# Chisago Lakes Chain of Lakes Watershed

## *Restoration and Protection Plan*

## *2013*

CLEAN WATER LAND & LEGACY AMENDMENT

wq-iw6-10c

# Chisago Lakes Chain of Lakes Watershed TMDL Restoration and Protection PLAN


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MPCA IP Checklist:

| Requirement | Location in Document |
|---|---|
| a.1. Geographical extent of watershed (use HUC's, stream segments, etc.) | Pg. 9, Sect. 1.1 |
| a.2. Measurable water quality goals | Pg. 35, Table 10<br>Pg. 75, Table 30 |
| a.3. Causes and sources or groups of similar sources | Pg. 12, Table 4 |
| b.1. Description of nonpoint source management measures | Pg. 21, Sect.3.3.1 |
| b.2. Description of point source management | Pg. 33, Sect. 3.3.3 |
| c.1. Estimate of load reductions for nonpoint source management measures listed in b.1 | Pg. 14, Table 5 |
| c.2. Estimate of load reductions for point source management measures listed in b.2 | Pg. 14, Table 5 |
| d.1. Estimate of costs for nonpoint source measures | Pg. 18, Table 6 |
| d.2. Estimate of costs for point source measures (see note 2) | N/A |
| e. Information/education component for implementing plan and assistance needed from agencies | Pg. 16, Sect. 2.4 |
| f.1. Schedule for implementing nonpoint source measures | Pg. 106, Sect. 5 |
| f.2. Schedule for implementing point source measures | N/A |
| g. A description of interim measurable milestones for implementing management measures (point source and nonpoint source) (by measure if needed) | Pg. 109, Sect 6.1 |
| h. Adaptive management process-that includes set of criteria-to determine progress toward attaining nonpoint source reductions | Pg. 16, Sect. 2.3 |
| i. Monitoring component (see note 3) | Pg. 109, Sect. 6 |

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## Abbreviations

**CALM** - Consolidation Assessment and Listing Methodology
**Chl-*a*** – Chlorophyll-*a*
**CLLID** – Chisago Lakes Lake Improvement District
**EPA** – Environmental Protection Agency
**ITPHSS** – Imminent Threat to Public Heath Septic System
**LA** – Load Allocation
**MN DNR** – Minnesota Department of Natural Resources
**MOS** – Margin of Safety
**MPCA** – Minnesota Pollution Control Agency
**MS4** – Municipal Separate Storm Sewer System
**NPDES** – National Pollutant Discharge Elimination System
**SSTS** – Subsurface Sewage Treatment System
**SWAT** – Soil and Water Assessment Tool
**SWCD** – Soil and Water Conservation District
**TMDL** – Total Maximum Daily Load
**TP** – Total Phosphorus (can be interchangeable with P – Phosphorus)
**US ACOE** – United States Army Corps of Engineers
**USDA** – United States Department of Agriculture
**USGS** – United States Geological Survey
**WLA** – Wasteload Allocation

## EXECUTIVE SUMMARY

Along with a Total Maximum Daily Load Study (TMDL) that is approved by the US Environmental Protection Agency (EPA), the Minnesota Pollution Control Agency (MPCA) requires a Restoration and Protection Plan that outlines the steps and costs associated with projects designed to improve lake water quality to meet State water quality standards. The Chisago Lakes Chain of Lakes Watershed currently has nine lakes that are on the EPA's 303(d) Impaired Waters List; these lakes are impaired for Excess Nutrients (phosphorus). In addition to those impaired lakes, there are ten other water bodies of concern within the watershed. Within this document, we will outline some of the steps that can be taken to restore the impaired lakes to meet water quality standards and protect the remaining waterbodies from future addition to the Impaired Waters List. The Chisago Lakes Chain of Lakes Watershed TMDL study can be found at http://www.pca.state.mn.us/lupgdd5.

#### Load Reduction Strategy

The TMDL study quantified the amount of phosphorus entering the lakes and the amount that would need to be reduced in order to meet the State water quality standards. These reductions are quantified below (Table 1).

Lake restoration activities can be grouped into two main categories: those practices aimed at reducing external nutrient loads, and those practices aimed at reducing internal loads. The focus of restoration activities will depend on the lake's nutrient balance and opportunities for restoration. However, it is always important to first address sources of external nutrient loads to lakes to prevent the accumulation of phosphorus in the sediments, which contributes to future internal loading, and to ensure long-term stability of in-lake restoration efforts.

**Table 1. Phosphorus Reductions Needed by Lake**

| Lake | Phosphorus reductions needed [lb/yr] | | | | Primary Reduction Strategy |
|---|---|---|---|---|---|
| | Total | Watershed | In-lake | Upstream lakes | |
| North Center | 1,108 | 595 | 0 | 513 | Watershed Reductions |
| South Center | 1,260 | 842 | 208 | 210 | |
| Ogren | 467 | 430 | 37 | 0 | |
| Pioneer | 1,771 | 21 | 1,750 | 0 | In-lake Reductions |
| Emily | 362 | 100 | 262 | 0 | Reductions from both Watershed and In-Lake |
| Linn | 2,395 | 848 | 1,547 | 0 | |
| Little | 2,658 | 1,562 | 1,096 | 0 | |
| School | 1,593 | 818 | 773 | 0 | |
| Wallmark | 3,997 | 1,052 | 2,945 | 0 | |

#### Restoration Activities

Load reduction restoration activities consist of watershed projects, in-lake projects, and point source Best Management Practices (BMPs), and were identified for each impaired and protection lake. A description of each implementation activity is presented in the following section. The methods used to identify implementation opportunities and estimate phosphorus load reductions and costs for each lake are also explained. The load reduction activities identified for this implementation plan include:

**Watershed Practices**

- Biofilters
  - Field/riparian/shoreline buffers and enhancements
  - Vegetated swales
- Sedimentation
  - Ponds and pond retrofits
  - Wetland restoration
  - Gully stabilization
- Bioretention and Infiltration
  - Rain gardens
  - Infiltration BMPs
- Agricultural BMPs
  - Feedlot runoff treatment
  - Conservation tillage
  - Nutrient management planning
  - Prescribed grazing
- Lawn management
- Sand-iron filtration
- Septic system upgrades

**In-Lake Practices**

- Sediment phosphorus inactivation
- Trophic state alteration
  - Fish kill/ fish stocking
  - Carp management
  - Curly-leaf pondweed management
  - Floating vegetation mat installation
  - Lake drawdown
  - Algaecide application
  - Barley straw installation

**Point Source BMPs**

**Costs**

The costs to implement water quality practices are hard to quantify without exact designs. Therefore, using literature and known local estimates, we were able to estimate a watershed-wide approximate cost to improve water quality in the impaired and protection lakes. These watershed cost estimates will aid funding grant applications to complete these projects at the watershed scale. Exact costs on a per lake project basis will be determined through additional feasibility and design studies.

# 1 INTRODUCTION

## 1.1 303(d) Listings

The TMDL addressed nine lake impairments within the Chisago Lakes Chain of Lakes Watershed. These nine lakes are listed on the 2010 EPA's 303(d) list of impaired waters, or are proposed to be listed on the 2012 EPA's 303(d) list of impaired waters due to excess nutrients.

The following applies to all impaired lakes within this watershed:

| | |
|---|---|
| *Impaired Use:* | Aquatic Recreation |
| *Pollutant or Stressor:* | Nutrient/Eutrophication Biological Indicators |
| *Hydrologic Unit Code:* | 070300050406 |

**Table 2. Impaired Waters Listing**

| Lake Name | Lake ID | Year Listed | Target Start/Completion | Lake Classification | CALM Category |
|---|---|---|---|---|---|
| South Center | 13-0027 | 2008 | 2009/2017 | Lake | 5B |
| North Center | 13-0032 | 2008 | 2009/2017 | Shallow Lake | 5C |
| Wallmark | 13-0029 | 2008 | 2009/2017 | Shallow Lake | 5C |
| Little | 13-0033 | 2010 | 2015/2020 | Lake | 5B |
| Ogren | 13-0011 | 2012 | 2012/2013 | Lake | 5C |
| Linn | 13-0014 | 2012 | 2012/2013 | Shallow Lake | 5C |
| Pioneer | 13-0034 | 2012 | 2012/2013 | Shallow Lake | 5C |
| School | 13-0044 | 2012 | 2012/2013 | Shallow Lake | 5C |
| Emily | 13-0046 | 2012 | 2012/2013 | Shallow Lake | 5C |

*Kroon Lake is currently on the list but is proposed to be removed in 2014.

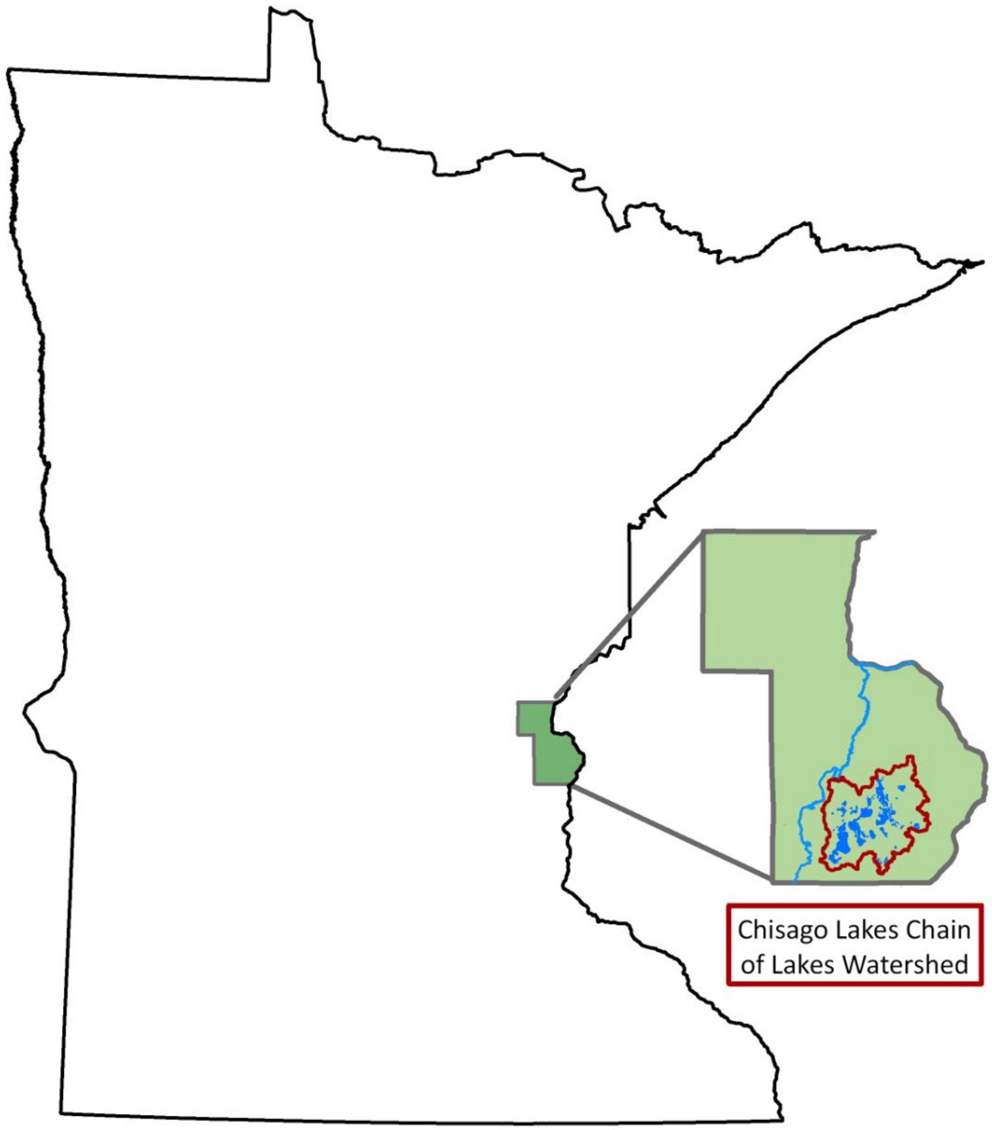
MPCA's projected schedule for TMDL completions (Table 2), as indicated on the 303(d) Impaired Waters List, implicitly reflects Minnesota's priority ranking of this TMDL. Ranking criteria for scheduling TMDL projects include, but are not limited to, impairment impacts on public health and aquatic life; public value of the impaired water resource; likelihood of completing the TMDL in an expedient manner, including a strong base of existing data and restorability of the waterbody; technical capability and willingness locally to assist with the TMDL; and appropriate sequencing of TMDLs within a watershed or basin.

Beyond the goal of restoring the impaired lakes for recreation to the state water quality goals, local citizens and professionals have placed importance on the protection of other lakes within the Chisago Lakes Chain of Lakes Watershed that are not currently on the 303(d) Impaired Waters List but have water quality close to State standards. Without protection, these lakes could be added to a future 303(d) Impaired Waters List.

## 1.2 Lake and Watershed Descriptions

The Chisago Lakes Chain of Lakes Watershed (HUC: 070300050406) is made up of 15 lakes with surface areas over 100 acres, and many streams within Chisago County. The area includes four incorporated cities (Wyoming, Chisago City, Lindstrom, and Center City) and covers portions of four townships (Lent, North Chisago Lake, South Chisago Lake, and Franconia). This region of Chisago County is highly populated and has been experiencing rapid growth.

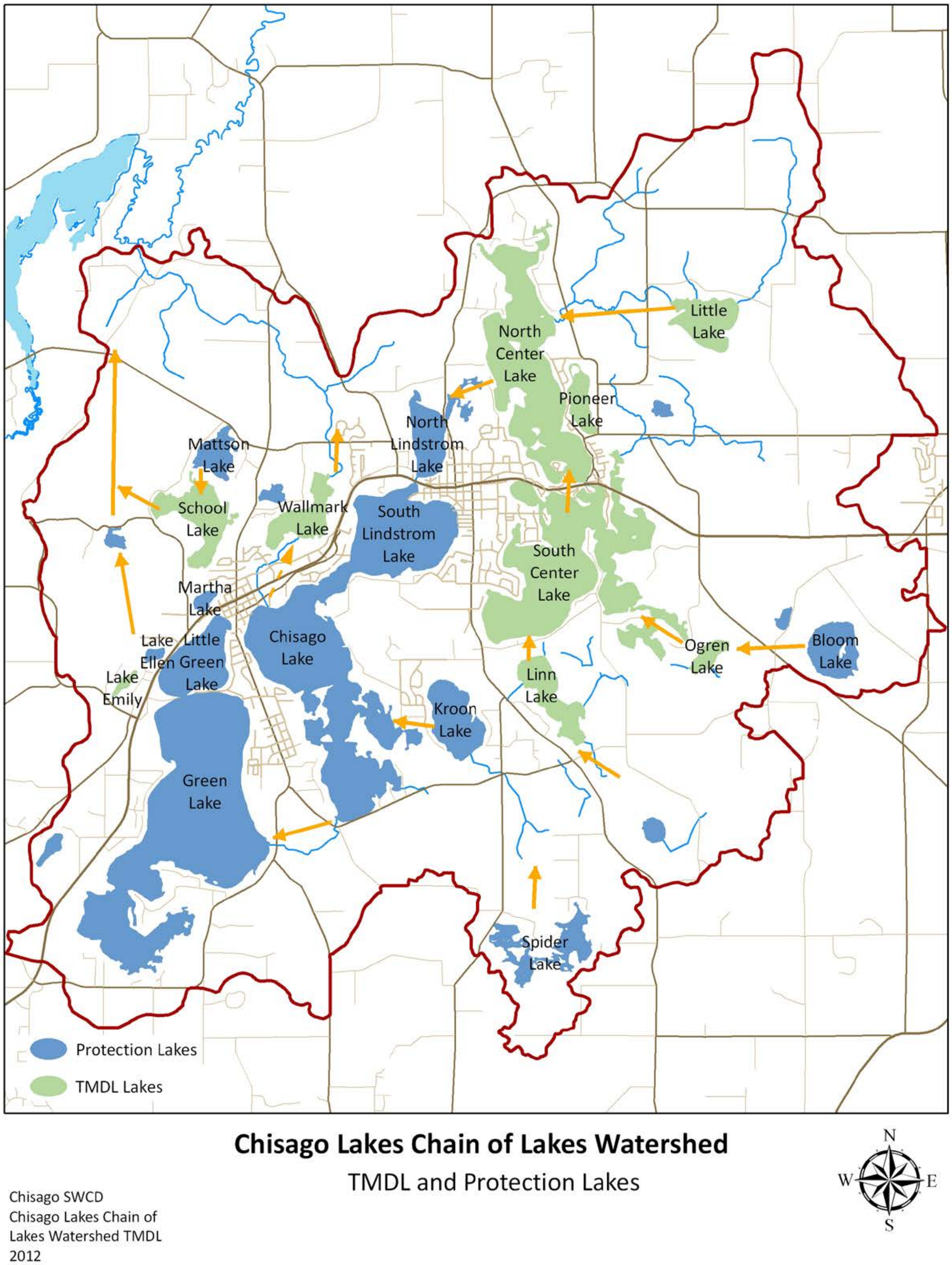
**Figure 1. Chisago Lakes Chain of Lakes Watershed Location Map**




The following section describes information about the watershed as a whole, rather than each lake's watershed individually. Refer to the "Chisago Lakes Chain of Lakes Watershed TMDL" for maps and more information.

The Chisago Lakes Chain of Lakes Watershed is a large chain including 20 lakes; these lakes range in size from 20 acres to over 1,500 acres. The largest of the impaired lakes included in the TMDL study is South Center Lake at 889 acres, while the smallest is Lake Emily which is 20 acres. The lakes within in the chain are all connected either through surface water tributaries or groundwater inflow/outflow. The principal outlet from the Chain of Lakes is located at Lake Ellen and flows out of that outlet at 898.2 feet above sea level; when the lakes reach 899.9 feet above sea level the outlet to Wallmark Lake functions as the secondary outlet to the Chain of Lakes. The outlet at Lake Ellen and the outlet from Chisago to Green Lake are controlled by weirs which are opened only during times of high water. Tributaries leaving the two outlets eventually meet up at Bloomquist Creek near the Sunrise River.

**Figure 2. TMDL and Protection Lakes with Flow Direction**



#### TMDL Baseline Years

The TMDLs are based on data through 2008, 2009, or 2010 (Table 3). Any activities implemented during or after the years indicated in Table 3 that lead to a reduction in phosphorus loads to the lake or an improvement in lake water quality may be considered as progress towards meeting a Waste Load Allocation (WLA) or Load Allocation (LA).

**Table 3. Baseline Years for TMDL Implementation**

| Lake | TMDL Baseline Year |
|---|---|
| North Center | 2010 |
| South Center | 2010 |
| Emily | 2009 |
| Linn | 2009 |
| Little | 2008 |
| Ogren | 2010 |
| Pioneer | 2009 |
| School | 2009 |
| Wallmark | 2010 |

## 1.3 TMDL Summary

Nine lakes within the Chisago Lakes Chain of Lakes Watershed are currently on the EPA's 303(d) Impaired Waters List (or Draft list): North Center, South Center, Wallmark, Little, Ogren, Linn, Pioneer, School, and Emily (see Table 2 for impairment listing). The TMDL report addressed the impairments, provided an assessment of the ecological health of each lake, assessed potential phosphorus sources, and provided guidelines on how to restore the aquatic recreational use of each lake.

The following phosphorus sources were evaluated for each lake: watershed runoff, animal operations, subsurface sewage treatment systems (SSTS), loading from upstream lakes, atmospheric deposition, shallow groundwater sources, and internal loading. An inventory of phosphorus sources was then used to develop a lake response model for each lake, and these models were used to determine the phosphorus reductions needed for the lakes to meet water quality standards. The implementation approach will include education and outreach, technical assistance, and partnerships with landowners, cities, Chisago County, lake associations, and the Chisago Lakes Lake Improvement District. A summary of necessary reductions is below (Table 4 and Table 5).

