed 68% of Other Farm NMP acres consistently implemented							

Pine Creek 9E Plan – FUTURE Practices and Combined BMP Pollutant Reduction Efficiencies

Estimate an area-weighted combined efficiency of multiple BMPs (in parallel) across a watershed

Enter total treated land use area (acre) 7027.00 Cropland

Update BMP List

Enter the subarea treated by each selected BMP type (upto 20 varying frequency of treatment allowed)

Treatment	Area (ac)	Select a BMP Type	N	P	BOD	Sediment	E. coli	
1- WetlandRestore	27.00	Land Retirement	0.898	0.808	0.000	0.950	0.000	
2- NMP2+CT1+Cover	1000.00	Combined BMPs-Calculated	0.490	0.740	0.000	0.460	0.000	
3 - NMP2 + LDM Injection (reduced tillage)	800.00	Conservation Tillage 1 (30-59% Residue)	0.360	0.720	0.000	0.403	0.000	Option to Verify BMP efficiency values using SNAP+
ıed Buffers - 100 ac CREP/easmts - 10 to	1000.00	Buffer - Grass (35ft wide)	0.338	0.435	0.000	0.533	0.000	
5 - CAFO NMPs - 2300ac total	1400.00	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.560	0.000	0.000	0.000	
6 - Other farm NMPs - 4400ac total	1600.00	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.560	0.000	0.000	0.000	
7 - Natural/Exist Grass Setbacks	0.00	Buffer - Grass (35ft wide)	0.338	0.435	0.000	0.533	0.000	Option to field verify watershed to confirm if some fi
8 - NMP2+ Cover2	1000.00	Combined BMPs-Calculated	0.395	0.590	0.000	0.100	0.000	
) - New Designed/Harvested Grass Buffe	200.00	Buffer - Grass (35ft wide)	0.338	0.435	0.000	0.533	0.000	
10		0 No BMP	0.000	0.000	0.000	0.000	0.000	
11		0 No BMP	0.000	0.000	0.000	0.000	0.000	
12		0 No BMP	0.000	0.000	0.000	0.000	0.000	
13		0 No BMP	0.000	0.000	0.000	0.000	0.000	
14		0 No BMP	0.000	0.000	0.000	0.000	0.000	
15		0 No BMP	0.000	0.000	0.000	0.000	0.000	
16		0 No BMP	0.000	0.000	0.000	0.000	0.000	
17		0 No BMP	0.000	0.000	0.000	0.000	0.000	
18		0 No BMP	0.000	0.000	0.000	0.000	0.000	
19		0 No BMP	0.000	0.000	0.000	0.000	0.000	
20		0 No BMP	0.000	0.000	0.000	0.000	0.000	
Total Land Use Area	7027.00	ter the calculated value in Table 7. located in "BMPs" tab, under the appropriate watershed -->	0.334	0.588	0.000	0.220	0.000	

Total Area check:	OK	
Total Cropland Acres	8061.00	
Total Cropland Acres with BMPs	7027.00	87%
New Practices	**Acres**	**Current**
NMP2+CT1+CoverCrop2	700.00	300
NMP2+Cover2	1000.00	0
NMP2 + LDMI	800.00	0
New Buffer - Designed/Harvested	200.00	0
Wetland Restore - Cropland Retire	5.00	22

STEPL Pollutant Load Reductions: Current Load – Future Load = Watershed Load Reduction

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	E. coli Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	E. coli Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	Billion MPN/y	lb/year	lb/year	lb/year	t/year	Billion MPN/y	lb/year	lb/year	lb/year	t/year
W1 - 603	99067.1	24089.6	193401.0	3909.3	0.0	25137.7	8676.8	4566.7	690.5	0.0	73929.4	15412.8	188834.3	3218.9
W2 - 602	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W3 - 601	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	99067.1	24089.6	193401.0	3909.3	0.0	25137.7	8676.8	4566.7	690.5	0.0	73929.4	15412.8	188834.3	3218.9

Future

2. Total load by land uses (with BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	E. coli Load (Billion MPN/yr)
Urban	15104.87	2539.65	52454.06	366.09	0.00
Cropland	45266.70	10192.02	105146.74	2822.18	0.00
Pastureland	535.73	47.36	1721.20	4.98	0.00
Forest	606.88	304.96	1486.82	18.98	0.00
Feedlots	12168.96	2230.98	27042.13	0.00	0.00
User Defined	0.00	0.00	0.00	0.00	0.00
Septic	235.62	92.28	962.11	0.00	0.00
Gully	10.63	5.58	21.25	6.64	0.00
Streambank	0.00	0.00	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00	0.00	0.00
Total	73929.39	15412.82	188834.30	3218.87	0.00
		12470.35		2827.16	