**Table 4. TMDL Summary of Reductions**

| Lake | Loading Capacity (TMDL) (lb /day) | Wasteload Alloc. (lb /day) | Load Alloc. (lb /day) | Reduction Needed (lb/yr) | Reduction Needed (%) |
|---|---|---|---|---|---|
| North Center | 15 | 0.0066 | 13 | 1,108 | 18% |
| South Center | 15 | 0.0072 | 13 | 1,260 | 21% |
| Emily | 0.082 | 0.000054 | 0.074 | 362 | 93% |
| Linn | 0.99 | 0.00088 | 0.89 | 2,395 | 88% |
| Little | 0.90 | 0.0013 | 0.81 | 2,658 | 90% |
| Ogren | 1.8 | 0.0038 | 1.6 | 467 | 45% |
| Pioneer | 0.22 | 0.0000054 | 0.20 | 1,771 | 96% |
| School | 0.66 | 0.00072 | 0.59 | 1,593 | 88% |
| Wallmark | 0.67 | 0.00040 | 0.60 | 3,997 | 95% |

More information can be found in the Chisago Lakes Chain of Lakes Watershed Total Maximum Daily Load study.

**Figure 3. TMDL Lake Watershed Boundaries and Flow Direction**

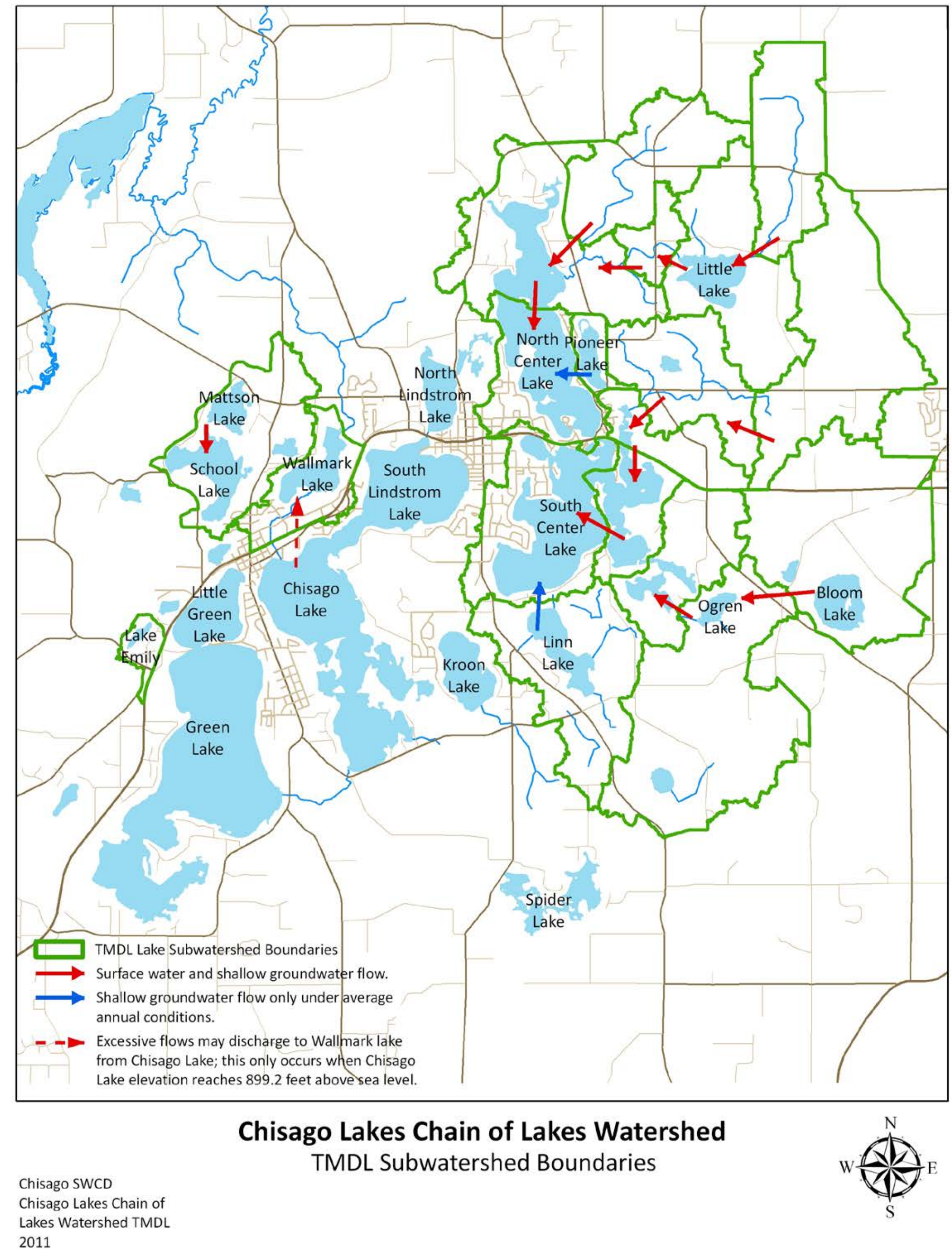


**Table 5. TMDL Load Reductions by Source**

| Load Reductions by Source | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Waste Load Allocation (Regulated) | | Load Allocation (Unregulated) | | | | TOTAL |
| | Construction Stormwater | Industrial Stormwater | Watershed Load (Direct Runoff) | Upstream Lakes | Atmospheric | Internal Loading | |
| **North Center Lake** | | | | | | | |
| Current Load (lbs/yr) * | 1.2 | 1.2 | 1,318 | 1,493 | 200 | 3,000 | 6,013 |
| % TP Reduction Needed | 0% | 0% | 45% | 34% | 0% | 0% | 18% |
| **South Center Lake** | | | | | | | |
| Current Load (lbs/yr) | 1.3 | 1.3 | 1,682 | 700 | 240 | 3,500 | 6,125 |
| % TP Reduction Needed | 0% | 0% | 50% | 30% | 0% | 6% | 21% |
| **Lake Emily** | | | | | | | |
| Current Load (lbs/yr) | 0.0099 | 0.0099 | 106 | NA | 4.6 | 278 | 389 |
| % TP Reduction Needed | 0% | 0% | 94% | 0% | 0% | 94% | 93% |
| **Linn Lake** | | | | | | | |
| Current Load (lbs/yr) | 0.16 | 0.16 | 945 | NA | 49 | 1,725 | 2,719 |
| % TP Reduction Needed | 0% | 0% | 90% | 0% | 0% | 90% | 89% |
| **Little Lake** | | | | | | | |
| Current Load (lbs/yr) | 0.24 | 0.24 | 1,710 | NA | 44 | 1,200 | 2,954 |
| % TP Reduction Needed | 0% | 0% | 91% | 0% | 0% | 91% | 90% |
| **Ogren Lake** | | | | | | | |
| Current Load (lbs/yr) | 0.69 | 0.69 | 859 | NA | 13 | 170 | 1,043 |
| % TP Reduction Needed | 0% | 0% | 50% | 0% | 0% | 22% | 45% |
| **Pioneer Lake** | | | | | | | |
| Current Load (lbs/yr) | 0.00099 | 0.00099 | 22 | NA | 21 | 1,800 | 1,843 |
| % TP Reduction Needed | 0% | 0% | 95% | 0% | 0% | 97% | 96% |
| **School Lake** | | | | | | | |
| Current Load (lbs/yr) | 0.13 | 0.13 | 899 | 19 | 39 | 850 | 1,807 |
| % TP Reduction Needed | 0% | 0% | 91% | 0% | 0% | 91% | 88% |
| **Wallmark Lake** | | | | | | | |
| Current Load (lbs/yr) | 0.074 | 0.074 | 1,098 | NA | 40 | 3,075 | 4,213 |
| % TP Reduction Needed | 0% | 0% | 96% | 0% | 0% | 96% | 95% |

* Current Load is Current Modeled Load (lbs/yr)

# 2 RESTORATION STRATEGY

The following report section summarizes general considerations of the Chisago Lakes Chain of Lakes Watershed implementation strategy for impaired and protection lakes. These include: existing stormwater ordinances and Low Impact Development guidelines, completed or in progress subwatershed assessments, overall adaptive management strategy, education and outreach components, watershed implementation rate estimates, sources of technical assistance and other partnerships, and watershed cost estimates of the implementation plan.

## 2.1 Stormwater Ordinances and Low Impact Development

The communities within the Chisago Lakes Chain of Lakes Watershed are currently not regulated Municipal Separate Storm Sewer System communities (; therefore, they are not required to obtain permit coverage for their stormwater discharges. Because they are not regulated under the state's general permit, they are not mandated to have ordinances in place to address stormwater runoff. However, the communities of Chisago City, Lindstrom, and Center City within the Chisago Chain of Lakes were chosen as a St. Croix Minimal Impact Design Standard (MIDS) Pilot Community. This program will provide assistance with reviewing and updating existing stormwater-related ordinances to better protect and restore water resources. The local communities will then be able to enhance new development and redevelopment ordinances, and allow the integration of Low Impact Development concepts into local codes and procedures.

While current regulations will keep stormwater pollution from increasing following new development, these ordinances will not improve lake water quality from current conditions. Additional stormwater BMPs are necessary to improve current water quality.  The current ordinances also do not adress runoff from existing developments unless an outfall is reconstructed or relocated. MN Public Waters Work Permit Rules 6115.0231 Subp. 31 (2) requires that reconstructed or relocated sewer outfalls must discharge to stormwater treatment ponds, artificial stilling or sedimentation basins, or other devices for entrapment of floating trash and litter, sand, silt, debris, and organic matter prior to discharge to public waters.

## 2.2 Subwatershed Assessments

Urban subwatershed assessments were completed for the developed portions of Center City, Lindstrom, and Chisago City. These documents can be found on the Chisago Soil & Water Conservation District website at (www.chisagoswcd.org).  These assessments help guide implementation activities by determining the potential runoff load as well as identifying the most logical locations to start with BMP implementation. The highest priority and/or most likely to be completed BMPs that were identified in these assessments were mapped on the Potential BMP Activity Locations maps for each lake's watershed (see Section 3 Impaired Lakes Restoration Plan).  Implementation activity prioritization in urban areas will begin with projects identified in these assessments.  These areas have already been modeled for pollution loading and potential reductions.  Designs and actual placement and sizing of BMPs have yet to be completed. Funding to start implementing these practices has been secured through the Clean Water Fund. This particular funding is to install BMPs identified in the Subwatershed Assessments of Chisago City, Lindstrom, and Center City.

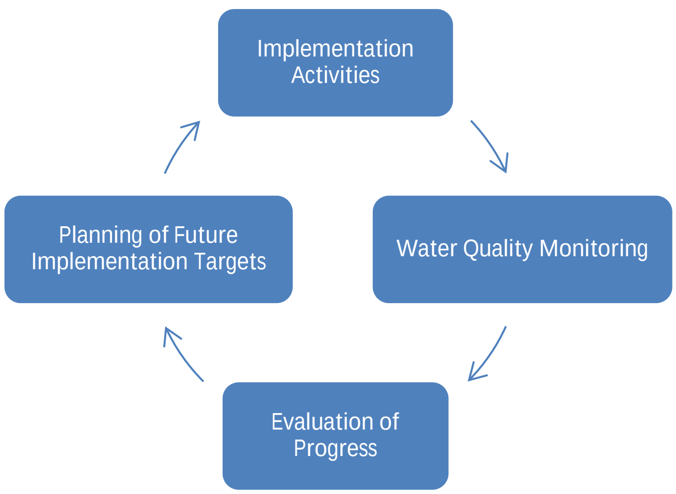
Rural subwatershed assessments are set to be completed in the rural portions of the watershed in 2013. These assessments will evaluate small subwatersheds that are made up of agricultural land (corn, soybean, hay, pasture, etc.) or rural land (forest, grassland, wetland, etc.). These subwatersheds may range from two acres to up to 100 acres. Potential BMPs will be identified and ranked based on a cost-benefit analysis.

## 2.3 Adaptive Management

The response of the lakes will be evaluated as management practices are implemented. This evaluation will occur every five years after the commencement of implementation actions. Monitoring data will be evaluated and decisions will be made as to how to proceed for the next five years. The management approach to achieving the goals should be adapted as new information is collected and evaluated.

As best management practices are implemented, monitoring of water quality will continue throughout the watershed. If water quality improves in the downstream impaired lakes (specifically, North Center and South Center), we can assume that the current plan to implement projects in the Little, Linn, Ogren, North Center, South Center, Emily, and Wallmark Lake watersheds is the correct approach. If the lakes are not responding to the BMPs as expected, the approach will need to be reevaluated. A reevaluation may determine if the implementation rate is not sufficient or if the wrong phosphorus sources were originally targeted.

Adaptive management involves the following four steps and repeats itself:




## 2.4 Education and Outreach

A crucial part in the success of the Restoration and Protection Plan designed to clean up the impaired lakes and protect the non-impaired lakes will be participation from local citizens. In order to gain support from these citizens, education will be necessary. A variety of educational avenues can and will be used throughout the watershed. These include (but are not limited to): press releases, newsletters, meetings, workshops, trainings, and websites. Chisago Lakes Lake Improvement District (CLLID) and Chisago SWCD staff and board members work to educate the residents of the watersheds about ways to clean up their lakes on a regular basis. Education will continue throughout the watershed.

## 2.5 Implementation Rates

Implementation rates of 10-25% were assumed for most load reduction activities. It is unreasonable to expect that all proposed activities can be completed due to site constraints and varying levels of participation. Implementation rates can be increased with more stringent policy and stakeholder education.

## 2.6 Technical Assistance

The Chisago SWCD provides assistance to landowners for a variety of projects that benefit water quality throughout Chisago County. Assistance provided to landowners varies from agricultural and rural best management practices to urban and lakeshore best management practices. This technical assistance includes education and one-on-one training. Many opportunities for technical assistance are a result of educational workshops and trainings. It is important that these outreach opportunities for Chisago County residents continue. Marketing is necessary to motivate landowners to participate in voluntary cost-share assistance programs.

Technical assistance is provided by a variety of entities, including but not limited to the Chisago SWCD and USDA Natural Resource Conservation Service (NRCS). Programs such as State cost-share, Clean Water Legacy funding, Environmental Quality Incentives Program (EQIP), and Conservation Reserve Program (CRP) are available to help implement the best conservation practices that each parcel of land is eligible for. Chisago County will provide technical assistance for upgrading non-compliant septic systems.

## 2.7 Partnerships

Partnerships with counties, cities, townships, citizens, businesses, and lake associations are one mechanism through which the CLLID and the Chisago SWCD protect and improve water quality. The CLLID and the Chisago SWCD will continue their strong tradition of partnering with state and local government to bring waters within the Chisago Lakes Chain of Lakes Watershed into compliance with State standards. A partnership with local government units and regulatory agencies such as Chisago City, Lindstrom, Center City, City of Wyoming, townships and Chisago County may be formed to develop and update ordinances to protect the area's water resources.

A partnership with the MN DNR during permit applications is also beneficial to improving the water quality of the area. When a landowner or local government unit applies for a shoreline permit, the MN DNR can suggest working with the SWCD for a project beneficial to water quality. This partnership will be continued in the future.

Partnerships with willing landowners may be the most important relationships that need to be established. All cost-share implementation programs are only as successful as the landowners who are willing to participate. Without willing landowners, the implementation program may be less successful as there are no requirements for landowners to implement practices. Ways to foster partnerships with landowners will include: workshops, newsletters, door to door marketing, and word of mouth.

## 2.8 Cost

The cost to implement projects and best management practices is difficult to quantify. Using a combination of actual calculated estimates and knowledge of past project costs we were able to roughly quantify the amount of money needed to achieve the goals outlined within the implementation plan for the entire watershed. The funding to complete these projects can be requested through a variety of sources including, but not limited to: Clean Water Fund, Clean Water Partnership, Federal 319, USDA Natural Resources Conservation Service (EQIP, WHIP, etc.), Agricultural BMP loan program (Minnesota Department of Agriculture), CLLID, lake associations, Cities and Townships, and landowners. Most of the time, to receive cost-share dollars to complete a project, the contract holder agrees to keep the practice in place for a minimum of 10 years after establishment.

All projects identified will need maintenance; this maintenance can be ongoing, yearly, or periodic over the life of the project. These costs can be better defined when actual designs and plans for implementing the practice are completed.

**Table 6. Implementation Cost Estimate**

| | IMPLEMENTATION PROJECT COST ESTIMATE | REDUCTION (LBS) | TREATMENT AREA | DESIGN COSTS | PROJECT INSTALLATION COSTS | TOTAL COST |
|---|---|---|---|---|---|---|
| | **TOTAL REDUCTION NEEDED** | 14,886 | | | | |
| | **IMPAIRED LAKES** | | | | | |
| Watershed | Biofilters | 140 | 62 acres | $ 9,300 | $ 24,800 | $ 34,100 |
| Watershed | Lawn management | 40 | 508 lots | $ 25,400 | $ 25,400 | $ 50,800 |
| Watershed | Septic upgrades | 281 | 10% of failing | $ 11,000 | $ 220,000 | $ 231,000 |
| Watershed | Bioretention & infiltration | 169 | 2.3 acres | $ 304,200 | $ 1,521,000 | $ 1,825,200 |
| Watershed | Sedimentation | 174 | 55 projects | $ 167,040 | $ 835,200 | $ 1,002,240 |
| Watershed | Feedlot/Animal Ag BMPs | 75 | 7 projects | $ 10,000 | $ 60,000 | $ 525,000 |
| Watershed | Conservation Tillage | 176 | 595 acres | $ 2,975 | $ 8,925 | $ 11,900 |
| Watershed | Sand iron filtration | 1,185 | 2 projects | $ 600,000 | $ 6,666,000 | $ 7,266,000 |
| Watershed | Total Watershed Achievable Load Reduction | **2,241** | | | | **$ 10,946,240** |
| Watershed | % Reduction of Total Needed | 36% | | | | |
| In-lake | Sediment P inactivation | 900 | 1 lake | varies | $ 400,000 | $ 400,000 |
| In-lake | Trophic state alteration | 5,425 | 3 lakes | varies | $ 30,000 | $ 90,000 |
| In-lake | Total In-lake Load Reduction | 9,518 | | | | **$ 490,000** |
| In-lake | % Reduction of Total Needed | 100% | | | | |
| | | | | **Total Cost Estimate for TMDL Lakes** | | **$ 11,436,240** |
| | | | | **Excluding sand iron filtration** | | **$ 4,170,240** |
| | **TOTAL LOAD ENTERING LAKES** | 1,742 | | | | |
| | **PROTECTION LAKES** | | | | | |
| Watershed | Biofilters | 22 | 27 acres | $ 4,050 | $ 10,800 | $ 14,850 |
| Watershed | Lawn management | 19 | 624 lots | $ 31,200 | $ 31,200 | $ 62,400 |
| Watershed | Septic upgrades | 254 | 10% of failing | $ 11,500 | $ 230,000 | $ 241,500 |
| Watershed | Bioretention & infiltration | 216 | 3.0 acres | $ 387,000 | $ 1,935,000 | $ 2,322,000 |
| Watershed | Sedimentation | 14 | 13 projects | $ 12,880 | $ 64,400 | $ 77,280 |
| Watershed | Feedlot/Animal Ag BMPs | 4 | 1 project | $ 10,000 | $ 60,000 | $ 70,000 |
| Watershed | Conservation Tillage | 10 | 128 acres | $ 640 | $ 1,920 | $ 2,560 |
| Watershed | Total Watershed Achievable Load Reduction | **540** | | | | **$ 2,790,590** |
| Watershed | % Reduction of Total Needed | 31% | | | | |
| | | | | **Total Cost Estimate for Protection Lakes** | | **$ 2,790,590** |

# 3 IMPAIRED LAKES RESTORATION PLAN

The objective of this restoration plan is to identify specific activities that reduce phosphorus loads to meet each lake TMDL with a 10% margin of safety, while also improving aquatic habitat, increasing stakeholder education, and restoring hydrologic connectivity for nesting and spawning.

## 3.1 Load Reduction Strategy

Lake restoration activities can be grouped into two main categories: those practices aimed at reducing external nutrient loads, and those practices aimed at reducing internal loads. The focus of restoration activities will depend on the lake's nutrient balance and opportunities for restoration. However, it is always important to first address sources of external nutrient loads to lakes to prevent the accumulation of phosphorus in the sediments, which contributes to future internal loading, and to ensure long-term stability of in-lake restoration efforts.