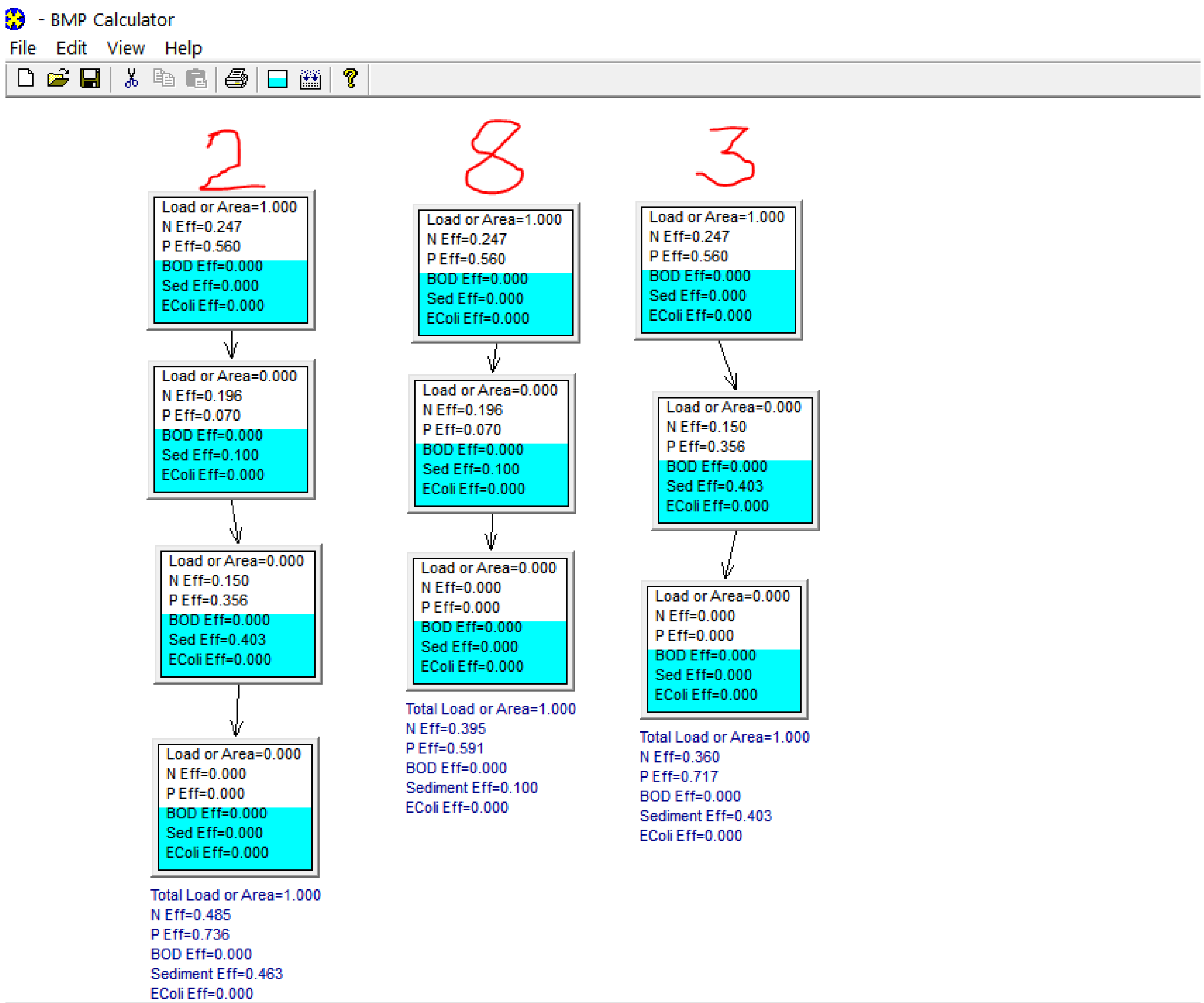
3492.07 lb/yr TP reduction
21.9%

369.07 t/yr Sediment Reduction
11.5%

Current

2. Total load by land uses (with BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	E. coli Load (Billion MPN/yr)
Urban	15104.87	2539.65	52454.06	366.09	0.00
Cropland	50549.19	11858.75	107508.80	3191.25	0.00
Pastureland	535.73	47.36	1721.20	4.98	0.00
Forest	606.88	304.96	1486.82	18.98	0.00
Feedlots	20281.60	4056.32	27042.13	0.00	0.00
User Defined	0.00	0.00	0.00	0.00	0.00
Septic	235.62	92.28	962.11	0.00	0.00
Gully	10.63	5.58	21.25	6.64	0.00
Streambank	0.00	0.00	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00	0.00	0.00
Total	87324.51	18904.89	191196.36	3587.94	0.00
		15962.42		3196.23	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File Edit View Help
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P Eff=0.560
BOD Eff=0.000
Sed Eff=0.000
EColi Eff=0.000
Load or Area=0.000
N Eff=0.196
P Eff=0.070
BOD Eff=0.000
Sed Eff=0.100
EColi Eff=0.000
Load or Area=0.000
N Eff=0.150
P Eff=0.356
BOD Eff=0.000
Sed Eff=0.403
EColi Eff=0.000
Load or Area=0.000
N Eff=0.000
P Eff=0.000
BOD Eff=0.000
Sed Eff=0.000
EColi Eff=0.000
Total Load or Area=1.000
N Eff=0.485
P Eff=0.736
BOD Eff=0.000
Sediment Eff=0.463
EColi Eff=0.000
8
Load or Area=1.000
N Eff=0.247
P Eff=0.560
BOD Eff=0.000
Sed Eff=0.000
EColi Eff=0.000
Load or Area=0.000
N Eff=0.196
P Eff=0.070
BOD Eff=0.000
Sed Eff=0.100
EColi Eff=0.000
Load or Area=0.000
N Eff=0.000
P Eff=0.000
BOD Eff=0.000
Sed Eff=0.000
EColi Eff=0.000
Total Load or Area=1.000
N Eff=0.395
P Eff=0.591
BOD Eff=0.000
Sediment Eff=0.100
EColi Eff=0.000
3
Load or Area=1.000
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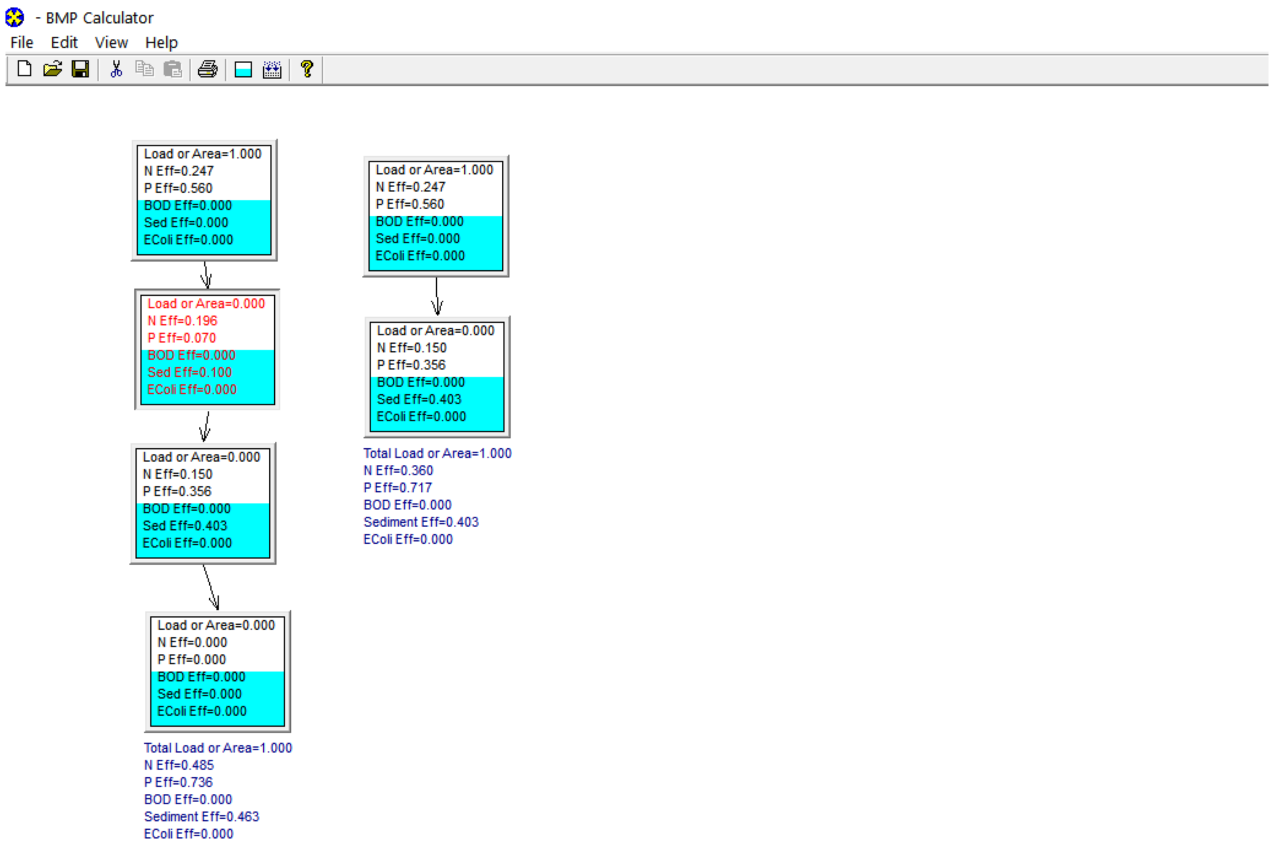
P Eff=0.560
BOD Eff=0.000
Sed Eff=0.000
EColi Eff=0.000
Load or Area=0.000
N Eff=0.150
P Eff=0.356
BOD Eff=0.000
Sed Eff=0.403
EColi Eff=0.000
Load or Area=0.000
N Eff=0.000
P Eff=0.000
BOD Eff=0.000
Sed Eff=0.000
EColi Eff=0.000
Total Load or Area=1.000
N Eff=0.360
P Eff=0.717
BOD Eff=0.000
Sediment Eff=0.403
EColi Eff=0.000


- BMP Calculator
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Load or Area=0.000
N Eff=0.196
P Eff=0.070
BOD Eff=0.000
Sed Eff=0.100
EColi Eff=0.000
Load or Area=0.000
N Eff=0.150
P Eff=0.356
BOD Eff=0.000
Sed Eff=0.403
EColi Eff=0.000
Load or Area=0.000
N Eff=0.000
P Eff=0.000
BOD Eff=0.000
Sed Eff=0.000
EColi Eff=0.000
Total Load or Area=1.000
N Eff=0.485
P Eff=0.736
BOD Eff=0.000
Sediment Eff=0.463
EColi Eff=0.000
Load or Area=1.000
N Eff=0.247
P Eff=0.560
BOD Eff=0.000
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EColi Eff=0.000
Load or Area=0.000
N Eff=0.150
P Eff=0.356
BOD Eff=0.000
Sed Eff=0.403
EColi Eff=0.000
Total Load or Area=1.000
N Eff=0.360
P Eff=0.717
BOD Eff=0.000
Sediment Eff=0.403
EColi Eff=0.000

EPA
United States
Environmental Protection
Agency

This Technical Memorandum is one of a series of publications designed to assist watershed projects, particularly those addressing nonpoint sources of pollution. Many of the lessons learned from the Clean Water Act Section 319 National Nonpoint Source Monitoring Program are incorporated in these publications.