In a lake that does not currently have an excessive internal loading problem, the focus will be solely on reducing external loads. In a lake that has high internal loading rates, practices that address internal loading will be central to the lake restoration effort and will be conducted in combination with the control of external loads. Internal load reduction efforts will be needed for all of the shallow lakes (Linn, Pioneer, School, and Wallmark Lakes) except North Center Lake. But controlling the external loads is also essential in the restoration of a shallow lake. A restoration is less likely to be stable when external nutrient loads are still high (Moss *et al.* 1996).

As a number of the lakes flow into each other (e.g., Ogren and Linn to South Center and Little to North Center), improvements in the water quality of upstream lakes are taken into account in the water quality of downstream lakes. Therefore the upstream lakes should be higher priority in overall implementation to ensure that downstream lakes can attain their water quality goal.

In the Chisago Chain of Lakes, the primary management area is the watershed, the source of new phosphorus to lakes. Non-point sources of phosphorus in the watershed include agriculture, runoff, urban runoff, septic system, and feedlot discharge. The main non-point source of phosphorus in the lake is from the sediments. Point sources of phosphorus in the watershed include construction stormwater and future industrial stormwater. Sometimes, there is sufficient legacy loading stored in lake sediments that internal (or recycled) P loads must be addressed.

## 3.2 Load Reduction Goals

Three main patterns of load reduction needs were identified and guided selection of implementation activities: watershed reductions, in-lake reductions, and reductions in both watershed and in-lake (Table 7). Lakes with primarily watershed phosphorus reductions needed were North Center, South Center, and Ogren. The lake with primarily in-lake phosphorus reductions needed is Pioneer (due to the small watershed and watershed phosphorus load relative to the internal load). Lakes with phosphorus reductions needed from the watershed and in-lake were Emily, Linn, Little, School, and Wallmark.

**Table 7. Implementation strategy based on phosphorus load reductions needed to meet TMDL**

| Lake | Phosphorus reductions needed [lb/yr] | | | | Primary Reduction Strategy |
|---|---|---|---|---|---|
| | Total | Watershed | In-lake | Upstream lakes | |
| **North Center** | 1,108 | 595 | 0 | 513 | Watershed Reductions |
| **South Center** | 1,260 | 842 | 208 | 210 | |
| **Ogren** | 467 | 430 | 37 | 0 | |
| **Pioneer** | 1,771 | 21 | 1,750 | 0 | In-lake Reductions |
| **Emily** | 362 | 100 | 262 | 0 | Reductions from Watershed and In-Lake |
| **Linn** | 2,395 | 848 | 1,547 | 0 | |
| **Little** | 2,658 | 1,562 | 1,096 | 0 | |
| **School** | 1,593 | 818 | 773 | 0 | |
| **Wallmark** | 3,997 | 1,052 | 2,945 | 0 | |

## 3.3 Implementation Activities: Description and Methods

Load reduction activities were identified throughout the entire Chisago Chain of Lakes watershed (including impaired and protection lakes) to provide a general estimate of the total phosphorus load reduction that is likely to be achieved through actual implementation of these projects. Due to the large number of impaired and protection lakes in the Chisago Chain of Lakes Watershed, a watershed-based approach was chosen to gain more general information about phosphorus reduction benefits of many activities for all lakes rather than gaining specific information for a few activities and only for impaired lakes. In addition, results from the watershed-based approach can be used to compare the relative effectiveness of the different load reduction activities for all the lakes and to guide prioritization of project implementation by lake and/or activity.

The watershed-based approach for identifying implementation activities and estimating total phosphorus load reductions involved the following four general steps:

1. Identify feasible locations for each implementation activity in each lake watershed.
2. Estimate the proportion of total watershed load treated by each implementation activity and the average percent phosphorus reduction for that activity.
3. Estimate an implementation rate (i.e., the proportion of identified projects that are likely to be built, e.g. 10%).
4. Calculate the total phosphorus load reduction for each implementation activity.

Load reduction implementation activities consist of watershed practices, in-lake practices, and point source BMPs. A description of each implementation activity is presented in the following section. The methods used to identify implementation opportunities and estimate phosphorus load reductions and costs are also explained. The load reduction implementation activities identified for this implementation plan include:

**Watershed Practices**

- Biofilters
  - Field/riparian/shoreline buffers and enhancements
  - Vegetated swales
- Sedimentation
  - Ponds and pond retrofits
  - Wetland restoration
  - Gully stabilization
- Bioretention and Infiltration
  - Rain gardens
  - Infiltration BMPs
- Agricultural BMPs
  - Feedlot runoff treatment
  - Conservation tillage
  - Nutrient management planning
  - Prescribed grazing
- Lawn management
- Sand-iron filtration
- Septic system upgrades

**In-Lake Practices**

- Sediment phosphorus inactivation
- Trophic state alteration
  - Fish kill/ fish stocking
  - Carp management
  - Curly-leaf pondweed management
  - Floating vegetation mat installation
  - Lake drawdown
  - Algaecide application
  - Barley straw installation

**Point Source BMPs**

- Permits

### 3.3.1 Watershed Projects

**Biofilters**

Description:

Biofilters, including buffer strips (field, riparian, or shoreline) and vegetated swales, are load reduction activities that reduce runoff velocities, provide settling of particulates, enhance infiltration, and increase vegetative phosphorus uptake. *Buffer strips* are areas of dense vegetation along lakeshores, riparian corridors, and agricultural fields, typically with native grasses or long-rooted plant species. Buffers perform optimally when the width of the vegetated strip is at least 25 feet wide with a preferable width of 50 to 100 feet. The State of Minnesota requires a buffer strip of permanent vegetation that is 50 feet wide downstream of agricultural land uses that are adjacent to lakes, rivers, and streams unless the land area is part of a resource management system plan (MN Rule 6120.330 Subp. 7). Additionally, for any new ditches or ditch improvements, the land adjacent to public ditches must include a buffer strip of permanent vegetation that is usually 16.5 feet wide on each side (MN Statute 103E.021). *Vegetated swales* are depressional areas of dense vegetation constructed in roadside ditches or natural valleys in the landscape. Downstream of roadways, they are particularly equipped to handle particulates (and associated phosphorus loads) discharged from roadway runoff. Check dams (or ditch checks) are permeable or semi-permeable weirs along swale cross-sections (perpendicular to flow) that can be included to provide additional reductions in flow velocity and an associated increase in particulate settling.

Identification of implementation opportunities:

Within each lake watershed, we used GIS aerial imagery to identify shorelines and riparian corridors with little or no buffering and large, isolated agricultural fields with little or no buffering along the downstream edge. More focused siting will occur later in implementation to eliminate sites with dry and/or erosive conditions that do not support vegetative growth.

Phosphorus removal:
The lake watershed area treated by the buffers was calculated as the total length of biofilters measured in GIS times the adjacent 100 feet of watershed perpendicular to the buffer. The proportion of the watershed load treated by the biofilters was calculated as an area-weighted fraction of the total watershed load. We assumed 50% of the phosphorus load was removed from the fraction of the total watershed load treated by the biofilters (MN DNR 2007). For buffer enhancements, the phosphorus removal was reduced to 25% to account for some pre-existing treatment by the buffer.

Cost-benefit:
The 30-year operation and maintenance (O&M) cost-benefit of biofilters varies considerably depending on specific site conditions, with previous estimates ranging from $1,765 to $8,314 per pound phosphorus removed (CLFLWD 2012; CMSCWD 2012 *draft*). For the overall cost-estimate (Table 6), we assumed that capital costs were $550 per acre of biofilter.

### Sedimentation

Description:
Sedimentation implementation activities include sedimentation ponds, wetland restorations, and gully stabilizations. These practices all reduce watershed phosphorus loading by promoting the settling of particulates and associated phosphorus loads. Wetland restorations and gully stabilizations reduce the source of sediment runoff in the watershed and should be prioritized over sedimentation ponds which primarily collect sediment runoff. *Sedimentation ponds* are artificial ponds that are constructed to retain watershed runoff. They typically have a high treatment volume, and some sedimentation ponds provide additional phosphorus treatment via infiltration or filtration. Stormwater wetlands are similar to sedimentation ponds in sedimentation function, but they differ in water depths and associated vegetative communities. *Wetland restorations* are historic wetlands that have been ditched and drained that are restored to their natural form and function. Gullies are areas of erosion along dominant flow paths that lose substantial amounts of soil (and associated phosphorus loads) to surface waters. *Gully stabilization* can significantly reduce phosphorus loads to surface waters by minimizing the erosion of soil from the watershed.

Identification of implementation opportunities:
Digital elevation models (DEM) in GIS were used to identify depressions and major flow paths in each lake watershed that could be potential locations for sedimentation ponds and gully erosion. Existing ponds, wetlands, and gullies were also identified for potential restoration opportunities.

Phosphorus removal:
We assumed that each sedimentation pond or wetland receives approximately 10 acres of watershed runoff. The proportion of the watershed load treated by sedimentation ponds or wetlands was calculated as an area-weighted fraction of the total watershed load. We assumed

that erosion from a typical gully results in the loss of about 1 ton of soil every year, which is equivalent to 1 pound of phosphorus. All sedimentation ponds and wetlands were assumed to remove 60% of the watershed phosphorus load they received (Walker 1988). Similarly, gully stabilizations were assumed to prevent 60% of the total annual loss of phosphorus due to erosion. Due to the small number of sedimentation practices identified per lake watershed, all sedimentation projects were assumed to be implemented (i.e., 100% implementation rate).

Cost-benefit:
The 30-year operation and maintenance cost-benefit of sedimentation ponds and wetlands varies considerably depending on specific site conditions, with a previous estimate average of $780 per pound phosphorus removed (CLFLWD 2012). For the overall cost-estimate (Table 6), we assumed that the capital costs for a 0.25 acre pond that removes about 5 pounds of phosphorus is $28,800.

#### Bioretention & Infiltration

Description:
Bioretention and infiltration areas are vegetated depressions that collect, temporarily store, and infiltrate phosphorus rich surface runoff into underlying soils. Bioretention facilities also provide water quality treatment via filtration through vegetation. *Rain gardens* are a common type of bioretention and typically include simple design and on-lot scale. *Infiltration best management practices* (BMPs) typically require large-scale features primarily designed for infiltration of larger storm events. All of these features require larger surface areas per treatment volume relative to stormwater ponds.

Identification of implementation opportunities:
We assumed that each parcel in the watershed could support one rain garden with an actual implementation rate of 10%. Also included were BMPs (bioretention, rain gardens, swales, and permeable surfaces) identified for the Chisago City, City of Lindstrom, and Center City Stormwater Retrofit Assessments (SRA) (CSWCD 2010, 2011a, and b) and recently implemented BMPs as part of the Clean Water Fund grant obtained to implement projects identified in the SRAs.

Phosphorus removal:
We estimated that rain gardens in good soils (hydrologic soil groups A and B) can reduce 1.0 pound of phosphorus per year per rain garden from the total watershed load, and rain gardens in poor soils (hydrologic soil groups C and D) can reduce up to 0.5 pound of phosphorus per year per rain garden. Most soils in the Chisago Lakes Watershed are B soils, but we conservatively assumed that each rain garden removes only 0.5 pound of phosphorus per year. Phosphorus removal from BMPs identified in the SRAs and recently installed BMPs were determined using one or more methods, including the Program for Predicting Polluting Particle Passage thru Pits, Puddles, & Ponds (P8), WINSLAMM, or simple spreadsheet methods using the Rational Method.

Cost-benefit:

The 30-year operation and maintenance cost-benefit of rain gardens varies considerably depending on specific site conditions, with previous estimates ranging from $440 to $6,300 per pound of phosphorus removed and an average of $2,049 per pound of phosphorus removed (CLFLWD 2012; CMSCWD 2012 *draft*). For the overall cost-estimate (Table 6), we assumed that the capital costs for a 300 square foot rain garden that removes about 0.5 pounds of phosphorus is $5,760.

Infiltration and recently completed BMPs were assigned estimated design, installation, and first-year establishment-related maintenance costs based on the cubic feet of treatment. An annual cost/pound of phosphorus-removed for each treatment level was then calculated for the life-cycle of said BMP which included promotional, administrative, and life-cycle operations and maintenance costs (CSWCD 2010, 2011a, and b).

#### Feedlot runoff treatment

Description:

Phosphorus loads from animal operations can be controlled through collection, storage, and treatment of livestock manure and feed waste as well as diversion of clean runoff away from the feedlot area. Storage can be accomplished with earthen impoundments or other structures. These facilities may be used to hold and treat manure and waste from animal operations, process wastewater, or contaminated runoff. Wastewater/feedlot filter strips are vegetated treatment areas that receive discharge from a settling basin or runoff from the feedlot itself. Clean runoff water diversions are channels constructed across (perpendicular to) the slope to prevent runoff from entering the feedlot area or the farmstead. In this manner, runoff from upstream areas is not contaminated through travel across the feedlot and associated operations.

Identification of implementation opportunities:

County-wide feedlot numbers for Chisago County were obtained from the National Agricultural Statistics Service (NASS) and adjusted with advice from Chisago County SWCD personnel. We assumed that all animal operations needed some improvement in manure management.

Phosphorus removal:

Livestock numbers were converted to manure quantities and phosphorus loads using the conversion factors for the St. Croix Basin from the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (MPCA 2004) listed in Table 8 below. Feedlot runoff treatment was assumed to remove 75% of the total manure phosphorus load reaching downstream waters.

**Table 8. Livestock animal units to phosphorus load conversion factors (derived from MPCA 2004)**

| Animal type | Average P produced per animal [lb/yr] | Fraction of animal units contributing to surface waters [%] | Fraction of manure P reaching downstream waters [%] |
|---|---|---|---|
| Beef cattle | 63.9 | 27% | 0.61% |
| Dairy cattle | 69.9 | | |
| Horse | 21.9 | | |

Cost-benefit:

The 30-year operation and maintenance cost-benefit of feedlot runoff treatment was assumed to be low and variable (<$500 to $1,500 per pound of phosphorus removed per year) based on the simple nature of many feedlot runoff treatment practices (e.g., earthen impoundments, filter strips, etc.) and the wide range in potential manure phosphorus loads produced by individual animal operations.  For the overall cost-estimate (Table 6), we assumed that the capital costs for one project would be $70,000.

### Conservation tillage

Description:

Conservation tillage is any tillage practice that leaves additional plant residue on the soil surface functioning as in-field erosion control. There are many variations of this common practice. Variations are driven by climatic conditions and equipment availability. Examples include no-till, minimum till, and strip till, which involve planting directly into crop residue that either has not been tilled at all (no-till), has been slightly tilled leaving a minimum of 30% crop residue (minimum till), or has been tilled only in narrow strips (strip-till). Conservation tillage is one of the basic BMPs used on farms state-wide and is considered by the NRCS as one of the *Core 4* practices that have conservation impact and can be implemented on almost every farm. Since 1994, the USDA has required the use of conservation measures on highly erodible land to remain eligible for program benefits.

Identification of implementation opportunities:

The total area of cropland in each lake watershed was estimated based on land use data for Chisago County from MN DNR GAP Land Cover data. We assumed that about 10% of all cropland would have conservation tillage implemented on it for erosion control.

Phosphorus removal:

The proportion of the watershed load from cropland under conservation tillage was calculated as an area-weighted fraction of the total watershed load. We assumed that conservation tillage reduces 50% of the phosphorus load exported from cropland.

Cost-benefit:

The 30-year operation and maintenance cost-benefit of conservation tillage is variable based on the type of crop in production. We are unaware of any studies with this quantification. For the overall cost-estimate (Table 6), we assumed that the capital costs are $20 per acre.

### Nutrient Management Planning

Description:

Nutrient Management is the management of the amount, source, placement, form, and timing of the applications of plant nutrients and soil amendments on agricultural land (USDA, NRCS 590 Standard).  By utilizing this practice, producers are able to test soil to determine the amount of nutrients (including manure and fertilizer) that is necessary to apply to their land to optimize the yield of specific crops on specific fields.  Nutrient Management Plans are completed by an agronomist.

Identification of implementation opportunities:
All agricultural fields (row crop or perennial cover) are eligible for this practice. Many producers already implement this practice on their farm.

Phosphorus removal:
Not quantified. It is estimated through literature from the US EPA that a 20-40% phosphorus removal can be obtained from a properly managed Nutrient Management Plan. Due to the variable starting points of each field, a reduction value is not quantifiable.

Cost-benefit:
Variable.

### Prescribed Grazing

Description:
Prescribed grazing includes managing the controlled harvest of vegetation with grazing animals (USDA, NRCS 528 Standard). Improving the health and vigor of plant communities will improve the forage for livestock and maintain or improve water quality through improved plant stands.

Identification of implementation opportunities:
All pasture lands are eligible for this practice. Many producers already implement this practice on their farm.

Phosphorus removal:
Not quantified. Due to the variable starting points of each field, a reduction value is not quantifiable.

Cost-benefit:
Variable.

### Lawn management

Description:
Phosphorus loading from lawns generally results from: a) the direct transport of grass clippings, leaves, and mulch into waterbodies, b) erosion of exposed soil, or c) the application of phosphorus containing fertilizer to soils with high phosphorus content. To reduce phosphorus loading from lawns, leaves and grass clippings should be kept out of contact with watershed runoff, driveways, and streets and a healthy, dense stand of turfgrass should be maintained to prevent erosion of the soil. Specifically, it is recommended to:

- Leave grass clippings on the lawn as fertilizer to promote the growth of healthy, dense stands of turfgrass.
- Use a phosphorus-free fertilizer and fertilize in the fall rather than the spring according to the recommendations published by the University of Minnesota Extension (from Rosen et al. 2012. *Fertilizing Lawns*. University of Minnesota Extension, http://www.extension.umn.edu/distribution/horticulture/dg3338.html)

- Mow higher (at least 2 ½ to 3 ½ inches) to shade out weeds.
- Mow often and do not cut off more than one-third of the grass blade so clippings will filter into the grass and quickly decompose.
- Keep leaves and grass clippings out of contact with watershed runoff by sweeping away from driveway and streets, spreading as mulch, composting, or hauling it away.

<u>Identification of implementation opportunities:</u>
We conservatively assumed that every parcel in each lake watershed could have approximately 0.125 acres of well managed turfgrass with a 25% implementation rate (i.e., 25% of residents follow proper lawn management recommendations). Implementation of proper lawn management is primarily achieved through landowner education, such as Blue Thumb workshops, Lake Associations, or distribution of turf grass resources available through the University of Minnesota and the Minnesota Department of Agriculture.

<u>Phosphorus removal:</u>
We used the total turf area to calculate the area weighted turf total phosphorus load as a function of the total watershed total phosphorus load. Previous estimates of the benefits of turfgrass management found that the surface phosphorus concentrations can be reduced from 0.4 mg/L (the event mean concentration of phosphorus in runoff from developed areas) to about 0.08 mg/L (twice the event mean concentration of phosphorus in runoff from mesic prairies), or an approximately 80% reduction in phosphorus load from the turf surface.

<u>Cost-benefit:</u>
Previous estimates of the 30-year operation and maintenance cost-benefit of lawn management ranges from $824 to $1,375 per pound of phosphorus removed (CMSCWD 2012 *Draft*). For the overall cost-estimate (Table 6), we assumed that the capital costs are $100 per lot.

#### Sand-iron filtration

<u>Description:</u>
Iron-enhanced sand filters remove both total and dissolved phosphorus from watershed runoff by filtration of particulate phosphorus and surface adsorption of dissolved phosphorus to iron oxide (rust). Iron filings or steel wool is added to a sand filter to enable the adsorption of dissolved phosphorus. Water is pumped (or gravity fed) from the stream to a pre-treatment feature and ultimately is gravity fed through the sand-iron filter and discharged downstream of the intake.