October 2015

Donald W. Meals and Steven A. Dressing. 2015. Technical Memorandum #1: Adjusting for Depreciation of Land Treatment When Planning Watershed Projects, October 2015. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc., Fairfax, VA, 16 p. Available online at https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/watershed-approach-technical-resources.

Technical Memorandum #1

Adjusting for Depreciation of Land Treatment When Planning Watershed Projects

Introduction


Fields near Seneca Lake, New York.

Watershed-based planning helps address water quality problems in a holistic manner by fully assessing the potential contributing causes and sources of pollution, then prioritizing restoration and protection strategies to address the problems (USEPA 2013). The U.S. Environmental Protection Agency (EPA) requires that watershed projects funded directly under section 319 of the Clean Water Act implement a watershed-based plan (WBP) addressing the nine key elements identified in EPA's *Handbook for Developing Watershed Plans to Restore and Protect our Waters (USEPA 2008)*. EPA further recommends that all other watershed plans intended to address water quality impairments also include the nine elements. The first element calls for the identification of causes and sources of impairment that must be controlled to achieve needed load reductions. Related elements include a description of the nonpoint source (NPS) management measures—or best management practices (BMPs)—needed to achieve required pollutant load reductions, a description of the critical areas in which the BMPs should be implemented, and an estimate of the load reductions expected from the BMPs.

Once the causes and sources of water resource impairment are assessed, identifying the appropriate BMPs to address the identified problems, the best locations for additional BMPs, and the pollutant load reductions likely to be achieved with the BMPs depends on accurate information on the performance levels of both BMPs already in place and BMPs to be implemented as part of the watershed project. All too often, watershed managers and Agency staff have assumed that, once certified as installed or adopted according to specifications, a BMP continues to perform its pollutant reduction function at the same efficiency (percent pollutant reduction) throughout its design or contract life, sometimes longer. An important corollary to this assumption is that BMPs in place during project planning are performing as originally intended. Experience in NPS watershed projects across the nation, however, shows that, without diligent operation and maintenance, BMPs and their effects probably will depreciate over time, resulting in less efficient pollution reduction. Recognition of this fact is important at the project planning phase, for both existing and planned BMPs.

Knowledge of land treatment depreciation is important to ensure project success through the adaptive management process (USEPA 2008). BMPs credited during the planning phase of a watershed project will be expected to achieve specific load reductions or other water quality benefits as part of the overall plan to protect or restore a water body. Verification that BMPs are still performing their functions at anticipated levels is essential to keeping a project on track to achieve its overall goals. Through adaptive management, verification results can be used to inform decisions about needs for additional BMPs or maintenance or repair of existing BMPs. In a watershed project that includes short-term (3–5 years) monitoring, subtle changes in BMP performance level might not be detectable or critical, but planners must account for catastrophic failures, BMP removal or discontinuation, and major maintenance shortcomings. Over the longer term, however, gradual changes in BMP performance level can be significant in terms of BMP-specific pollutant control or the role of single BMPs within a BMP system or train. The weakest link in a BMP train can be the driving force in overall BMP performance.

Application of and methods for BMP tracking in NPS watershed projects are described in detail in *Tech Notes 11* (Meals et al. 2014).

This technical memorandum addresses the major causes of land treatment depreciation, ways to assess the extent of depreciation, and options for adjusting for depreciation. While depreciation occurs throughout the life of a watershed project, the emphasis is on the planning phase and the short term (i.e., 3–5 years).

Causes of Depreciation

Depreciation of land treatment function occurs as a result of many factors and processes. Three of the primary causes are natural variability, lack of proper maintenance, and unforeseen consequences.

Natural Variability

Climate and soil variations across the nation influence how BMPs perform. Tiessen et al. (2010), for example, reported that management practices designed to improve water quality by reducing sediment and sediment-bound nutrient export from agricultural fields can be less effective in cold, dry regions where nutrient export is primarily snowmelt driven and in the dissolved form, compared to similar practices in warm, humid regions. Performance levels of vegetation-based BMPs in both agricultural and urban settings can vary significantly through the year due to seasonal dormancy. In a single locale, year-to-year variation in precipitation affects both agricultural management and BMP performance levels. Drought, for example, can suppress crop yields, reduce nutrient uptake, and result in nutrient surpluses left in the soil after harvest where they are vulnerable to runoff or leaching loss despite careful nutrient management. Increasing incidence of extreme weather and intense storms can overwhelm otherwise well-designed stormwater management facilities in urban areas.

Lack of Proper Maintenance

Most BMPs—both structural and management—must be operated and maintained properly to continue to function as designed. Otherwise, treatment effectiveness can depreciate over time. For example, in a properly functioning detention pond, sediment typically accumulates in the forebay. Without proper maintenance to remove accumulated sediment, the capacity of the BMP to contain and treat stormwater is diminished. Similarly, a nutrient management plan is only as effective as its implementation. Failure to adhere to phosphorus (P) application limits, for example, can result in soil P buildup and increased surface and subsurface losses of P rather than the loss reductions anticipated.

Jackson-Smith et al. (2010) reported that over 20 percent of implemented BMPs in a Utah watershed project appeared to be no longer maintained or in use when evaluated just 5 years after project completion. BMPs related to crop production enterprises and irrigation systems had the lowest rate of continued use and maintenance (~75 percent of implemented BMPs were still in use), followed by pasture and grazing planting and management BMPs (81 percent of implemented BMPs were still in use). Management practices (e.g., nutrient management) were found to be particularly susceptible to failure.