<u>Identification of implementation opportunities:</u>
A total of four potential iron-sand filter treatment areas were reviewed at major tributaries to North Center and South Center Lakes, summarized below. At each location the existing available GIS information was reviewed including wetlands, soil types, and topography to see if the sites were suitable for the proposed treatment facility and to help locate the facility along the storm water conveyance system. The initial feasibility study results are summarized below.

**Note**: The phosphorus reductions reported in this section are reduced from the potential phosphorus reductions identified from the feasibility study so that the total phosphorus reductions for North Center and South Center Lakes do not exceed the total phosphorus reductions needed to meet their TMDL.

*1. Between Linn and South Center*

There is an existing ditch that flows from Linn Lake to a culvert under the existing street and discharges to South Center Lake. From Chisago County GIS mapping, most of the ditch area is mapped as a semi-permanently wet wetland. It does appear that there are smaller areas near Linn and the road that may be uplands, with the area near the outlet of Linn Lake being the site with the most potential. The soils in this area are mapped as 543, Markey Muck, and will likely have low infiltration rates making it unsuitable for an infiltration area. The system designed in this area will likely need to be designed as a filtration system with a series of drain tiles located in the bottom of the filter bed to collect and discharge water to South Center Lake. A filter system in this location may require impacting the existing wetland, but a wetland mitigation exemption may be available since this is a water quality improvement project. This land is also under private ownership and easement acquisition would be required to complete the project and for the long-term maintenance of the facility.

This facility would treat a base flow of 1.08 cubic feet per second (cfs) and an annual total phosphorus (TP) loading of 11 Kg/yr (24 lbs/yr). Based upon this, it is anticipated that the treatment facility would require approximately 250 cubic yards of filter media.

*2. Between Ogren and South Center*

These water bodies are connected by a large meandering system of creeks and wetlands, with most of the area mapped as a variety of wetland types. There are several larger open upland areas adjacent to the ditch/wetland complex that could be utilized to develop an “off-line” treatment system. The soils in the upland areas are mapped as Nebish loams, which have fair infiltration rates. The off-line treatment systems could be designed to capture a portion of the flow, treat it and infiltrate the treated water into the existing soil system. Some wetland impact would be required in order to ditch or pipe a portion of the flow from the existing ditch into the treatment area. It is recommended that the connection point is located at a narrow “pinch” point along the existing ditch/wetland system in order to minimize this disturbance. A wetland exemption for utility work, water quality improvement project, or deminimus may be available. All of the potential upland areas appear to be under private ownership and, therefore, an easement would be required for the construction and long term maintenance of the facility.

This facility would treat a base flow of 1.32 cfs and an annual TP loading of 278 Kg/yr (613 lbs/yr). Based upon this, it is anticipated that the treatment facility would require approximately 5,800 cubic yards of filter media.

*3. From the Wetland North of Lake Street to East Bay of South Center*

There is a large wetland complex north of Lake Street that discharges to the east bay of South Center Lake. There are some larger open upland areas adjacent to the wetland complex that could be utilized for an “off-line” system to treat a portion of the flow going through the wetland complex. The wetland complex is fed by a stream that enters the northeast corner of the wetland. It appears that there are a couple of open upland areas along this stream between Pleasant Valley Road and 310th Street that could be utilized to construct either an off-line system or an in-line system.  Most of the upland soils are mapped as a variety of loam with fair infiltration rates.  It appears that most of the properties in the potential project sites are privately owned and easements would be required for the construction and long term maintenance of the facility.  It is recommended that the facility is located and designed in a manner that minimizes the potential for wetland impacts.

This facility would treat a base flow of 3.07 cfs and an annual TP loading of 970 Kg/yr (2139 lbs/yr).  Based upon this, it is anticipated that the treatment facility would require approximately 20,000 cubic yards of filter media.

*4. Between Little Lake and North Center*
There is an existing stream that flows from Little Lake and discharges into the east side of North Center Lake.  Along the steam, it appears that most of the land is upland with isolated pockets of wetlands.  Either an off-line or on-line system could be constructed most anywhere along the length of the stream.  Two likely locations would be near Oasis Road or Park Trail due to ease of access.  Most of the soils along the stream are mapped as loams with fair infiltration rates.  It appears that the majority of the properties located along the stream are under private ownership and easements for the construction and long-term maintenance of the facility would be required.

This facility would treat a base flow of 0.0809 cms (2.86 cfs) and an annual TP loading of 1,044 Kg/yr (2,302 lbs/yr).  Based upon this, it is anticipated that the treatment facility would require approximately 21,500 cubic yards of filter media.

*Comparison Summary*
Due to the amount of wetland area, poor soils and limited opportunity locations, the Linn-South Center location may be the most challenging site. The Ogren-South Center site has better opportunities, but all of the potential sites are located in relatively remote areas with limited access. For the east bay of South Center, a location along the stream between Pleasant Valley Road and 310th Street has the greatest potential.  There are a variety of potential sites located along the stream between Little Lake and North Center, with a location just west of Park Trail being the most likely.

<u>Phosphorus removal:</u>
The existing flow and TP loading data was reviewed for each site based upon the appropriate subwatershed contained in the SWAT model (Almendinger and Ulrich 2010). It is anticipated that the facilities are capable of removing a target amount of 70% of the total annual TP loading for each site.  However, the removal capabilities of sand-iron facilities reported in the implementation plan were reduced to match the TMDL load reduction goals and lower capital costs. During low flow/base flow periods, the treatment facility is expected to treat most of the flow and there will be some by-pass of larger flows during storm events.

<u>Cost-benefit:</u>
The anticipated construction costs were obtained by comparing the project size and scope to other projects and applying appropriate adjustment factors to the base comparison projects.  The design cost for these facilities are anticipated to be between 10%-15% of the construction costs, depending on the size and complexity of the project.  It is anticipated that all of the facilities will

be constructed for a 30-year life span. During this lifespan additional operating and maintenance (O&M) expenses will occur. It is anticipated that the O&M costs for the facilities over the 30-year lifespan will be approximately 35%-40% of the construction costs. In addition to the design, construction and O&M costs, there will be additional costs for land/easement acquisition and long-term monitoring of the facility. These costs have not been included at this point.

### Septic system upgrades

Description:

A failing (non-conforming) septic system is a septic system that fails to treat sewage to the extent to which it was designed based on regulations. Failing septic systems allow excess nutrients to reach nearby lakes and streams, promoting algae and weed growth. Septic systems near shorelines are more likely to contribute phosphorus to downstream waters than septic systems further upland because longer soil residence times allow for greater microbial uptake of phosphorus. For this reason, this implementation plan only considers shoreline on-site septic systems.

As an alternative to septic system upgrades, another mechanism for reducing phosphorus load from septic systems is connecting to sanitary sewer. In this manner, waste is delivered to a wastewater treatment facility rather than to septic systems. This alternative was not evaluated for this implementation plan.

Identification of implementation opportunities:

Approximately 25% of septic systems are failing in Chisago County (Chisago County Sanitarian, personal correspondence). The phosphorus reduction from imminent threat to public health septic systems (ITPHSS) that were recently upgraded through the Chisago County Septic Pilot Program was also included in the total phosphorus load reduction from septic system upgrades because the ITPHSS upgrades were completed within the TMDL period of record (2002-2011). The number of ITPHSS that were recently upgraded for each lake watershed was obtained from Chisago County Environmental Services Department.

Phosphorus removal:

Phosphorus loads from septic systems were implicit to the SWAT modeling in the TMDL study. For this implementation plan, phosphorus loads from shoreline and upland septic systems were explicitly quantified through the use of the MPCA 2004 Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Phosphorus reductions are based on regional failure rates and the differences in load between failing (non-conforming) and conforming septic systems (

Table 9). The total phosphorus reduction achieved through septic system upgrades was calculated as the number of failing/ITPHSS multiplied by the average capita per parcel multiplied by the TP removed (as pounds of phosphorus per capita-year) by upgrading failing/ITPHSS to conforming.

**Table 9. Typical phosphorus loads from septic systems for the St. Croix Basin**
(Based on the MPCA 2004 Detailed Assessment of Phosphorus Sources to Minnesota Watersheds)

| Septic System | Population [capita/parcel] | P removal: failing to conforming [lb/capita/yr] | P removal: ITPHSS to conforming [lb/capita/yr] |
|---|---|---|---|
| Seasonal (Shoreline) | 2.1 | 0.45 | 0.45 |
| Permanent (Upland) | 2.76 | 0.39 | 0.64 |

Cost-benefit:
We assumed that a complete upgrade of a septic system costs about $10,000 with an average lifespan of 15 years (a properly maintained septic system could be fully functional for up to 30 years and greatly decrease the cost per pound of phosphorus removal). The 30-year O&M cost-benefit for septic systems upgrades was calculated by dividing $20,000 (two upgrades in 30 years) by the total phosphorus reduction achieved over 30 years, or $378 to $704 per pound of phosphorus removed per year.

### 3.3.2 In-lake Projects

**Sediment phosphorus inactivation**

Description:
Internal loading in lakes refers to the phosphorus load that originates in the bottom sediments and is released back into the water column. The phosphorus in the sediments was originally deposited in the lake sediments through the settling of particulates (attached to sediment that entered the lake from watershed runoff, or as phosphorus incorporated into biomass) out of the water column. Internal loading can occur through various mechanisms including, anoxic (lack of oxygen) conditions in the overlying waters, physical disturbance by bottom-feeding fish such as carp and bullhead, physical disturbance due to wind mixing or boats and phosphorus release from decaying curly-leaf pondweed.

One common method to reduce the release of phosphorus from the sediment into the water column is to apply aluminum sulfate to the lake (alum treatment). Aluminum sulfate permanently binds with phosphorus through a chemical reaction, prohibiting phosphorus release during anoxic conditions. The alum strips phosphorus from the water column during application and also forms a layer on the surface of lake bottom sediments having the effect of ‘capping’ the sediment. Alum treatments are typically effective at sediment phosphorus inactivation for 5 to 10 years. While alum treatments are the most common, there are other methods that may work for particular lakes within the watershed.

Identification of implementation opportunities:
Deep, stratified lakes with large internal phosphorus loads are suitable locations for sediment phosphorus inactivation. Of the Chain of Lakes impaired lakes, only Little Lake fits this criteria. A more detailed feasibility study is needed to determine if Little Lake is suitable for an alum treatment.

Phosphorus removal:
We assumed that 75% of the internal load would be reduced through an alum treatment due to uncertainties in the estimation of internal loads and application of alum.

Cost-benefit:
The cost of an alum treatment ranges from tens to hundreds of thousands of dollars. Assuming the average lifespan of an alum treatment is 10 years and reduces 75% of the annual internal load, the 30-year O&M cost-benefit for a Little Lake alum treatment will be less than $100 per pounds of phosphorus reduced per year. For the overall cost-estimate (Table 6), we assumed that the capital costs for an alum treatment that removes 900 pounds of phosphorus per year is $400,000.

#### Trophic state alteration

Description:
Several of the impaired lakes are shallow (North Center, Emily, Linn, Pioneer, School, and Wallmark), and their water quality responds to nutrient loading differently than deeper lakes. In shallow lakes, the biological components (such as microbes, algae, macrophytes, zooplankton and other invertebrates, and fish) are concentrated into less volume and exert a stronger influence on the ecological interactions compared to deeper lakes. There is a more dense biological community at the bottom of shallow lakes than in deeper lakes because of the fact that oxygen is replenished in the bottom waters and light can often penetrate to the bottom. These biological components can control the relationship between phosphorus and the response factors.

Shallow lakes can be managed to promote a clear water, macrophyte dominated state instead of a turbid water, algae dominated state. For example, in the clear state, phytoplankton communities (composed mostly of algae) are held in check by diverse and healthy zooplankton and fish communities. Fewer nutrients are released from the sediments in this state. The roots of the macrophytes stabilize the sediments, lessening the amount of sediment stirred up by the wind. Therefore, managing a healthy macrophyte population with minimal invasive species (e.g. curly-leaf pondweed) is one method of trophic state management.

If enough stressors are present in the lake, increased phosphorus inputs may lead to a shift to the turbid state with an increase in algal density and decreased transparency. The two main categories of stressors that can shift the lake to the turbid state are:

- Disturbance to the macrophyte community, for example from wind, bottom feeding fish, boat activity, or light availability (influenced by algal density or water depth).
- A decrease in zooplankton grazer density, which allows unchecked growth of sestonic (suspended) algae. These changes in zooplankton density could be caused by an increase in predation, either directly by an increase in planktivorous fish that feed on zooplankton, or indirectly through a decrease in piscivorous fish that feed on the planktivorous fish.

Therefore, shallow lake restoration often focuses on restoring the macrophyte, zooplankton, and fish communities to the lake. Specific management strategies include, but are not limited to fish kills, fish stocking, carp management, floating vegetation mat installation, lake drawdown, curly-leaf pondweed management, algaecide application, and barley straw installation.

Identification of implementation opportunities:
Shallow lakes with large internal phosphorus loads are suitable locations for trophic state alterations to promote the clear water phase. Of the Chain of Lakes impaired lakes, Emily, Linn, Pioneer, School, and Wallmark fit this criteria. A more detailed feasibility study is needed to determine the most suitable in-lake treatment method for each of these lakes.

Phosphorus removal:
There is no direct phosphorus removal from this management technique, but water clarity improves due to a reallocation of phosphorus from the surface water and algae community to the sediments and rooted aquatic plants. There is limited field success with long-term shallow lake management of clear water states, but scientific understanding of this process is continually improving. We assumed that 70% of the effects of the current internal load on surface water quality would be reduced through altering the trophic state of a lake from turbid to clear.

Cost-benefit:
The 30-year operation and maintenance cost-benefit of trophic state alteration is variable based on the in-lake treatment method and effectiveness. We are unaware of any studies with this quantification. For the overall cost-estimate (Table 6), we assumed that the capital costs are approximately $30,000 per lake.

### 3.3.3 Point Source BMPs

Construction and industrial stormwater BMPs will be implemented through their NPDES permit and the BMPs identified in the Stormwater Pollution Prevention Plan (SWPPP). SWPPP BMPs include, but are not limited to: wet sedimentation basins, infiltration/filtration, and regional ponds.

The wasteload allocation for stormwater discharges from sites where there is construction activities reflects the number of construction sites greater than 1 acre expected to be active in the watershed at any one time, and the Best Management Practices (BMPs) and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in the State's NPDES/SDS General Stormwater Permit for Construction Activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS General Stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Appendix A of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local construction stormwater requirements must also be met.

The wasteload allocation for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES industrial stormwater permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in the

State’s NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) of NPDES/SDS General Permit for Construction Sand & Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000).  If a facility owner/operator obtains coverage under the appropriate NPDES/SDS General Stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL.  It should be noted that all local stormwater management requirements must also be met.

## 3.4 Implementation Activities: Selection and Justification

Implementation activities identified in the impaired lake watersheds are summarized in Table 10. The objective of this table is to guide selection of implementation activities appropriate for each lake watershed. Included in the table are:

1. Lake settings to provide context for the watershed, in-lake, and other load reductions needed and load reductions that can be achieved by implementation activities, including: current in-lake TP concentrations relative to water quality standards, drainage and lake surface areas, dominant land use, and primary phosphorus sources.
2. Load reductions needed by the watershed, in-lake, and upstream lakes
3. Load reductions achieved by individual implementation activities:
    - Biofilters
    - Lawn management
    - Septic system upgrades
    - Bioretention & infiltration features
    - Sedimentation ponds and wetlands
    - Agricultural BMPs
    - Sand iron filtration
    - Sediment P inactivation
    - Trophic state alteration
    - Improved water quality in upstream lakes

Implementation activities with the largest load reductions are highlighted in yellow for each lake. This table is a summary of the individual impaired lake implementation tables found in the Section 3.4 subsections below.

## Table 10. Implementation Activity and Load Reduction Summary

| | IMPAIRED LAKES | | | N CENTER | S CENTER | EMILY | LINN | LITTLE | OGREN | PIONEER | SCHOOL | WALLMARK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SETTING | Lake Type | | | Shallow | Lake | Shallow | Shallow | Lake | Lake | Shallow | Shallow | Shallow |
| SETTING | In-lake TP Concentration | | [µg/L] | 70 | 50 | 341 | 217 | 173 | 64 | 345 | 216 | 322 |
| SETTING | TP Standard | | [µg/L] | 60 | 40 | 60 | 60 | 40 | 40 | 60 | 60 | 60 |
| SETTING | Lake Surface Area | | [ac] | 754 | 889 | 17 | 177 | 164 | 49 | 77 | 145 | 145 |
| SETTING | Drainage Area‡ | | [ac] | 2,702 | 4,635 | 110 | 1,149 | 2,014 | 4,101 | 91 | 348 | 397 |
| SETTING | Direct Drainage Dominant Land Covers | Developed | | 6% | 15% | 2% | 1% | 1% | 2% | 6% | 1% | 14% |
| SETTING | | Cropland | | 36% | 18% | 79% | 58% | 47% | 52% | 29% | 43% | 33% |
| SETTING | | Woodland | | 11% | 9% | 2% | 12% | 20% | 15% | 12% | 12% | 15% |
| SETTING | | Grassland | | 8% | 2% | 4% | 6% | 6% | 6% | 3% | 8% | 7% |
| SETTING | | Aquatic | | 39% | 57% | 13% | 24% | 26% | 26% | 50% | 36% | 31% |
| SETTING | Primary Phosphorus Sources | In-Lake | | 50% | 57% | 72% | 63% | 41% | 16% | 99% | 47% | 74% |
| SETTING | | Watershed | | 22% | 39% | 28% | 35% | 59% | 84% | 1% | 50% | 26% |
| SETTING | | Upstream Lakes | | 28% | 4% | 0% | 2% | 0% | 0% | 0% | 3% | 0% |
| WATERSHED | **Load Reduction Needed*** | | [lb/yr] | 595 | 842 | 100 | 848 | 1,562 | 430 | 21 | 818 | 1,052 |
| WATERSHED | | Biofilters | | 33 | 22 | 11 | 8 | 3 | 7 | 1 | 16 | 39 |
| WATERSHED | | Lawn management | | 6 | 8 | 1 | 2 | 1 | 1 | 0.3 | 3 | 19 |
| WATERSHED | | Septic upgrades | | 59 | 85 | 8 | 25 | 19 | 52 | 4 | 11 | 18 |
| WATERSHED | | Bioretention & infiltration | | 43 | 75 | 2 | 5 | 2 | 7 | 6 | 4 | 25 |
| WATERSHED | | Sedimentation | | 16 | 50 | 6 | 17 | 51 | 17 | | | 18 |
| WATERSHED | | Agricultural BMPs | | 28 | 37 | 11 | 28 | 62 | 47 | 0.3 | 20 | 18 |
| WATERSHED | | Sand iron filtration | | 411 | 774 | | | | | | | |
| WATERSHED | **Load Reduction Achieved** | | [lb/yr] | **595** | **1,050** | **38** | **85** | **139** | **130** | **12** | **55** | **137** |
| WATERSHED | | | [% of goal] | 100% | 125% | 38% | 10% | 9% | 30% | 56% | 7% | 13% |
| IN-LAKE | **Load Reduction Needed** | | [lb/yr] | 0 | 208 | 262 | 1,547 | 1,096 | 37 | 1,750 | 773 | 2,945 |
| IN-LAKE | | Sediment P inactivation | | | | | | 900 | | | | |
| IN-LAKE | | Trophic state alteration | | | | 210 | 1,190 | | | 1,260 | 595 | 2,170 |
| IN-LAKE | **Load Reduction Achieved** | | [lb/yr] | **0** | **0** | **210** | **1,190** | **900** | **0** | **1,260** | **595** | **2,170** |
| IN-LAKE | | | [% of goal] | | 0% | 80% | 77% | 82% | 0% | 72% | 77% | 74% |
| OTHER | **Load Reduction Needed** | Upstream lake TMDLs | | 513 | 210 | | | | | | | |
| OTHER | **Load Reduction Achieved** | | | **513** | **210** | | | | | | | |
| TOTAL | **Total Reduction Needed** | | | 1,108 | 1,260 | 362 | 2,395 | 2,658 | 467 | 1,771 | 1,591 | 3,997 |
| TOTAL | **Total Reduction Achieved** | | [lb/yr] | **1,108** | **1,260** | **248** | **1,275** | **1,039** | **130** | **1,272** | **650** | **2,307** |
| TOTAL | | | [% of goal] | 100% | 100% | 69% | 53% | 39% | 28% | 72% | 41% | 58% |

‡excluding upstream lake watersheds

*Does not include the predicted load reductions needed from upstream impaired lakes meeting goals

### 3.4.1 North Center Lake

North Center Lake (MN DNR Lake ID 13-0032-01) is a shallow lake located in southern Chisago County and borders Lindstrom to the west and Center City to the east. The dominant land cover in the watershed is agriculture and woodland. The lake does not meet shallow lake water quality standards for total phosphorus (TP) or chlorophyll-*a* (Chl-*a*), and just meets the Secchi transparency standard.

Watershed assessment summary:

- The lake water quality violates the phosphorus and chlorophyll-*a* water quality standards and just meets the Secchi transparency standard.
- The lake vegetation is dominated by curly-leaf pondweed and Eurasian watermilfoil. Curly-leaf pondweed contributes to internal loading from the sediments.
- Black bullhead and carp are present in the lake, which could lead to high internal loading rates due to their habit of foraging in bottom sediments.
- Phosphorus concentration in sediments is high, indicating a high potential for internal loading from sediments.
- A large portion of the shoreline is developed.
- Approximately 50% of the watershed is cropland, and there are 15 animal operations in the watershed.
- Approximately half of the watershed is served by private on-site septic systems, which are estimated to have a 25% failure rate.
- Seven imminent threat to public health septic systems, three of which were in the shoreland area, were recently upgraded.
- Three other impaired lakes drain to North Center Lake: Little Lake, Pioneer Lake (shallow groundwater only), and South Center Lake.

Phosphorus sources to the lake are dominated by upstream loading, watershed runoff, animal operations, and internal loading. An overall reduction of 18% of phosphorus loading to North Center Lake is needed to restore the lake to suitable aquatic recreation uses. To meet the TMDL, taking into account the Margin of Safety (MOS), total loading to the lake needs to be reduced by 1,108 lb/yr, or 18% (Table 11). If the upstream lakes (Little, Pioneer, and South Center Lakes) all meet their water quality goals, the load to North Center Lake would be reduced by 513 lb/yr. The remaining 595 lb/yr reduction should come from watershed BMPs. Watershed load reduction practices will include urban stormwater reduction practices, lakeshore and streambank buffers, and a wide variety of agricultural Best Management Practices (BMPs). Internal loading is not excessively high in North Center Lake and is not a primary focus of restoration efforts.

**Table 11. North Center Lake Phosphorus Reduction Summary**

| Phosphorus Source | Existing Annual TP Load (lb/yr) | Implementation Scenario Annual TP Load (lb/yr) | Load Reduction Needed (lb/yr) | Percent Reduction (%) |
|---|---|---|---|---|
| Watershed | 2,813 | 1,703 | 1,108 | 39% |
| Atmospheric Deposition | 200 | 200 | 0 | 0% |
| Internal | 3,000 | 3,000 | 0 | 0% |
| **Total** | **6,013** | **4,903** | **1,108** | **18%** |

#### Priority Implementation Activities

Implementation activities needed to reduce the phosphorus loading to North Center Lake by 595 lb/yr were watershed-based. No in-lake load reductions are needed. The implementation activity identified with the largest phosphorus load reduction for North Center Lake was *iron-enhanced sand filtration at the Little Lake tributary inlet* (411 lb TP/yr). Additional phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Septic system upgrades (59 lb TP/yr)
- Rain gardens and infiltration BMPs (43 lb TP/yr)
- Buffer strips and vegetated swales (33 lb TP/yr)
- Agricultural BMPs (28 lb TP/yr)
- Sedimentation ponds and gully stabilization (16 lb TP/yr)
- Lawn management practices (6 lb TP/yr)

If the upstream impaired Little Lake achieves its TMDL goal, an additional 513 lb TP/yr will be reduced to North Center Lake. Refer to Table 12 and Figure 4 for detailed information on and the locations of the implementation activities identified in the North Center Lake watershed.

## Table 12. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for North Center Lake Watershed

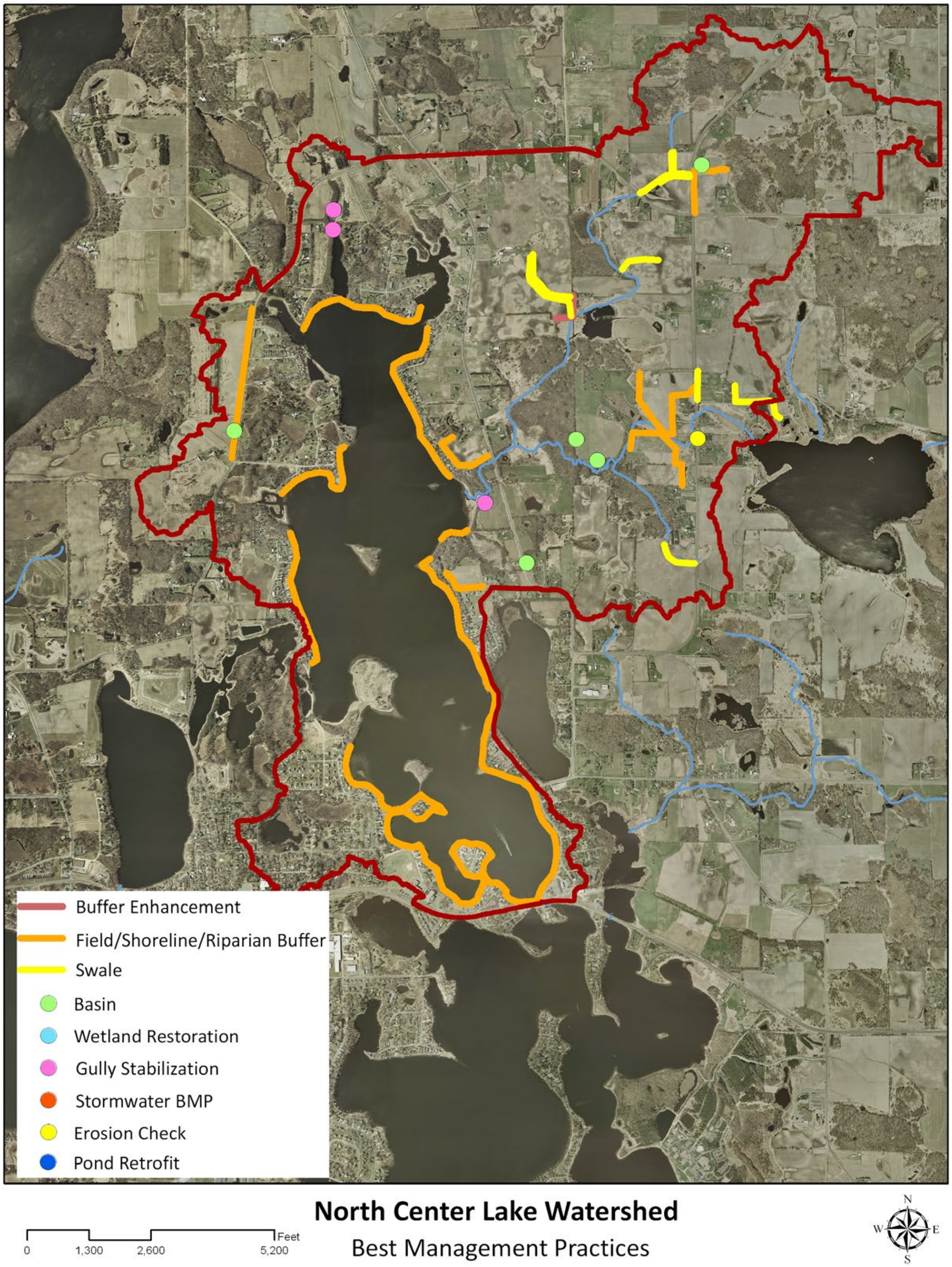
| NORTH CENTER LAKE IMPLEMENTATION ACTIVITES<br>CURRENT TP = 70 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Needed] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| IN-LAKE | Load Reduction Needed: | | | 0 | | | | |
| | Load Reduction Achieved: | | | 0 | 0.0% | | | |
| None | | | | | | | | |
| WATERSHED | Load Reduction Needed: | | | 595 | | | | |
| | Load Reduction Achieved: | | | 595 | 53.7% | | | |
| Biofilters | Buffer strips | 106 | 3.9% | 26 | 2.3% | NRCS; CWF | NRCS; LID; SWCD; LA; LO | $-$$ |
| | Vegetated swales (proposed) | 21 | 0.8% | 5 | 0.5% | | | |
| | Vegetated swales (completed) | 0.02 | 0.0% | 2 | 0.2% | | | |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 61 | 2.3% | 6 | 0.5% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 49 | 4.4% | CWF | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 10 | 0.9% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 24 | 2.2% | CWF; LID | SWCD; LID; LA; LO | $$-$$$ |
| | Bioretention (completed) | 0.06 | 0.0% | 5 | 0.5% | | SWCD; LID; City; LA; LO | |
| | Infiltration BMPs (Center City) | 31 | 1.2% | 11 | 1.0% | | | $$ |
| | Infiltration BMPs (City of Lindstrom) | 33 | 1.2% | 3 | 0.2% | | | |
| Sedimentation | Sedimentation ponds | 40 | 1.5% | 16 | 1.4% | NRCS; CWF; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Gully stabilization | | | | | | | $-$$ |
| Agricultural BMPs | Collection, storage, and treatment of manure | | | 4 | 0.4% | NRCS; Ag BMP; CWF | NRCS; SWCD; LO | $-$$ |
| | 10% of cropland with conservation tillage | 97 | 3.6% | 24 | 2.1% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |
| Sand iron filtration | In subbasin 5 at outlet of stream from subbasin 3 (Little) | | | 411 | 37.1% | CWF | SWCD; LID | $ |
| UPSTREAM | Load Reduction Achieved: | | | 513 | 46.3% | | | |
| Improve water quality | Little, Pioneer, and South Center meet lake water quality standards | | | 513 | | | | |
| TOTAL | Load Reduction Needed: | | | 1,108 | | | | |
| | Load Reduction Achieved: | | | 1,108 | 100% | | | |

Symbol key

- Ag BMP MDA Agricultural BMP Loan Program
- CWF Clean Water Fund
- CWP Clean Water Partnerships/ 319 Grants
- LA Lake Associations
- LID Lake Improvement District
- LO Landowners
- NRCS Natural Resources Conservation Service
- SWCD Soil and Water Conservation District

$ < $500/lb TP removed/yr
$$ = $500-$1500/lb TP removed/yr
$$$ > $1500 lb TP removed/yr

**Figure 4. Proposed Implementation Activity Locations for North Center Lake Watershed**



### 3.4.2 South Center Lake

South Center Lake (MN DNR Lake ID 13-0037) is a lake located in southern Chisago County and borders Lindstrom to the west. The dominant land cover of the watershed is agricultural and wetland. The lake does not meet lake water quality standards for total phosphorus, chlorophyll-*a*, or Secchi transparency.

Watershed assessment summary:

- The lake water quality violates the phosphorus, chlorophyll-*a*, and Secchi transparency water quality standards.
- The lake vegetation is dominated by curly-leaf pondweed. Curly-leaf pondweed contributes to internal loading from the sediments.
- Black bullhead and carp are present in the lake, which could lead to high internal loading rates due to their habit of foraging in bottom sediments.
- Phosphorus concentration in sediments is high, indicating a high potential for internal loading from sediments.
- A large portion of the shoreline is developed.
- Approximately 51% of the watershed is cropland, and there are 3 animal operations in the direct drainage area.
- Approximately half of the watershed is served by private on-site septic systems, which are estimated to have a 25% failure rate.
- Ten imminent threat to public health septic systems, 2 of which were in the shoreland area, were recently upgraded.
- Two other impaired lakes drain to South Center Lake: Linn Lake and Ogren Lake.

Phosphorus sources to the lake are dominated by upstream loading, watershed runoff, animal operations, and internal loading. An overall reduction of 21% of phosphorus loading to South Center Lake is needed to restore the lake to suitable aquatic recreation uses. To meet the TMDL, taking into account the MOS, total loading to the lake needs to be reduced by 1,260 lb/yr, or 21% (Table 13). If the upstream lakes (Linn and Ogren Lakes) all meet their water quality goals, the load to South Center Lake would be reduced by 210 lb/yr. Of the remaining load reduction needed, approximately 842 lb/yr should come from the watershed load and approximately 208 lb/yr should come from internal load. Watershed load reduction practices will include urban stormwater reduction practices, lakeshore and streambank buffers, and a wide variety of agricultural Best Management Practices (BMPs). Due to the small amount of internal load reduction needed for South Center Lake, internal load reduction practices should not be a primary focus of restoration efforts. As watershed loads to the lake are reduced, the lake should respond with lower internal loading rates.

**Table 13. South Center Lake Phosphorus Reduction Summary**

| Phosphorus Source | Existing Annual TP Load (lb/yr) | Implementation Scenario Annual TP Load (lb/yr) | Load Reduction Needed (lb/yr) | Percent Reduction (%) |
|---|---|---|---|---|
| Watershed | 2,385 | 1,330 | 1,052 | 44% |
| Atmospheric Deposition | 240 | 240 | 0 | 0% |
| Internal | 3,500 | 3,292 | 208 | 6% |
| **Total** | **6,125** | **4,862** | **1,260** | **21%** |

#### Priority Implementation Activities

Implementation activities needed to reduce the phosphorus loading to South Center Lake by 842 lb/yr were watershed-based. Some in-lake load reductions (208 lb TP/yr) were identified in the South Center Lake TMDL, but they were not a priority for this implementation plan. The implementation activity identified with the largest phosphorus load reduction for South Center Lake was *iron-enhanced sand filtration at the Ogren Lake tributary inlet* (774 lb TP/yr). However, it must be determined through the DNR review and permitting process whether an iron-enhanced sand filtration system would disconnect northern pike spawning from nearby flooded vegetation and wetlands. Additional phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Septic system upgrades (85 lb TP/yr)
- Rain gardens and infiltration BMPs (75 lb TP/yr)
- Sedimentation ponds, wetland restorations, and gully stabilization (50 lb TP/yr)
- Agricultural BMPs (37 lb TP/yr)
- Buffer strips and vegetated swales (22 lb TP/yr)
- Lawn management practices (8 lb TP/yr)

If the upstream impaired Ogren and Linn Lakes achieve their TMDL goals, an additional 210 lb TP/yr will be reduced to South Center Lake. Refer to Table 14 and Figure 5 for detailed information on and the locations of the implementation activities identified in the South Center Lake watershed.

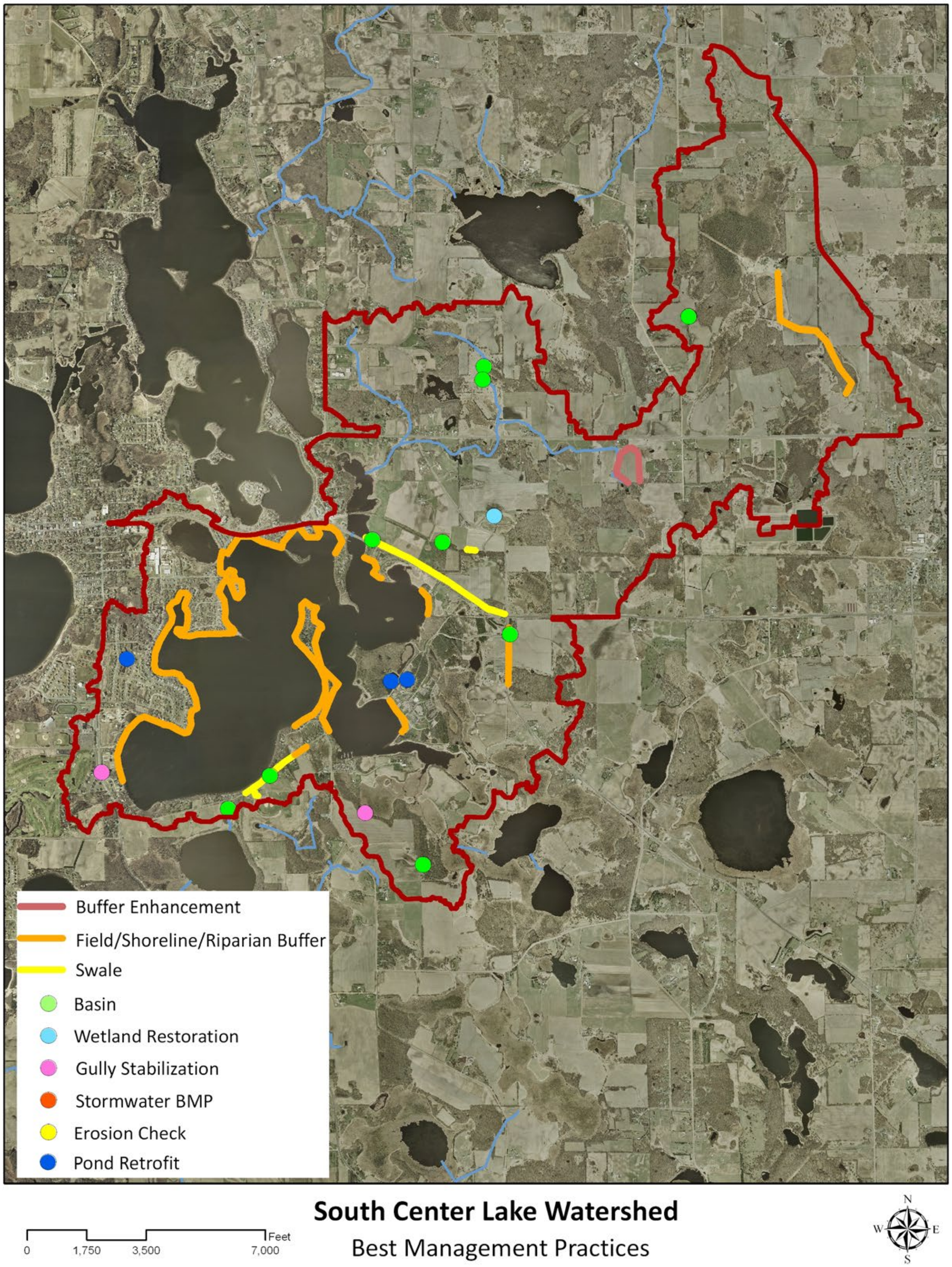
**Table 14. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for South Center Lake Watershed**

| SOUTH CENTER LAKE IMPLEMENTATION ACTIVITES<br>CURRENT TP = 50 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Needed] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| IN-LAKE | | | Load Reduction Needed: | 208 | | | | |
| | | | Load Reduction Achieved: | 0 | 0.0% | | | |
| None | | | | | | | | |
| WATERSHED | | | Load Reduction Needed: | 842 | | | | |
| | | | Load Reduction Achieved: | 1,050 | 83.4% | | | |
| Biofilters | Buffer strips | 97 | 2.1% | 18 | 1.4% | NRCS; CWF | NRCS; LID; SWCD; LA; LO | $-$$ |
| | Vegetated swales (proposed) | 16 | 0.3% | 3 | 0.2% | | | |
| | Vegetated swales (completed) | 0.49 | 0.0% | 2 | 0.1% | | | |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 107 | 2.3% | 8 | 0.6% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 69 | 5.4% | CWF | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 16 | 1.3% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 43 | 3.4% | CWF; LID | SWCD; LID; LA; LO | $$-$$$ |
| | Bioretention (completed) | 0.15 | 0.0% | 7 | 0.5% | | SWCD; LID; City; LA; LO | |
| | Infiltration BMPs (Center City) | 28 | 0.6% | 8 | 0.7% | | | $$ |
| | Infiltration BMPs (City of Lindstrom) | 103 | 2.2% | 17 | 1.3% | | | |
| Sedimentation | Sedimentation ponds | 130 | 2.8% | 31 | 2.5% | NRCS; CWF; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Wetland restorations | 10 | 0.2% | | | | | |
| | Gully stabilization | 0.05 | 0.0% | 18 | 1.4% | | | $-$$ |
| Agricultural BMPs | Collection, storage, and treatment of manure | | | 22 | 1.8% | NRCS; Ag BMP; CWF | NRCS; SWCD; LO | $-$$ |
| | 10% of cropland with conservation tillage | 83 | 1.8% | 15 | 1.2% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |
| Sand iron filtration | In subbasin 13 at outlet of subbasin 15 (Ogren) | | | 774 | 61.4% | CWF | SWCD; LID | $ |
| UPSTREAM | | | Load Reduction Achieved: | 210 | 16.7% | | | |
| Improve water quality | Linn and Ogren meet lake water quality standards | | | 210 | | | | |
| TOTAL | | | Load Reduction Needed: | 1,260 | | | | |
| | | | Load Reduction Achieved: | 1,260 | 100% | | | |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 5. Proposed Implementation Activity Locations for South Center Lake Watershed**



### 3.4.3 Lake Emily

Lake Emily (MN DNR Lake ID 13-0046) is a lake located in southern Chisago County. This waterbody is listed as a wetland on the Public Waters Inventory; however, it is used as a lake. There is no public access on Lake Emily. Major land use within the watershed is agricultural. The lake does not meet shallow lake water quality standards for total phosphorus, chlorophyll-*a*, or Secchi transparency.