Practices are sometimes simply abandoned as a result of changes in landowner circumstances or attitudes. In a Kansas watershed project, farmers abandoned a nutrient management program because of perceived restrictive reporting requirements (Osmond et al. 2012).

Abandoned waste storage structure.

In the urban arena, a study of more than 250 stormwater facilities in Maryland found that nearly one-third of stormwater BMPs were not functioning as designed and that most needed maintenance (Lindsey et al. 1992). Sedimentation was a major problem and had occurred at nearly half of the facilities; those problems could have been prevented with timely maintenance.

Hunt and Lord (2006) describe basic maintenance requirements for bioretention practices and the consequences of failing to perform those tasks. For example, they indicate that mulch should be removed every 1–2 years to both maintain available water storage volume and increase the surface infiltration rate of fill soil. In addition, biological films might need to be removed every 2–3 years because they can cause the bioretention cell to clog.

In plot studies, Dillaha et al. (1986) observed that vegetative filter strip-effectiveness for sediment removal appeared to decrease with time as sediment accumulated within the filter strips. One set of the filters was almost totally inundated with sediment during the cropland experiments and filter effectiveness dropped 30–60 percent between the first and second experiments. Dosskey et al. (2002) reported that up to 99 percent of sediment was removed from cropland runoff when uniformly distributed over a buffer area, but as concentrated flow paths developed over time (due to lack of maintenance), sediment removal dropped to 15–45 percent. In the end, most structural BMPs have a design life (i.e., the length of time the item is expected to work within its specified parameters). This period is measured from when the BMP is placed into service until the end of its full pollutant reduction function.

Unforeseen Consequences

The effects of a BMP can change directly or indirectly due to unexpected interactions with site conditions or other activities. Incorporating manure into cropland soils to reduce nutrient runoff, for example, can increase erosion and soil loss due to soil disturbance, especially in comparison to reduced tillage. On the other hand, conservation tillage can result in accumulation of fertilizer nutrients at the soil surface, increasing their availability for loss in runoff (Rhoton et al. 1993). Long-term reduction in tillage also can promote the formation of soil macropores, enhancing leaching of soluble nutrients and agrichemicals into ground water (Shipitalo et al. 2000). Stutter et al. (2009) reported that establishment of vegetated buffers between cropland and a watercourse led to enhanced rates of soil P cycling within the buffer, increasing soil P solubility and the potential for leaching to watercourses.

Despite widespread adoption of conservation tillage and observed reductions in particulate P loads, a marked increase in loads of dissolved bioavailable P in agricultural tributaries to Lake Erie has been documented since the mid-1990s. This shift has been attributed to changes in application rates, methods, and timing of P fertilizers on cropland in conservation tillage not subject to annual tillage (Baker 2010; Joosse and Baker 2011). Further complicating matters, recent research on fields in the St. Joseph River watershed in northeast Indiana has demonstrated that about half of both soluble P and total P losses from research fields occurred via tile discharge, indicating a need to address both surface and subsurface loads to reach the goal of 41 percent reduction in P loading for the Lake Erie Basin (Smith et al. 2015).

Several important project planning lessons were learned from the White Clay Lake, Wisconsin, demonstration projects in the 1970s, including the need to accurately assess pollutant inputs and the performance levels of BMPs (NRC 1999). Regarding unforeseen consequences, the project learned through monitoring that a manure storage pit built according to prevailing specifications actually caused ground water contamination that threatened a farmer's well water. This illustrates the importance of monitoring implemented practices over time to ensure that they function properly and provide the intended benefits.

Control of urban stormwater runoff (e.g., through detention) has been widely implemented to reduce peak flows from large storms in order to prevent stream channel erosion. Research has shown, however, that although large peak flows might be controlled effectively by detention storage, stormflow conditions are extended over a longer period of time. Duration of erosive and bankfull flows are increased, constituting channel-forming events. Urbonas and Wulliman (2007) reported that, when captured runoff from a number of individual detention basins in a stream system is released over time, the flows accumulate as they travel downstream, actually increasing peak flows along the receiving waters. This situation can diminish the collective effectiveness of detention basins as a watershed management strategy.

Assessment of Depreciation

The first—and possibly most important—step in adjusting for depreciation of implemented BMPs is to determine its extent and magnitude through BMP verification.

BMP Verification

At its core, BMP verification confirms that a BMP is in place and functioning properly as expected based on contract, permit, or other implementation evidence. A BMP verification process that documents the presence and function of BMPs over time should be included in all NPS watershed projects.

Depreciation assessment indicators

Ideally, assessment of BMP depreciation would be based on actual measurement of each BMP's performance level (e.g., monitoring of input and output pollutant loads for each practice). Except in very rare circumstances, this type of monitoring is impractical. Rather, a watershed project generally must depend on the use of indicators to assess BMP performance level.

The most useful indicators for assessing depreciation are determined primarily by the type of BMP and pollutants controlled, but indicators might be limited by the general verification approach used. For example, inflow and outflow measurements of pollutant load can be used to determine the effectiveness of constructed wetlands, but a verification effort that uses only visual observations will not provide that data or other information about wetland functionality. A central challenge, therefore, is to identify meaningful indicators of BMP performance level that can be tracked under different verification schemes. This technical memorandum provides examples of how to accomplish that end.

Nonvegetative structural practices

Performance levels of nonvegetative structural practices—such as animal waste lagoons, digesters, terraces, irrigation tailwater management, stormwater detention ponds, and pervious pavement—can be assessed using the following types of indicators:

- Measured on-site performance data (e.g., infiltration capacity of pervious pavement),
- Structural integrity (e.g., condition of berms or other containment structures), and
- Water volume capacity (e.g., existing pond volume vs. design) and mass or volume of captured material removed (e.g., sediment removed from stormwater pond forebay at cleanout).