Watershed assessment summary:

- The lake water quality violates the phosphorus, chlorophyll-*a*, and Secchi transparency water quality standards. The lake is hypereutrophic, with an average phosphorus concentration of 350 µg/L.
- Lake Emily is a classified as a wetland by MN DNR but is used recreationally as a lake.
- Curly-leaf pondweed exists in the lake, although the extent is not known. Curly-leaf pondweed contributes to internal loading from the sediments.
- There is an abundance of stunted sunfish and black bullhead. The presence of stunted sunfish often indicates an overabundance of planktivorous fish such as sunfish. This overabundance leads to overgrazing on zooplankton and a resultant increase in algae. Black bullhead can lead to high internal loading rates due to their habit of foraging in bottom sediments.
- A large portion of the shoreline is developed.
- Approximately 80% of the watershed is cropland.
- The entire watershed is served by private on-site septic systems, which are estimated to have a 25% failure rate.
- The lake model indicated that there is a large phosphorus load that is unaccounted for in the current phosphorus source inventory. This load is likely a mix of internal load and load from failing septic systems.

Phosphorus sources to the lake are dominated by internal loading and watershed runoff. A reduction of 93% will be needed to achieve water quality goals. To meet the TMDL, taking into account the MOS, total loading to the lake needs to be reduced by 362 lb/yr, or 93% (Table 15). Approximately 100 lb/yr should come from the watershed load and approximately 262 lb/yr should come from internal load. Watershed load reduction practices will include stormwater reduction practices, lakeshore buffers, and a wide variety of agricultural Best Management Practices (BMPs). In-lake practices may consist of fish and aquatic plant management and management of internal nutrient cycling.

**Table 15. Lake Emily Phosphorus Reduction Summary**

| Phosphorus Source | Existing Annual TP Load (lb/yr) | Implementation Scenario Annual TP Load (lb/yr) | Load Reduction Needed (lb/yr) | Percent Reduction (%) |
|---|---|---|---|---|
| Watershed | 106 | 6.2 | 100 | 94% |
| Atmospheric Deposition | 4.6 | 4.6 | 0 | 0% |
| Internal | 278 | 16 | 262 | 94% |
| **Total** | **389** | **27** | **362** | **93%** |

#### Priority Implementation Activities

Implementation activities needed to reduce the phosphorus loading to Lake Emily were a mix of watershed and in-lake projects. For Lake Emily to meet the TMDL, watershed loads need to be reduced by 100 lb TP/yr and in-lake loads need to be reduced by 262 lb TP/yr. The implementation activity identified with the largest phosphorus load reduction for Lake Emily was *in-lake trophic state alteration* (210 lb TP/yr). This could be achieved through management of curly-leaf pondweed, and fish stocking combined with aeration to promote a clear water state. However, a detailed feasibility study is necessary to determine the most suitable in-lake treatment method for Lake Emily. Additional phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Agricultural BMPs (11 lb TP/yr)
- Buffer strips and vegetated swales (11 lb TP/yr)
- Septic system upgrades (8 lb TP/yr)
- Sedimentation ponds and gully stabilization (6 lb TP/yr)
- Rain gardens (2 lb TP/yr)
- Lawn management practices (1 lb TP/yr)

Refer to Table 16 and Figure 6 for detailed information on and the locations of the implementation activities identified in the Lake Emily watershed.

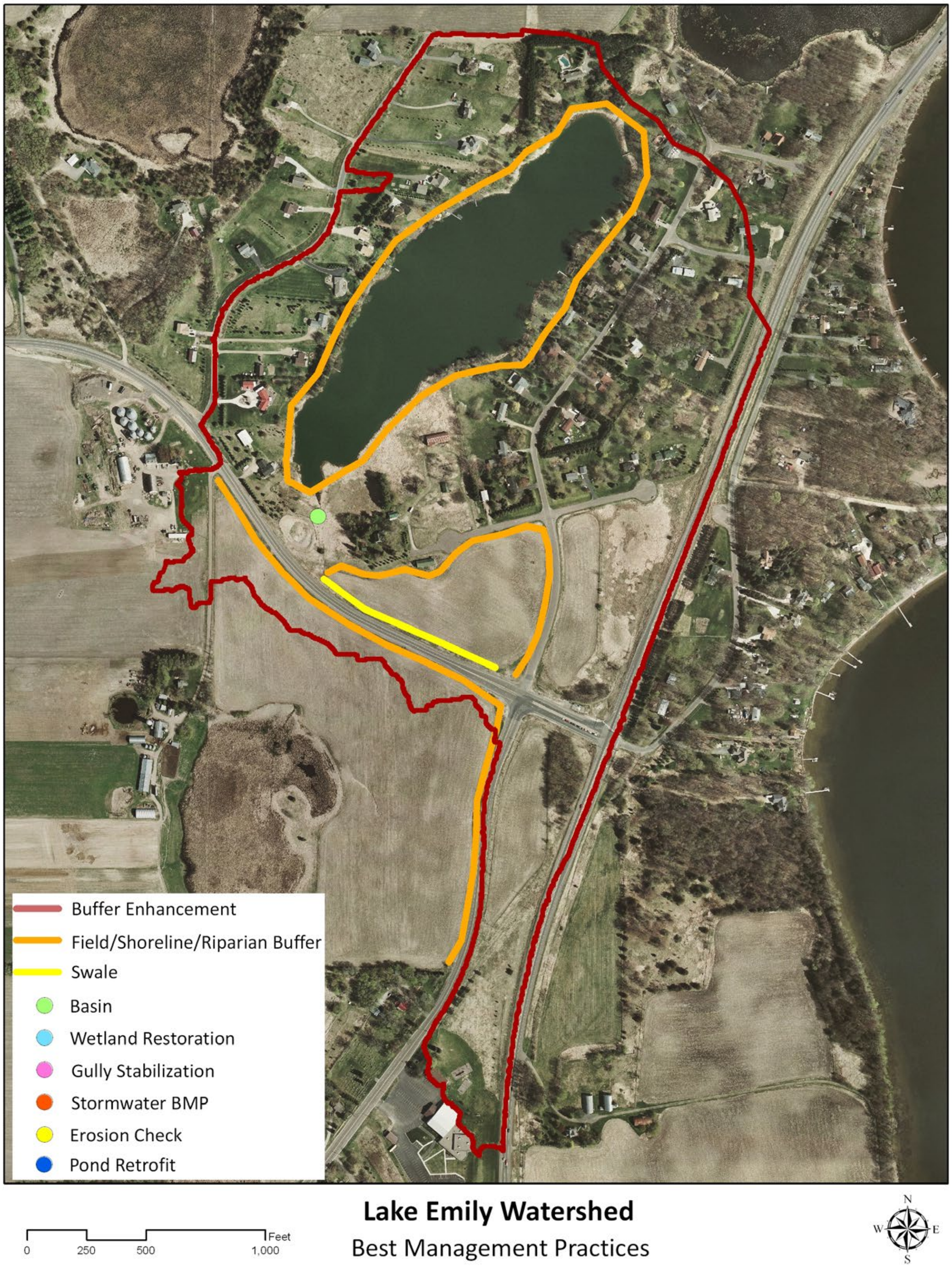
**Table 16. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Lake Emily Watershed**

| LAKE EMILY IMPLEMENTATION PROJECTS<br>CURRENT TP = 341 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Needed] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| IN-LAKE | Load Reduction Needed: | | | 262 | | | | |
| | Load Reduction Achieved: | | | 210 | 58.0% | | | |
| Trophic state alteration | Includes fish kill, fish stocking, carp management, curly-leaf pondweed management, and/or lake drawdown | | | 210 | 58.0% | CWF; LID; LA | LID; LA; SWCD | $ |
| WATERSHED | Load Reduction Needed: | | | 100 | | | | |
| | Load Reduction Achieved: | | | 38 | 10.5% | | | |
| Biofilters | Buffer strips | 21 | 18.9% | 10 | 2.8% | NRCS; CWF | NRCS; LID; SWCD; LA; LO | $-$$ |
| | Vegetated swales | 2 | 1.7% | 1 | 0.2% | | | |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 4 | 3.9% | 1 | 0.2% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 8 | 2.3% | CWF | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 0 | 0.0% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 2 | 0.5% | CWF; LID | SWCD; LID; LA; LO | $$-$$$ |
| Sedimentation | Sedimentation ponds | 10 | 9.1% | 6 | 1.6% | NRCS; CWF; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Gully stabilization | | | | | | | $-$$ |
| Agricultural BMPs | Collection, storage, and treatment of manure | | | 6 | 1.7% | NRCS; Ag BMP; CWF | NRCS; SWCD; LO | $-$$ |
| | 10% of cropland with conservation tillage | 9 | 7.9% | 4 | 1.2% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |
| TOTAL | Load Reduction Needed: | | | 362 | | | | |
| | Load Reduction Achieved: | | | 248 | 69% | | | |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 6. Proposed Implementation Activity Locations for Lake Emily Watershed**



### 3.4.4 Linn Lake

Linn Lake (MN DNR Lake ID 13-0014) is a shallow lake located in southern Chisago County, south of Lindstrom. The dominant land cover in the watershed is agriculture and woodland. The lake does not meet shallow lake water quality standards for total phosphorus, chlorophyll-*a*, or Secchi transparency.

Watershed assessment summary:

- The lake water quality violates the phosphorus, chlorophyll-*a*, and Secchi transparency water quality standards. The lake is hypereutrophic, with an average phosphorus concentration of 217 µg/L.
- Curly-leaf pondweed exists in the lake, although the extent is not known. Curly-leaf pondweed contributes to internal loading from the sediments. Many emergent macrophytes also exist.
- In a 1978 fish survey, black bullhead were abundant; there has not been a fish survey since then. Black bullhead can lead to high internal loading rates due to their habit of foraging in bottom sediments.
- Approximately 58% of the watershed is cropland, and there are three small animal operations in the watershed.
- The majority of the watershed is served by private on-site septic systems, which are estimated to have a 25% failure rate.
- Two imminent threat to public health septic systems, both of which were in the shoreland area, were recently upgraded.
- The lake model indicated that there is a large phosphorus load that is unaccounted for in the current phosphorus source inventory. This load is likely a mix of internal load and load from failing septic systems.

Phosphorus sources to Linn Lake are dominated by internal loading and watershed runoff. A phosphorus load reduction of 88% is needed in Linn Lake to achieve water quality goals. To meet the TMDL, taking into account the MOS, total loading to the lake needs to be reduced by 2,395 lb/yr, or 88% (Table 17). Approximately 848 lb/yr should come from the watershed load and approximately 1,547 lb/yr should come from internal load. Watershed load reduction practices will include stormwater reduction practices, lakeshore and streambank buffers, and a wide variety of agricultural Best Management Practices (BMPs). In-lake practices may consist of fish and aquatic plant management and management of internal nutrient cycling.

**Table 17. Linn Lake Phosphorus Reduction Summary**

| Phosphorus Source | Existing Annual TP Load (lb/yr) | Implementation Scenario Annual TP Load (lb/yr) | Load Reduction Needed (lb/yr) | Percent Reduction (%) |
|---|---|---|---|---|
| Watershed | 945 | 97 | 848 | 90% |
| Atmospheric Deposition | 49 | 49 | 0 | 0% |
| Internal | 1,725 | 178 | 1,547 | 90% |
| **Total** | **2,719** | **324** | **2,395** | **88%** |

### Priority Implementation Activities

Implementation activities needed to reduce the phosphorus loading to Linn Lake were a mix of watershed and in-lake projects. For Linn Lake to meet the TMDL, watershed loads need to be reduced by 848 lb TP/yr and in-lake loads need to be reduced by 1,547 lb TP/yr. The implementation activity identified with the largest phosphorus load reduction for Linn Lake was *in-lake trophic state alteration* (1,190 lb TP/yr). This could be achieved through management of carp, curly-leaf pondweed, and/or a fish kill to promote a clear water state. However, a detailed feasibility study is necessary to determine the most suitable in-lake treatment method for Linn Lake. Additional phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Agricultural BMPs (28 lb TP/yr)
- Septic system upgrades (25 lb TP/yr)
- Sedimentation ponds and gully stabilization (17 lb TP/yr)
- Buffer strips (8 lb TP/yr)
- Rain gardens (5 lb TP/yr)
- Lawn management practices (2 lb TP/yr)

Refer to Table 18 and Figure 7 for detailed information on and the locations of the implementation activities identified in the Linn Lake watershed.

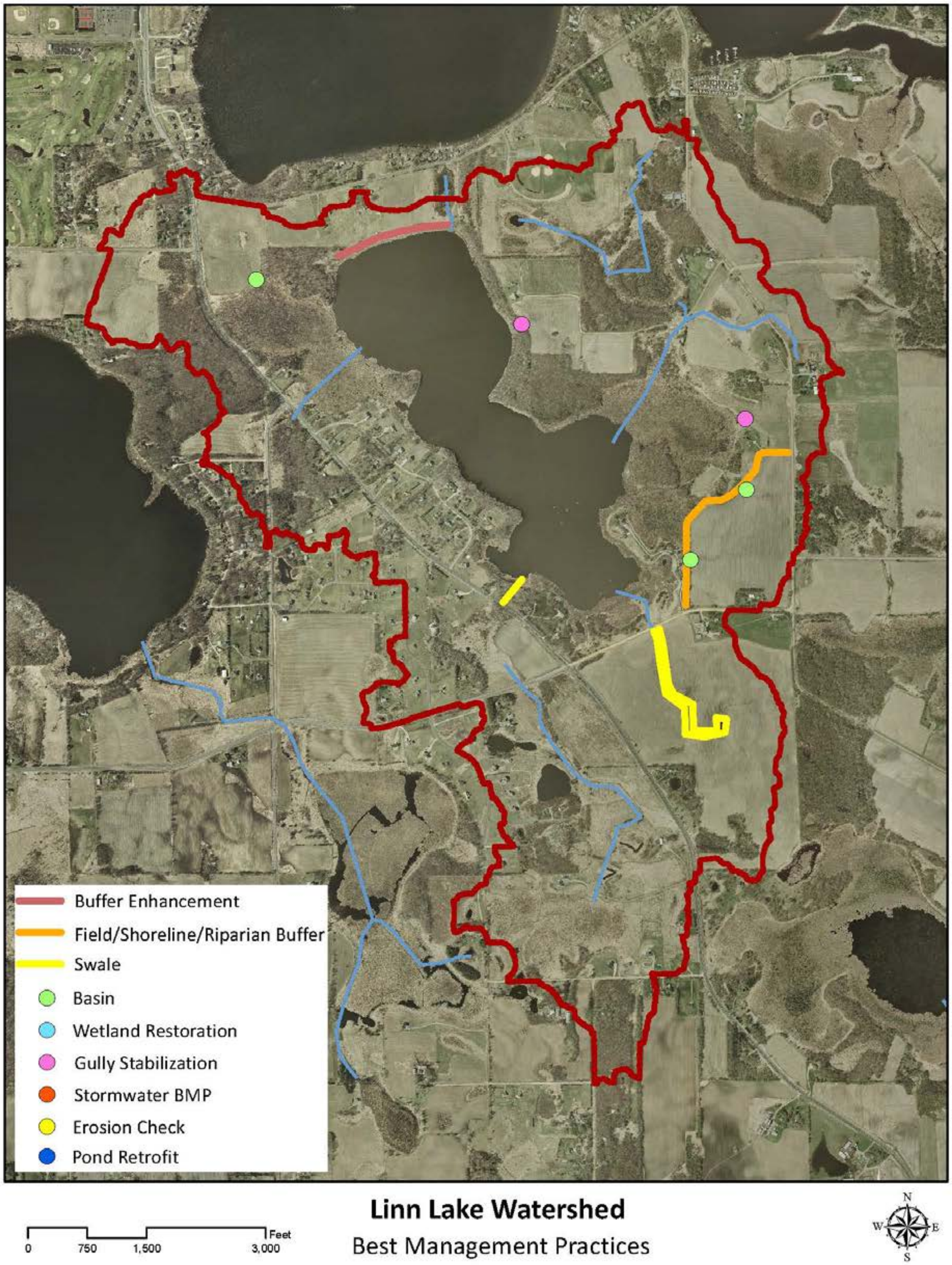
**Table 18. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Linn Lake Watershed**

| LINN LAKE IMPLEMENTATION PROJECTS CURRENT TP = 217 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Needed] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| IN-LAKE | Load Reduction Needed: | | | 1,547 | | | | |
| | Load Reduction Achieved: | | | 1,190 | 49.7% | | | |
| Trophic state alteration | Includes fish kill, fish stocking, carp management, curly-leaf pondweed management, and/or lake drawdown | | | 1,190 | 49.7% | | | Variable |
| WATERSHED | Load Reduction Needed: | | | 848 | | | | |
| | Load Reduction Achieved: | | | 85 | 3.5% | | | |
| Biofilters | Buffer strips | 18 | 1.6% | 8 | 0.3% | NRCS; CWF | NRCS; LID; SWCD; LA; LO | $-$$ |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 12 | 1.1% | 2 | 0.1% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 24 | 1.0% | CWF | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 2 | 0.1% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 5 | 0.2% | CWF; LID | SWCD; LID; LA; LO | $$-$$$ |
| Sedimentation | Sedimentation ponds | 30 | 2.6% | 17 | 0.7% | NRCS; CWF; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Gully stabilization | | | | | | | $-$$ |
| Agricultural BMPs | Collection, storage, and treatment of manure | | | 1 | 0.0% | NRCS; Ag BMP; CWF | NRCS; SWCD; LO | $-$$ |
| | 10% of cropland with conservation tillage | 67 | 5.8% | 27 | 1.1% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |
| **TOTAL** | **Load Reduction Needed:** | | | **2,395** | | | | |
| | **Load Reduction Achieved:** | | | **1,275** | **53%** | | | |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 7. Proposed Implementation Activity Locations for Linn Lake Watershed**



### 3.4.5 Little Lake

Little Lake (MN DNR Lake ID 13-0033) is a lake located in southern Chisago County, two miles northeast of Center City. The dominant land cover in the watershed is agriculture and woodland. The lake does not meet lake water quality standards for total phosphorus, chlorophyll-*a*, or Secchi transparency.

Watershed assessment summary:

- The lake water quality violates the phosphorus, chlorophyll-*a*, and Secchi transparency water quality standards. The lake is hypereutrophic, with an average phosphorus concentration of 173 µg/L.
- Curly-leaf pondweed exists in the lake, and was the most common plant in the lake in a 2004 survey. Curly-leaf pondweed contributes to internal loading from the sediments.
- Phosphorus concentration in sediments is high, indicating a high potential for internal loading from sediments.
- Approximately 55% of the watershed is cropland, and there are ten animal operations in the watershed.
- The entire watershed is served by private on-site septic systems, which are estimated to have a 25% failure rate.
- Five imminent threat to public health septic systems, two of which were in the shoreland area, were recently upgraded.
- The lake model indicated that there is a large phosphorus load that is unaccounted for in the current phosphorus source inventory. This load is likely a mix of internal load, load from animal operations, and load from failing septic systems.