In some cases, useful indicators can be identified directly from practice standards. For example, the Natural Resources Conservation Service lists operation and maintenance elements for a water and sediment control basin (WASCoB) (*USDA-NRCS 2008*) that include:

- Maintenance of basin ridge height and outlet elevations,
- Removal of sediment that has accumulated in the basin to maintain capacity and grade,
- Removal of sediment around inlets to ensure that the inlet remains the lowest spot in the basin, and
- Regular mowing and control of trees and brush.

These elements suggest that ridge and outlet elevations, sediment accumulation, inlet integrity, and vegetation control would be important indicators of WASCoB performance level.

Required maintenance checklists contained in stormwater permits also can suggest useful indicators. For example, the *Virginia Stormwater Management Handbook* (VA DCR 1999) provides an extensive checklist for annual operation and maintenance inspection of wet ponds. The list includes many elements that could serve as BMP performance level indicators:

- Excessive sediment, debris, or trash accumulated at inlet,
- Clogging of outlet structures,

- Cracking, erosion, or animal burrows in berms, and
- More than 1 foot of sediment accumulated in permanent pool.

Assessment of these and other indicators would require on-site inspection and/or measurement by landowners, permit-holders, or oversight agencies.

Vegetative structural practices

Performance levels of vegetative structural practices—such as constructed wetlands, swales, rain gardens, riparian buffers, and filter strips—can be assessed using the following types of indicators:

- Extent and health of vegetation (e.g., measurements of soil cover or plant density),
- Quality of overland flow filtering (e.g., evidence of short-circuiting by concentrated flow or gullies through buffers or filter strips),
- On-site capacity testing of rain gardens using infiltrometers or similar devices, and
- Visual observations (e.g., presence of water in swales and rain gardens).

Parking lot rain garden.

As for non-vegetative structural practices, assessment of these indicators would require on-site inspection and/or measurement by landowners, permit-holders, or oversight agencies.

Nonstructural vegetative practices

Performance levels of nonstructural vegetative practices—such as cover crops, reforestation of logged tracts, and construction site seeding—can be assessed using the following types of indicators:

- Density of cover crop planting (e.g., plant count),
- Percent of area covered by cover crop, and
- Extent and vitality of tree seedlings.

These indicators could be assessed by on-site inspection or, in some cases, by remote sensing, either from satellite imagery or aerial photography.

Management practices

Performance levels of management practices—such as nutrient management, conservation tillage, pesticide management, and street sweeping—can be assessed using the following types of indicators:

- Records of street sweeping frequency and mass of material collected,
- Area or percent of cropland under conservation tillage,

- Extent of crop residue coverage on conservation tillage cropland, and
- Fertilizer and/or manure application rates and schedules, crop yields, soil test data, plant tissue test results, and fall residual nitrate tests.

Illustration of line-transect method for residue.

Assessment of these indicators would generally require reporting by private landowners or municipalities, reporting that is required under some regulatory programs. Visual observation of indicators such as residue cover, however, can also be made by on-site inspection or windshield survey.

Data analysis

Data on indicators can be expressed and analyzed in several ways, depending on the nature of the indicators used. Indicators reporting continuous numerical data—such as acres of cover crop or conservation tillage, manure application rates, miles of street sweeping, mass of material removed from catch basins or detention ponds, or acres of logging roads/landings revegetated—can be expressed either in the raw form (e.g., acres with 30 percent or more residue cover) or as a percentage of the design or target quantity (e.g., percent of contracted acres achieving 30 percent or more of residue cover). These metrics can be tracked year to year as a measure of BMP depreciation (or achievement). During the planning phase of a watershed project, it might be appropriate to collect indicator data for multiple years prior to project startup to enable calculation of averages or ranges to better estimate BMP performance levels over crop rotation cycles or variable weather conditions.

Indicators reporting categorical data—such as maintenance of detention basin ridge height and outlet elevations, condition of berms or terraces, or observations of water accumulation and flow—are more difficult to express quantitatively. It might be necessary to establish an ordinal scale (e.g., condition rated on a scale of 1–10) or a binary yes/no condition, then use best professional judgment to assess influence on BMP performance.

In some cases, it might be possible to use modeling or other quantitative analysis to estimate individual or watershed-level BMP performance levels based on verification data. In an analysis of stormwater BMP performance levels, Tetra Tech (2010) presented a series of BMP performance curves based on monitoring and modeling data that relate pollutant removal efficiency to depth of runoff treated (Figure 1). Where depreciation indicators track changes in depth of runoff treated as the capacity of a BMP decreases (e.g., from sedimentation), resulting changes in pollutant removal could be determined from a performance curve. This type of information can be particularly useful during the planning phase of a watershed project to estimate realistic performance levels for existing BMPs that have been in place for a substantial portion of their expected lifespans.

The performance levels of structural agricultural BMPs in varying condition can be estimated by altering input parameters in the *Soil and Water Assessment Tool* (SWAT) model (Texas A&M University 2015a); other models such as the *Agricultural Policy/Environmental eXtender* (APEX) model (Texas A&M

University 2015b) also can be used in this way (including application to some urban BMPs). For urban stormwater, engineering models like *HydroCAD* (HydroCAD Software Solutions 2011) can be used to simulate hydrologic response to stormwater BMPs with different physical characteristics (e.g., to compare performance levels under actual vs. design conditions). Even simple spreadsheet models such as the Spreadsheet Tool for Estimating Pollutant Load (*STEPL*) (USEPA 2015) can be used to quantify the effects of BMP depreciation by varying the effectiveness coefficients in the model.

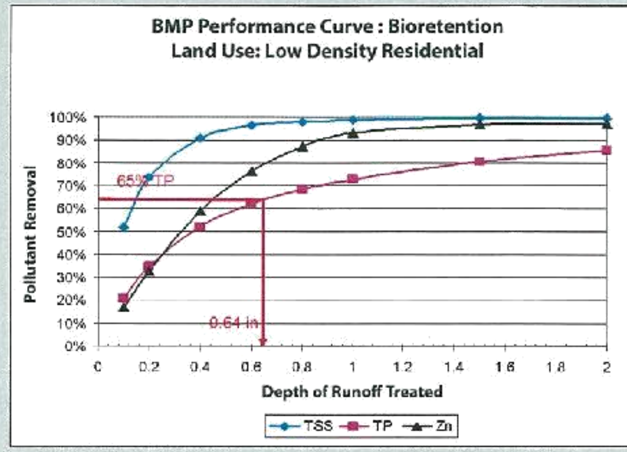

Figure 1. BMP Performance Curve for Bioretention BMP (Tetra Tech 2010).

Data from verification efforts and analysis of the effects of depreciation on BMP performance levels must be qualified based on data confidence. "Confidence" refers mainly to a quantitative assessment of the accuracy of a verification result. For example, the number of acres of cover crops or the continuity of streamside buffers on logging sites determined from aerial photography could be determined by ground-truthing to be within +10 percent of the true value at the 95 percent confidence level. Confidence also can refer to the level of trust that BMPs previously implemented continue to function (e.g., the proportion of BMPs still in place and meeting performance standards). For example, reporting that 75 percent of planned BMPs have been verified is a measure of confidence that the desired level of treatment has been applied.

While specific methods to evaluate data confidence are beyond the scope of this memo, it is essential to be able to express some degree of confidence in verification results—both during the planning phase and over time as the project is implemented. For example, an assessment of relative uncertainty of BMP performance during the planning phase can be used as direct follow-up to verification efforts to those practices for which greater quantification of performance level is needed. In addition, plans to implement new BMPs also can be developed with full consideration of the reliability of BMPs already in place.

Adjusting for Depreciation

Information on BMP depreciation can be used to improve both project management and project evaluation.

Project Planning and Management

Establishing baseline conditions

Baseline conditions of pollutant loading include not only pollutant source activity but also the influence of BMPs already in place at the start of the project. Adjustments based on knowledge of BMP depreciation can provide a more realistic estimate of baseline pollutant loads than assuming that existing land treatment has reduced NPS pollutant loads by some standard efficiency value.

Establishing an accurate starting point will make load reduction targets—and, therefore, land treatment design—more accurate. Selecting appropriate BMPs, identifying critical source areas, and prioritizing land treatment sites will all benefit from an accurate assessment of baseline conditions. Knowledge of depreciation of existing BMPs can be factored into models used for project planning (e.g., by adjusting pollutant removal efficiencies), resulting in improved understanding of overall baseline NPS loads and their sources.

While not a depreciation issue per se, when a BMP is first installed—especially a vegetative BMP like a buffer or filter strip—it usually takes a certain amount of time before its pollutant reduction capacity is fully realized. For example, Dosskey et al. (2007) reported that the nutrient reduction performance of newly established vegetated filter strips increased over the first 3 years as dense stands of vegetation grew in and soil infiltration improved; thereafter, performance level was stable over a decade. When planning a watershed project, vegetative practices should be examined to determine the proper level of effectiveness to assume based on growth stage. Also, because of weather or management conditions, some practices (e.g., trees) might take longer to reach their full effectiveness or might never reach it. The Stroud Preserve, Pennsylvania, section 319 National Nonpoint Source Monitoring Program (NNPSMP) project (1992–2007) found that slow tree growth in a newly established riparian forest buffer delayed significant NO_3–N (nitrate) removal from ground water until about 10 years after the trees were planted (Newbold et al. 2008).

The performance of practices can change in multiple ways over time. For example, excessive deposition in a detention pond that is not properly maintained could reduce overall percent removal of sediment because of reduced capacity as illustrated in Figure 1. The relative and absolute removal efficiencies for various particle size fractions (and associated pollutants) also can change due to reduced hydraulic retention time. Fine particles generally require longer settling times than larger particles, so removal efficiency of fine particles (e.g., silt, clay) can be disproportionally reduced as a detention pond or similar BMP fills with sediment and retention time deteriorates. Expert assessment of the condition and likely current performance level of existing BMPs, particularly those for which a significant amount of pollutant removal is assumed, is essential to establishing an accurate baseline for project planning.

Adaptive watershed management

Watershed planning and management is an iterative process; project goals might not all be fully met during the first project cycle and management efforts usually need to be adjusted in light of ongoing changes. In many cases, several cycles—including mid-course corrections—might be needed for a project to achieve its goals. Consequently, EPA recommends that watershed projects pursue a dynamic and adaptive approach so that implementation of a watershed plan can proceed and be modified as new information becomes available (USEPA 2008). Measures of BMP implementation commonly used as part of progress assessment should be augmented with indicators of BMP depreciation. Combining this information with other relevant project data can provide reliable progress assessments that will indicate gaps and weaknesses that need to be addressed to achieve project goals.