Phosphorus sources to Little Lake are dominated by internal loading and watershed runoff. A phosphorus load reduction of 90% is needed to achieve water quality standards in Little Lake. To meet the TMDL, taking into account the MOS, total loading to the lake needs to be reduced by 2,658 lb/yr, or 90% (Table 19). Approximately 1,562 lb/yr should come from the watershed load and approximately 1,096 lb/yr should come from internal load. Watershed load reduction practices will include a wide variety of agricultural BMPs and lakeshore and streambank buffers. In-lake practices may consist of fish and aquatic plant management and management of internal nutrient cycling.

**Table 19. Little Lake Phosphorus Reduction Summary**

| Phosphorus Source | Existing Annual TP Load (lb/yr) | Implementation Scenario Annual TP Load (lb/yr) | Load Reduction Needed (lb/yr) | Percent Reduction (%) |
|---|---|---|---|---|
| Watershed | 1,710 | 148 | 1,562 | 91% |
| Atmospheric Deposition | 44 | 44 | 0 | 0% |
| Internal | 1,200 | 104 | 1,096 | 91% |
| **Total** | **2,954** | **296** | **2,658** | **90%** |

### Priority Implementation Activities

Implementation activities needed to reduce the phosphorus loading to Little Lake were a mix of watershed and in-lake projects. For Little Lake to meet the TMDL, watershed loads need to be reduced by 1,562 lb TP/yr and in-lake loads need to be reduced by 1,096 lb TP/yr. The implementation activity identified with the largest phosphorus load reduction for Little Lake was *sediment phosphorus inactivation* (900 lb TP/yr). This could be achieved through a sediment alum treatment to reduce anoxic P release from deep sediments. However, a detailed feasibility study is necessary to determine the most suitable in-lake treatment method for Little Lake. Additional phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Agricultural BMPs (62 lb TP/yr)
- Septic system upgrades (19 lb TP/yr)
- Sedimentation ponds, wetland restorations, and gully stabilization (51 lb TP/yr)
- Buffer strips and vegetated swales (3 lb TP/yr)
- Rain gardens (2 lb TP/yr)
- Lawn management practices (1 lb TP/yr)

Refer to Table 20 and Figure 8 for detailed information on and the locations of the implementation activities identified in the Little Lake watershed.

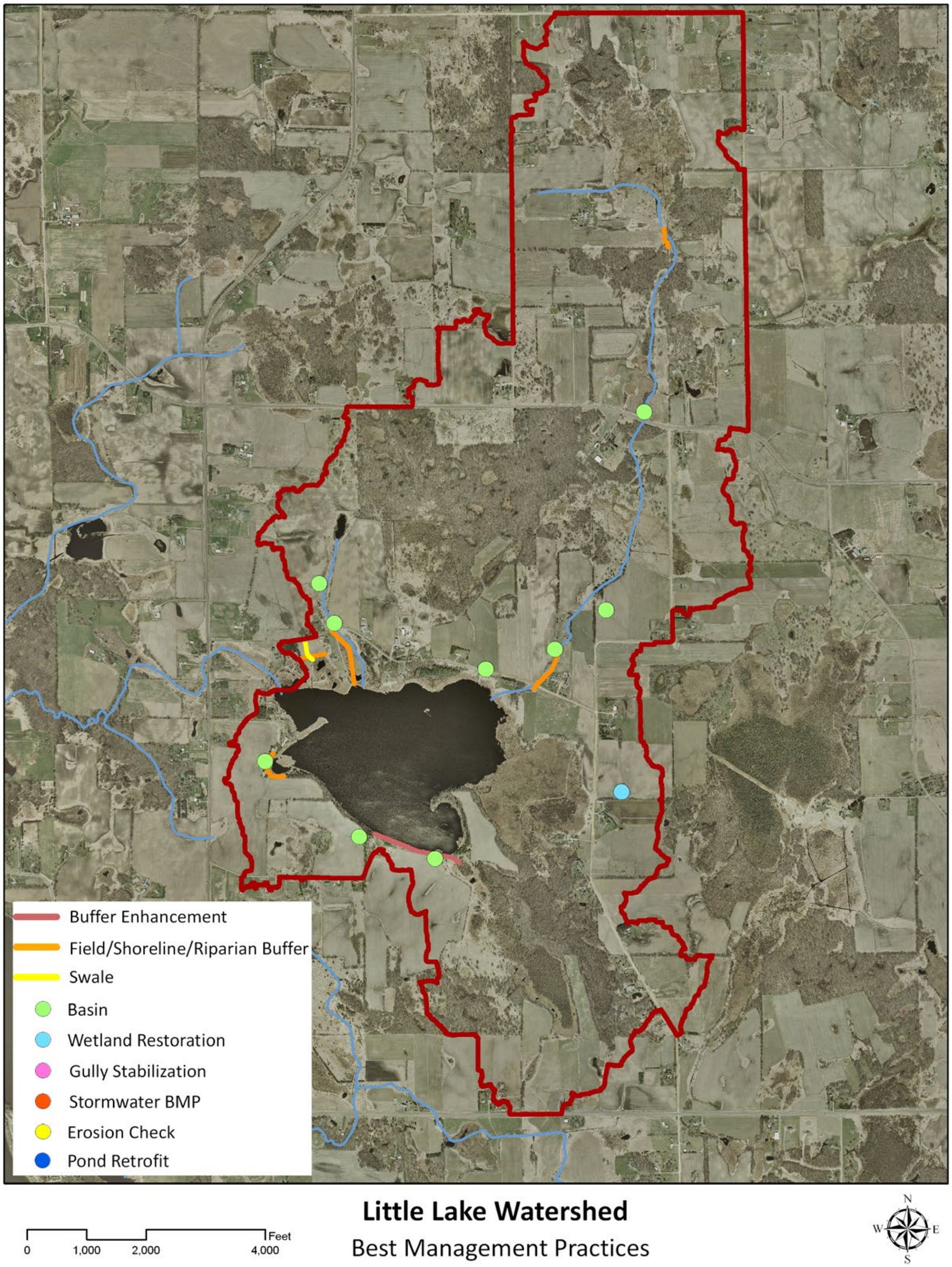
### Table 20. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Little Lake Watershed

| LITTLE LAKE IMPLEMENTATION PROJECTS CURRENT TP = 173 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Needed] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| IN-LAKE | Load Reduction Needed: | | | 1,096 | | | | |
| | Load Reduction Achieved: | | | 900 | 33.9% | | | |
| Sediment phosphorus inactivation | Application of aluminum sulfate to strip phosphorus in the water column and bind phosphorus in surface sediments. | | | 900 | 33.9% | | | $ |
| WATERSHED | Load Reduction Needed: | | | 1,562 | | | | |
| | Load Reduction Achieved: | | | 139 | 5.2% | | | |
| Biofilters | Buffer strips | 7 | 0.4% | 3 | 0.1% | NRCS; CWF | NRCS; LID; SWCD; LA; LO | $-$$ |
| | Vegetated swales | 1 | 0.0% | 0 | 0.0% | | | |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 6 | 0.3% | 1 | 0.0% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 12 | 0.5% | CWF | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 7 | 0.3% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 2 | 0.1% | CWF; LID | SWCD; LID; LA; LO | $$-$$$ |
| Sedimentation | Sedimentation ponds | 90 | 4.5% | 51 | 1.9% | NRCS; CWF; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Wetland restorations | 10 | 0.5% | | | | | |
| | Gully stabilization | | | | | | | $-$$ |
| Agricultural BMPs | Collection, storage, and treatment of manure | | | 22 | 0.8% | NRCS; Ag BMP; CWF | NRCS; SWCD; LO | $-$$ |
| | 10% of cropland with conservation tillage | 95 | 4.7% | 40 | 1.5% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |
| TOTAL | Load Reduction Needed: | | | 2,658 | | | | |
| | Load Reduction Achieved: | | | 1,039 | 39% | | | |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 8. Proposed Implementation Activity Locations for Little Lake Watershed**



### 3.4.6 Ogren Lake

Ogren Lake (MN DNR Lake ID 13-0011) is a lake located in southern Chisago County to the southeast of South Center Lake. Ogren Lake has a very large watershed area that is primarily dominated by agricultural land use and wetlands. The lake does not meet shallow lake water quality standards for total phosphorus or chlorophyll-*a*, but meets the standard for Secchi transparency.

Watershed assessment summary:

- The lake water quality violates the phosphorus and chlorophyll-*a* water quality standards but meets the Secchi transparency standard.
- There are no invasive aquatic macrophytes in the lake; the lake has a desirable mix of emergent and submergent macrophytes.
- Phosphorus concentration in sediments is high, indicating a high potential for internal loading from sediments.
- A 1989 fish survey indicated the presence of black bullhead; there has not been a fish survey since then. Black bullhead can lead to high internal loading rates due to their habit of foraging in bottom sediments.
- Approximately 54% of the watershed is cropland, and there are nine animal operations in the watershed.
- The entire watershed is served by private on-site septic systems, which are estimated to have a 25% failure rate.
- Ten imminent threat to public health septic systems, four of which were in the shoreland area, were recently upgraded.

Phosphorus sources to Ogren Lake are mainly rural watershed runoff. A phosphorus load reduction of 45% is needed to bring the aquatic recreation of Ogren Lake back to a useable state. To meet the TMDL, taking into account the MOS, total loading to the lake needs to be reduced by 467 lb/yr, or 45% (Table 21). Approximately 430 lb/yr should come from the watershed load and approximately 37 lb/yr should come from internal load. Watershed load reduction practices will include a wide variety of agricultural Best Management Practices (BMPs) and lakeshore and streambank buffers. In-lake practices may consist of fish and aquatic plant management and management of internal nutrient cycling.

**Table 21. Ogren Lake Phosphorus Reduction Summary**

| Phosphorus Source | Existing Annual TP Load (lb/yr) | Implementation Scenario Annual TP Load (lb/yr) | Load Reduction Needed (lb/yr) | Percent Reduction (%) |
|---|---|---|---|---|
| Watershed | 860 | 430 | 430 | 50% |
| Atmospheric Deposition | 13 | 13 | 0 | 0% |
| Internal | 170 | 133 | 37 | 22% |
| **Total** | **1,043** | **576** | **467** | **45%** |

#### Priority Implementation Activities

Implementation activities needed to reduce the phosphorus loading to Ogren Lake by 430 lb/yr were watershed-based. Some in-lake load reductions (37 lb TP/yr) were identified in the Ogren Lake TMDL, but they were not a priority for this implementation plan. The implementation activity identified with the largest phosphorus load reduction for Ogren Lake was *septic system upgrades* (52 lb TP/yr). Additional phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Agricultural BMPs (47 lb TP/yr)
- Sedimentation ponds and gully stabilization (17 lb TP/yr)
- Buffer strips (7 lb TP/yr)
- Rain gardens (7 lb TP/yr)
- Lawn management practices (1 lb TP/yr)

Refer to Table 22 and Figure 9 for detailed information on and the locations of the implementation activities identified in the Ogren Lake watershed.

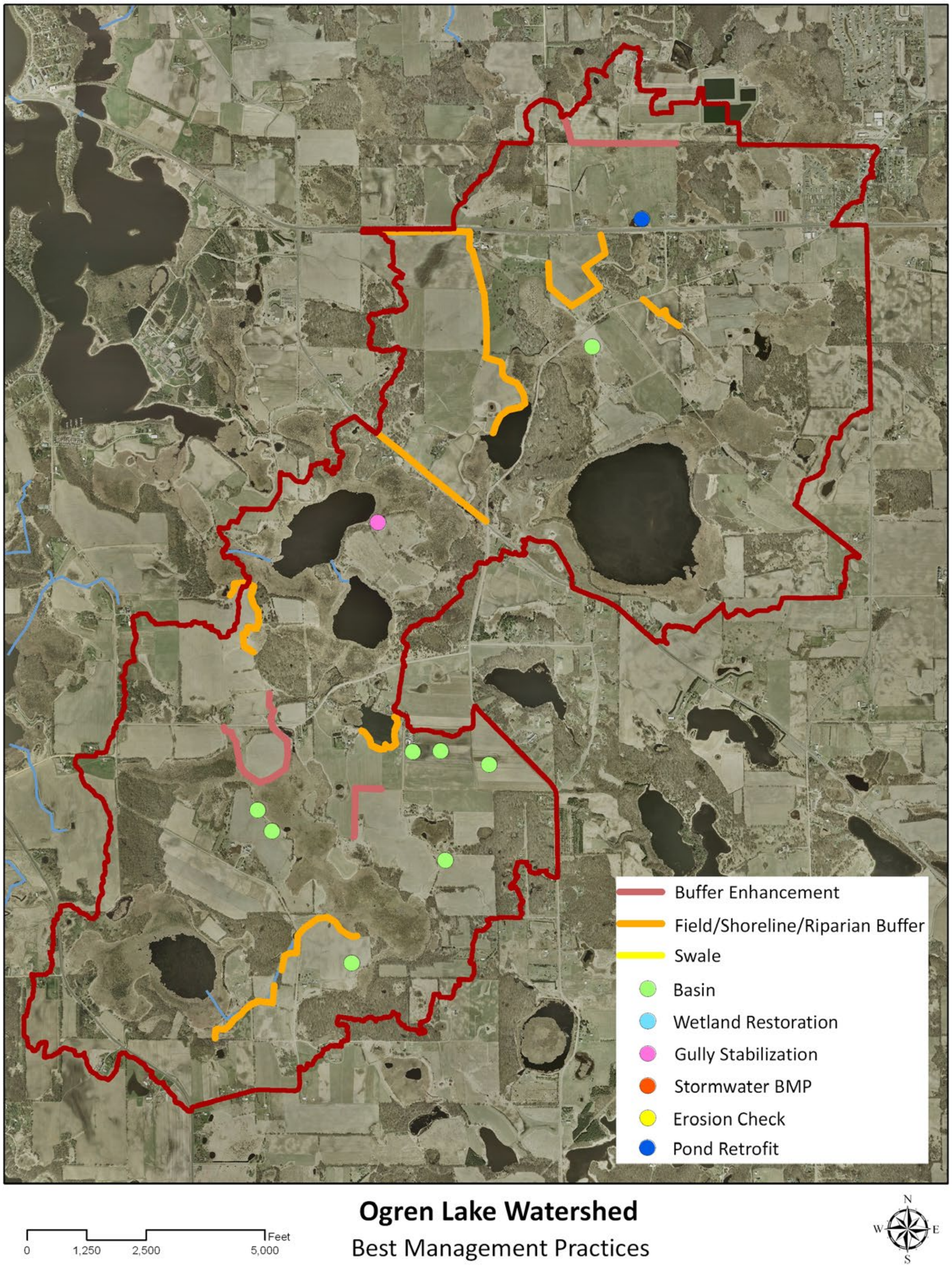
**Table 22. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Ogren Lake Watershed**

| OGREN LAKE IMPLEMENTATION PROJECTS<br>CURRENT TP = 64 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Needed] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| IN-LAKE | Load Reduction Needed: | | | 37 | | | | |
| | Load Reduction Achieved: | | | 0 | 0.0% | | | |
| None | | | | | | | | |
| WATERSHED | Load Reduction Needed: | | | 430 | | | | |
| | Load Reduction Achieved: | | | 130 | 27.9% | | | |
| Biofilters | Buffer strips | 62 | 1.5% | 7 | 1.4% | NRCS; CWF | NRCS; LID; SWCD; LA; LO | $-$$ |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 17 | 0.4% | 1 | 0.2% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 37 | 8.0% | CWF | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 14 | 3.1% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 7 | 1.5% | CWF; LID | SWCD; LID; LA; LO | $$-$$$ |
| Sedimentation | Sedimentation ponds | 130 | 3.2% | 17 | 3.7% | NRCS; CWF; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Gully stabilization | | | | | | | $-$$ |
| Agricultural BMPs | Collection, storage, and treatment of manure | | | 25 | 5.3% | NRCS; Ag BMP; CWF | NRCS; SWCD; LO | $-$$ |
| | 10% of cropland with conservation tillage | 213 | 5.2% | 22 | 4.8% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |
| TOTAL | Load Reduction Needed: | | | 467 | | | | |
| | Load Reduction Achieved: | | | 130 | 28% | | | |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 9. Proposed Implementation Activity Locations for Ogren Lake Watershed**



### 3.4.7 Pioneer Lake

Pioneer Lake (MN DNR Lake ID 13-0034) is a shallow lake located in southern Chisago County, 0.5 mile north of Center City. The watershed for Pioneer Lake is very small (roughly twice the size of the lake) and is dominated by cropland and woodland. The lake does not meet shallow lake water quality standards for total phosphorus, chlorophyll-a, or Secchi transparency.

Watershed assessment summary:

- The lake water quality violates the phosphorus, chlorophyll-*a*, and Secchi transparency water quality standards. The lake is hypereutrophic, with an average phosphorus concentration of 345 µg/L.
- The lake is very shallow, with a mean depth of five feet and a maximum depth of eight feet.
- Curly-leaf pondweed exists in the lake, although the extent is not known. Curly-leaf pondweed contributes to internal loading from the sediments. A dense mat of Canada waterweed was present in a 2001 survey.
- Black bullhead were the most abundant fish observed in a 2001 fish survey. Black bullhead can lead to high internal loading rates due to their habit of foraging in bottom sediments.
- A large portion of the shoreline is developed.
- Approximately 30% of the watershed is cropland.
- Approximately 20% of the watershed is served by private on-site septic systems, which are estimated to have a 25% failure rate.
- One imminent threat to public health septic system located in the shoreland area was recently upgraded.
- The lake model indicated that there is a large phosphorus load that is unaccounted for in the current phosphorus source inventory. This load is likely due to internal load.

The main phosphorus source to Pioneer Lake is internal load. A phosphorus load reduction of 96% is needed to bring water quality standards for a shallow lake. To meet the TMDL, taking into account the MOS, total loading to the lake needs to be reduced by 1,771 lb/yr, or 96% (Table 23). Approximately 21 lb/yr should come from the watershed load and approximately 1,750 lb/yr should come from internal load. Watershed load reduction practices will include urban stormwater reduction practices, lakeshore and streambank buffers, and a wide variety of agricultural Best Management Practices (BMPs). In-lake practices may consist of fish and aquatic plant management and management of internal nutrient cycling.

**Table 23. Pioneer Lake Phosphorus Reduction Summary**

| Phosphorus Source | Existing Annual TP Load (lb/yr) | Implementation Scenario Annual TP Load (lb/yr) | Load Reduction Needed (lb/yr) | Percent Reduction (%) |
|---|---|---|---|---|
| Watershed | 22 | 0.61 | 21 | 95% |
| Atmospheric Deposition | 21 | 21 | 0 | 0% |
| Internal | 1,800 | 50 | 1,750 | 97% |
| **Total** | **1,843** | **72** | **1,771** | **96%** |

#### Priority Implementation Activities

Implementation activities needed to reduce the phosphorus loading to Pioneer Lake by 1,750 lb/yr were primarily in-lake. Small in-lake load reductions (21 lb TP/yr) were identified in the Pioneer Lake TMDL, and potential watershed implementation projects are listed below. The implementation activity identified with the largest phosphorus load reduction for Pioneer Lake was *in-lake trophic state alteration* (1,260 lb TP/yr). This could be achieved through management of curly-leaf pondweed, and a fish stocking combined with aeration to promote a clear water state. However, a detailed feasibility study is necessary to determine the most suitable in-lake treatment method for Pioneer Lake. Additional phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Rain gardens and infiltration BMPs (6 lb TP/yr)
- Septic system upgrades (4 lb TP/yr)
- Buffer strips (1 lb TP/yr)
- Agricultural BMPs (0.3 lb TP/yr)
- Lawn management practices (0.3 lb TP/yr)

Refer to Table 24 and Figure 10 for detailed information on and the locations of the implementation activities identified in the Pioneer Lake watershed.