BMP design and delivery system

Patterns in BMP depreciation might yield information on systematic failures in BMP design or management that can be addressed through changes to standards and specifications, contract terms, or permit requirements. This information could be particularly helpful during the project planning phase when both the BMPs and their implementation mechanisms are being considered. For example, a cost-sharing schedule that has traditionally provided all or most funding upon initial installation of a BMP could be adjusted to distribute a portion of the funds over time if operation and maintenance are determined to be a significant issue based on pre-project information. Some BMP components, on the other hand, might need to be dropped or changed to make them more appealing to or easier to manage by landowners. Within the context of a permit program, for example, corrective actions reports might indicate specific changes that should be made to BMPs to ensure their proper performance.

Project Evaluation

Monitoring

Although short-term (3–5 year) NPS watershed projects will not usually have a sufficiently long data record to evaluate incremental project effects, data on BMP depreciation might still improve interpretation of collected water quality data. Even in the short term, water quality monitoring data might reflect cases in which BMPs have suffered catastrophic failures (e.g., an animal waste lagoon breach), been abandoned, or been maintained poorly. Meals (2001), for example, was able to interpret unexpected spikes in stream P and suspended sediment concentrations by walking the watershed and discovering that a landowner had over-applied manure and plowed soil directly into the stream.

Longer-term efforts (e.g., total maximum daily loads[1]) might engage in sustained monitoring beyond individual watershed project lifetime(s). The extended monitoring period will generally allow detection of more subtle water quality impacts for which interpretation could be enhanced with information on BMP depreciation. While not designed as BMP depreciation studies, the following two examples illustrate how changes in BMP performance can be related to water quality.

In a New York dairy watershed treated with multiple BMPs, Lewis and Makarewicz (2009) reported that the suspension of a ban on winter manure application 3 years into the monitoring study led to dramatic increases in stream nitrogen and phosphorus concentrations. First and foremost, knowledge of that suspension provided a reasonable explanation for the observed increase in nutrient levels. Secondly, the study was able to use data from the documented depreciation of land treatment to determine that the winter spreading ban had yielded 60–75 percent reductions in average stream nutrient concentrations.

The Walnut Creek, Iowa, Section 319 NNPSMP project promoted conversion of row crop land to native prairie to reduce stream NO_3-N levels and used simple linear regression to show association of two monitored variables: tracked conversion of row crop land to restored prairie vegetation and stream NO_3-N concentrations (Schilling and Spooner 2006). Because some of the restored prairie was plowed back into cropland during the project period—and because that change was

[1] "Total maximum daily loads" as defined in §303(d) of the Clean Water Act.

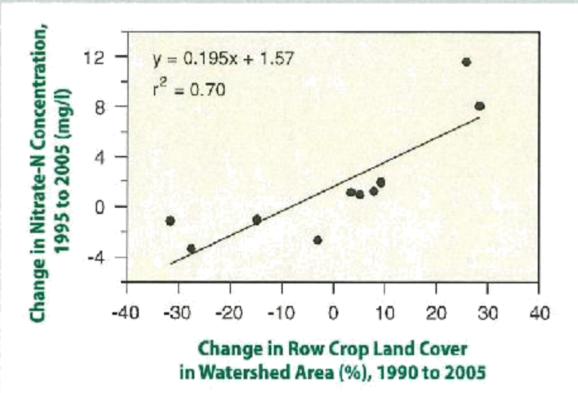

Figure 2. Relating Changes in Stream Nitrate Concentrations to Changes in Row Crop Land Cover in Walnut Creek, Iowa (Schilling and Spooner 2006)).

documented—the project was able to show not only that converting crop land to prairie reduced stream NO_3-N concentrations but also that increasing row crop land led to increased NO_3-N levels (Figure 2).

Modeling

When watershed management projects are guided or supported by modeling, knowledge of BMP depreciation should be part of model inputs and parameterization.

The magnitude of implementation (e.g., acres of treatment) and the spatial distribution of both annual and structural BMPs should be part of model input and should not be static parameters. Where BMPs are represented by pollutant reduction efficiencies, those percentages can be adjusted based on verification of land treatment performance levels in the watershed. Incorporating BMP depreciation factors into models might require setting up a tiered approach for BMP efficiencies (e.g., different efficiency values for BMPs determined to be in fair, good, or excellent condition) rather than the currently common practice of setting a single efficiency value for a practice assumed to exist. This approach could be particularly important for management practices such as agricultural nutrient management or street sweeping, in which degree of treatment is highly variable. For structural practices, a depreciation schedule could be incorporated into the project, similar to depreciating business assets. In the planning phase of a watershed project, multiple scenarios could be modeled to reflect the potential range of performance levels for BMPs already in place.

Recommendations

The importance of having accurate information on BMP depreciation varies across projects and during the timeline of a single project. During the project planning phase, when plans for the achievement of pollutant reduction targets rely heavily on existing BMPs, it is essential to obtain good information on the level of performance of the BMPs to ensure that plan development is properly informed. If existing BMPs are a trivial part of the overall watershed plan, knowledge of BMP depreciation might not be critical during planning. As projects move forward, however, the types of BMPs implemented, their relative costs and contributions to achievement of project pollutant reduction goals, and the likelihood that BMP depreciation will occur during the period of interest will largely determine the type and extent of BMP verification required over time. The following recommendations should be considered within this context:

- For improved characterization of overall baseline NPS loads, better identification of critical source areas, and more effective prioritization of new land treatment during project planning, collect accurate and complete information about:
    - Land use,

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