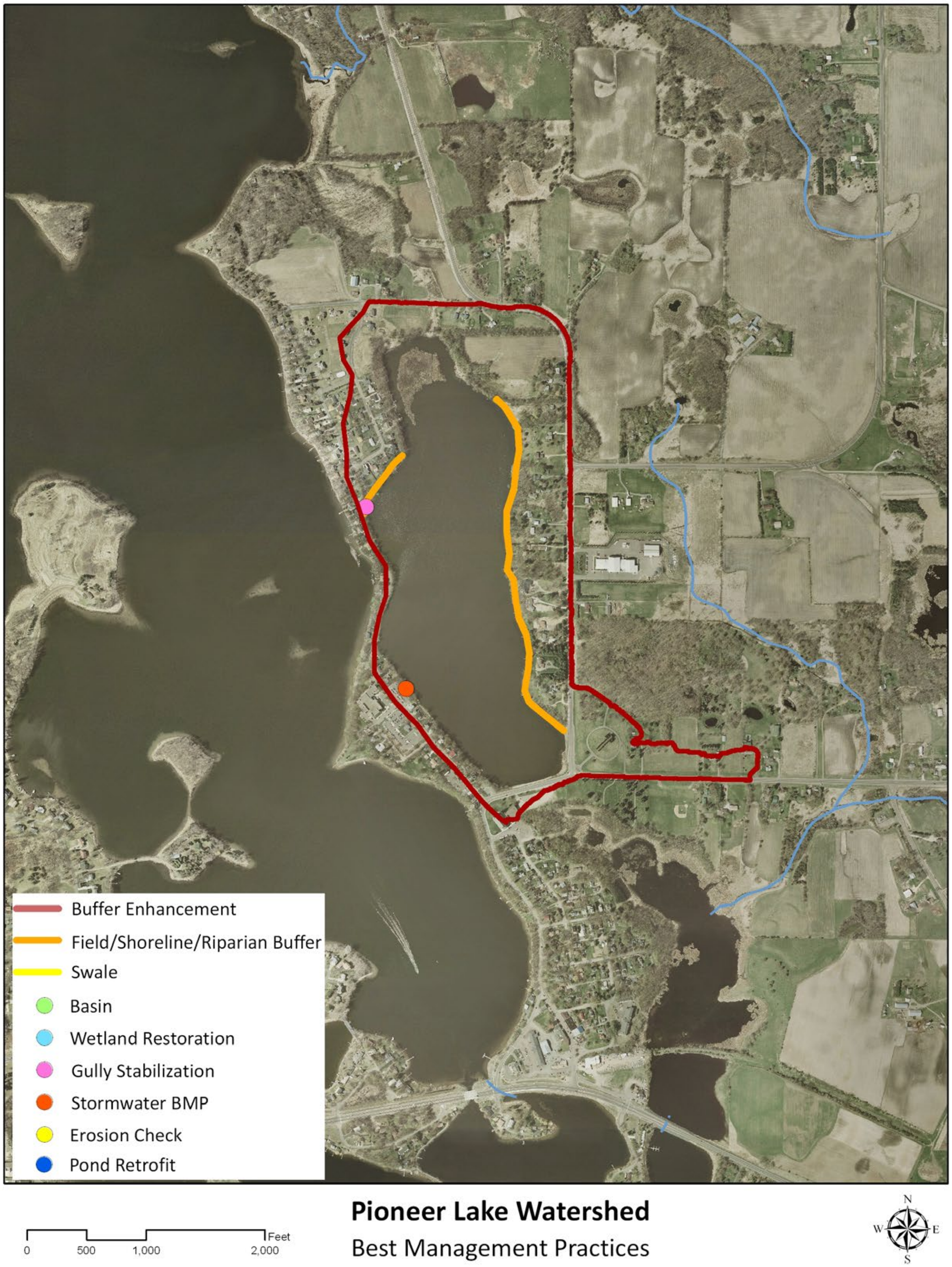
**Table 24. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Pioneer Lake Watershed**

| PIONEER LAKE IMPLEMENTATION ACTIVITES<br>CURRENT TP = 345 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Needed] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| IN-LAKE | Load Reduction Needed: | | | 1,750 | | | | |
| | Load Reduction Achieved: | | | 1,260 | 71.1% | | | |
| Trophic state alteration | Includes fish kill, fish stocking, carp management, curly-leaf pondweed management, and/or lake drawdown | | | 1,260 | 71.1% | | | Variable |
| WATERSHED | Load Reduction Needed: | | | 21 | | | | |
| | Load Reduction Achieved: | | | 12 | 0.7% | | | |
| Biofilters | Buffer strips | 8 | 9.2% | 1 | 0.1% | NRCS; CWF | NRCS; LID; SWCD; LA; LO | $-$$ |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 7 | 7.1% | 0 | 0.0% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 3 | 0.2% | CWF | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 1 | 0.1% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 3 | 0.1% | CWF; LID | SWCD; LID; LA; LO | $$-$$$ |
| | Infiltration BMPs (Center City) | 12 | 13.3% | 4 | 0.2% | | SWCD; LID; City; LA; LO | $$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 3 | 2.9% | 0.3 | 0.0% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |
| **TOTAL** | **Load Reduction Needed:** | | | **1,771** | | | | |
| | **Load Reduction Achieved:** | | | **1,272** | **72%** | | | |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 10. Proposed Implementation Activity Locations for Pioneer Lake Watershed**



### 3.4.8 School Lake

School Lake (MN DNR Lake ID 13-0044) is a shallow lake located in southern Chisago County, 0.5 miles north of Chisago City. School Lake has a watershed area that is primarily dominated by agricultural land use and wetlands. The lake does not meet shallow lake water quality standards for total phosphorus, chlorophyll-*a*, or Secchi transparency.

Watershed assessment summary:

- The lake water quality violates the phosphorus, chlorophyll-*a*, and Secchi transparency water quality standards.
- The lake is very shallow, with a mean depth of five feet and a maximum depth of eight feet.
- Curly-leaf pondweed exists in the lake, although the extent is not known. Curly-leaf pondweed contributes to internal loading from the sediments.
- There is an abundance of stunted sunfish and black bullhead. The presence of stunted sunfish often indicates an overabundance of planktivorous fish such as sunfish. This overabundance leads to overgrazing on zooplankton and a resultant increase in algae. Black bullhead can lead to high internal loading rates due to their habit of foraging in bottom sediments.
- Approximately 43% of the watershed is cropland, and there are three small animal operations in the watershed.
- The majority of the watershed is served by private on-site septic systems, which are estimated to have a 25% failure rate.
- Three imminent threat to public health septic systems, one of which was in the shoreland area, were recently upgraded.
- The lake model indicated that there is a large phosphorus load that is unaccounted for in the current phosphorus source inventory. This load is likely a mix of internal load, load from animal operations, and load from failing septic systems.

The main phosphorus sources to School Lake are watershed runoff and internal load. A phosphorus load reduction of 88% is needed to meet water quality standards for a shallow lake.

To meet the TMDL, taking into account the MOS, total loading to the lake needs to be reduced by 1,591 lb/yr, or 88% (Table 25). Approximately 818 lb/yr should come from the watershed load and approximately 773 lb/yr should come from internal load. Watershed load reduction practices will include urban stormwater reduction practices, lakeshore and streambank buffers, and a wide variety of agricultural Best Management Practices (BMPs). In-lake practices may consist of fish and aquatic plant management and management of internal nutrient cycling.

**Table 25. School Lake Phosphorus Reduction Summary**

| Phosphorus Source | Existing Annual TP Load (lb/yr) | Implementation Scenario Annual TP Load (lb/yr) | Load Reduction Needed (lb/yr) | Percent Reduction (%) |
|---|---|---|---|---|
| Watershed | 918 | 100 | 818 | 89% |
| Atmospheric Deposition | 39 | 39 | 0 | 0% |
| Internal | 850 | 77 | 773 | 91% |
| **Total** | **1,807** | **216** | **1,591** | **88%** |

### Priority Implementation Activities

Implementation activities needed to reduce the phosphorus loading to School Lake were a mix of watershed and in-lake projects. For School Lake to meet the TMDL, watershed loads need to be reduced by 818 lb P/yr and in-lake loads need to be reduced by 773 lb TP/yr. The implementation activity identified with the largest phosphorus load reduction for School Lake was *in-lake trophic state alteration* (773 lb TP/yr). This could be achieved through management of curly-leaf pondweed, and fish stocking combined with aeration to promote a clear water state. However, a detailed feasibility study is necessary to determine the most suitable in-lake treatment method for School Lake. Additional phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Agricultural BMPs (20 lb TP/yr)
- Buffer strips (16 lb TP/yr)
- Septic system upgrades (11 lb TP/yr)
- Rain gardens and infiltration BMPs (4 lb TP/yr)
- Lawn management practices (3 lb TP/yr)

Refer to Table 26 and Figure 11 for detailed information on and the locations of the implementation activities identified in the School Lake watershed.

**Table 26. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for School Lake Watershed**

| SCHOOL LAKE IMPLEMENTATION ACTIVITES<br>CURRENT TP = 216 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Needed] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| IN-LAKE | Load Reduction Needed: | | | 773 | | | | |
| | Load Reduction Achieved: | | | 595 | 37.4% | | | |
| Trophic state alteration | Includes fish kill, fish stocking, carp management, curly-leaf pondweed management, and/or lake drawdown | | | 595 | 37.4% | | | Variable |
| WATERSHED | Load Reduction Needed: | | | 818 | | | | |
| | Load Reduction Achieved: | | | 55 | 3.4% | | | |
| Biofilters | Buffer strips | 12 | 3.6% | 16 | 1.0% | NRCS; CWF | NRCS; LID; SWCD; LA; LO | $-$$ |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 6 | 1.8% | 3 | 0.2% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 7 | 0.4% | CWF | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 4 | 0.3% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 2 | 0.2% | CWF; LID | SWCD; LID; LA; LO | $$-$$$ |
| | Infiltration BMPs (Chisago City) | 20 | 5.8% | 2 | 0.1% | | SWCD; LID; City; LA; LO | $$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 15 | 4.3% | 20 | 1.2% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |
| **TOTAL** | **Load Reduction Needed:** | | | **1,591** | | | | |
| | **Load Reduction Achieved:** | | | **650** | **41%** | | | |

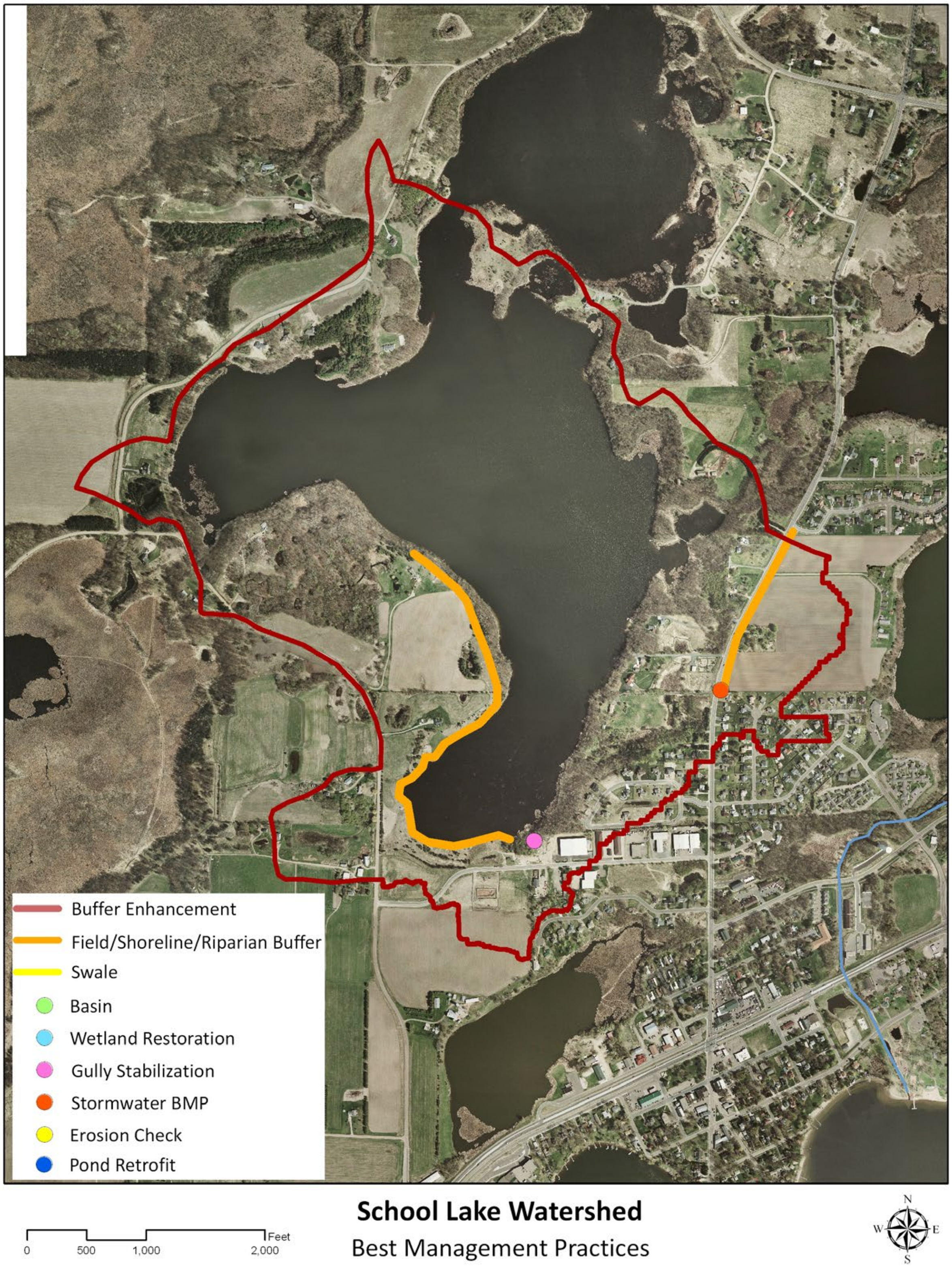
Symbol key

Ag BMP MDA Agricultural BMP Loan Program
CWF Clean Water Fund
CWP Clean Water Partnerships/ 319 Grants
LA Lake Associations

LID Lake Improvement District
LO Landowners
NRCS Natural Resources Conservation Service
SWCD Soil and Water Conservation District

$ < $500/lb TP removed/yr
$$ = $500-$1500/lb TP removed/yr
$$$ > $1500 lb TP removed/yr

**Figure 11. Proposed Implementation Activity Locations for School Lake Watershed**



### 3.4.9 Wallmark Lake

Wallmark Lake (MN DNR Lake ID 13-0029) is a shallow lake located in southern Chisago County, one mile north of Chisago City. Agricultural cropland and woodland are the main cover types within the watershed. At one time, Wallmark Lake accepted wastewater from the communities of Chisago City and Lindstrom. This was discontinued in the mid-1980s and routed to an unnamed ditch and eventually to the Chisago Lakes Joint Sewage Treatment Commission facility (MPCA, CLMP+ Report, 2002). The lake does not meet shallow lake water quality standards for total phosphorus, chlorophyll-*a*, or Secchi transparency.

Watershed assessment summary:

- The lake water quality violates the phosphorus, chlorophyll-*a*, and Secchi transparency water quality standards. The lake is hypereutrophic, with an average phosphorus concentration of 322 µg/L.
- Curly-leaf pondweed exists in the lake, although the extent is not known. Curly-leaf pondweed contributes to internal loading from the sediments.
- There is an abundance of stunted sunfish and black bullhead. The presence of stunted sunfish often indicates an overabundance of planktivorous fish such as sunfish. This overabundance leads to overgrazing on zooplankton and a resultant increase in algae. Black bullhead can lead to high internal loading rates due to their habit of foraging in bottom sediments.
- Approximately 33% of the watershed is cropland.
- The majority of the watershed is served by private on-site septic systems, which are estimated to have a 25% failure rate.
- Two imminent threat to public health septic systems located in the shoreland area were recently upgraded.
- Wallmark Lake was the receiving water for the discharge from the Chisago City and Lindstrom wastewater treatment facility until the mid-1980s.
- The model indicated that there is a large phosphorus load that is unaccounted for in the phosphorus source inventory. This load is likely a mix of internal load and load from failing septic systems.

The main phosphorus sources to Wallmark Lake are watershed runoff and internal load. A phosphorus load reduction of 95% is needed to meet water quality standards for a shallow lake. To meet the TMDL, taking into account the MOS, total loading to the lake needs to be reduced by 3,997 lb/yr, or 95% (Table 27). Approximately 1,052 lb/yr should come from the watershed load and approximately 2,945 lb/yr should come from internal load. Watershed load reduction practices will include urban stormwater reduction practices, and lakeshore and shoreline buffers. In-lake practices may consist of fish and aquatic plant management and management of internal nutrient cycling.

**Table 27. Wallmark Lake Phosphorus Reduction Summary**

| Phosphorus Source | Existing Annual TP Load (lb/yr) | Implementation Scenario Annual TP Load (lb/yr) | Load Reduction Needed (lb/yr) | Percent Reduction (%) |
|---|---|---|---|---|
| Watershed | 1,098 | 46 | 1,052 | 96% |
| Atmospheric Deposition | 40 | 40 | 0 | 0% |
| Internal | 3,075 | 130 | 2,945 | 96% |
| **Total** | **4,213** | **216** | **3,997** | **95%** |

#### Priority Implementation Activities

Implementation activities needed to reduce the phosphorus loading to Wallmark Lake were a mix of watershed and in-lake projects. For Wallmark Lake to meet the TMDL, watershed loads need to be reduced by 1,052 lb TP/yr and in-lake loads need to be reduced by 2,945 lb TP/yr. The implementation activity identified with the largest phosphorus load reduction for Wallmark Lake was *in-lake trophic state alteration* (2,170 lb TP/yr). This could be achieved through management of carp, curly-leaf pondweed, and fish stocking combined with aeration to promote a clear water state. However, a detailed feasibility study is necessary to determine the most suitable in-lake treatment method for Wallmark Lake. Additional phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Buffer strips (39 lb TP/yr)
- Rain gardens and infiltration BMPs (25 lb TP/yr)
- Lawn management practices (19 lb TP/yr)
- Agricultural BMPs (18 lb TP/yr)
- Septic system upgrades (18 lb TP/yr)
- Sedimentation ponds and gully stabilization (18 lb TP/yr)

Refer to Table 28 and Figure 12 for detailed information on and the locations of the implementation activities identified in the Wallmark Lake watershed.

**Table 28. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Wallmark Lake Watershed**

| WALLMARK LAKE IMPLEMENTATION ACTIVITES CURRENT TP = 322 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Needed] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| IN-LAKE | Load Reduction Needed: | | | 2,945 | | | | |
| | Load Reduction Achieved: | | | 2,170 | 54.3% | | | |
| Trophic state alteration | Includes fish kill, fish stocking, carp management, curly-leaf pondweed management, and/or lake drawdown | | | 2,170 | 54.3% | | | Variable |
| WATERSHED | Load Reduction Needed: | | | 1,052 | | | | |
| | Load Reduction Achieved: | | | 137 | 3.4% | | | |
| Biofilters | Buffer strips | 28 | 7.2% | 39 | 1.0% | NRCS; CWF | NRCS; LID; SWCD; LA; LO | $-$$ |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 34 | 8.4% | 19 | 0.5% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 16 | 0.4% | CWF | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 2 | 0.0% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 13 | 0.3% | CWF; LID | SWCD; LID; LA; LO | $$-$$$ |
| | Infiltration BMPs (Chisago City) | 38 | 9.5% | 12 | 0.3% | | SWCD; LID; City; LA; LO | $$ |
| Sedimentation | Sedimentation ponds | 10 | 2.5% | 18 | 0.4% | NRCS; CWF; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Gully stabilization | | | | | | | $-$$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 13 | 3.3% | 18 | 0.5% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |
| TOTAL | Load Reduction Needed: | | | 3,997 | | | | |
| | Load Reduction Achieved: | | | 2,307 | 58% | | | |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 12. Proposed Implementation Activity Locations for Wallmark Lake Watershed**

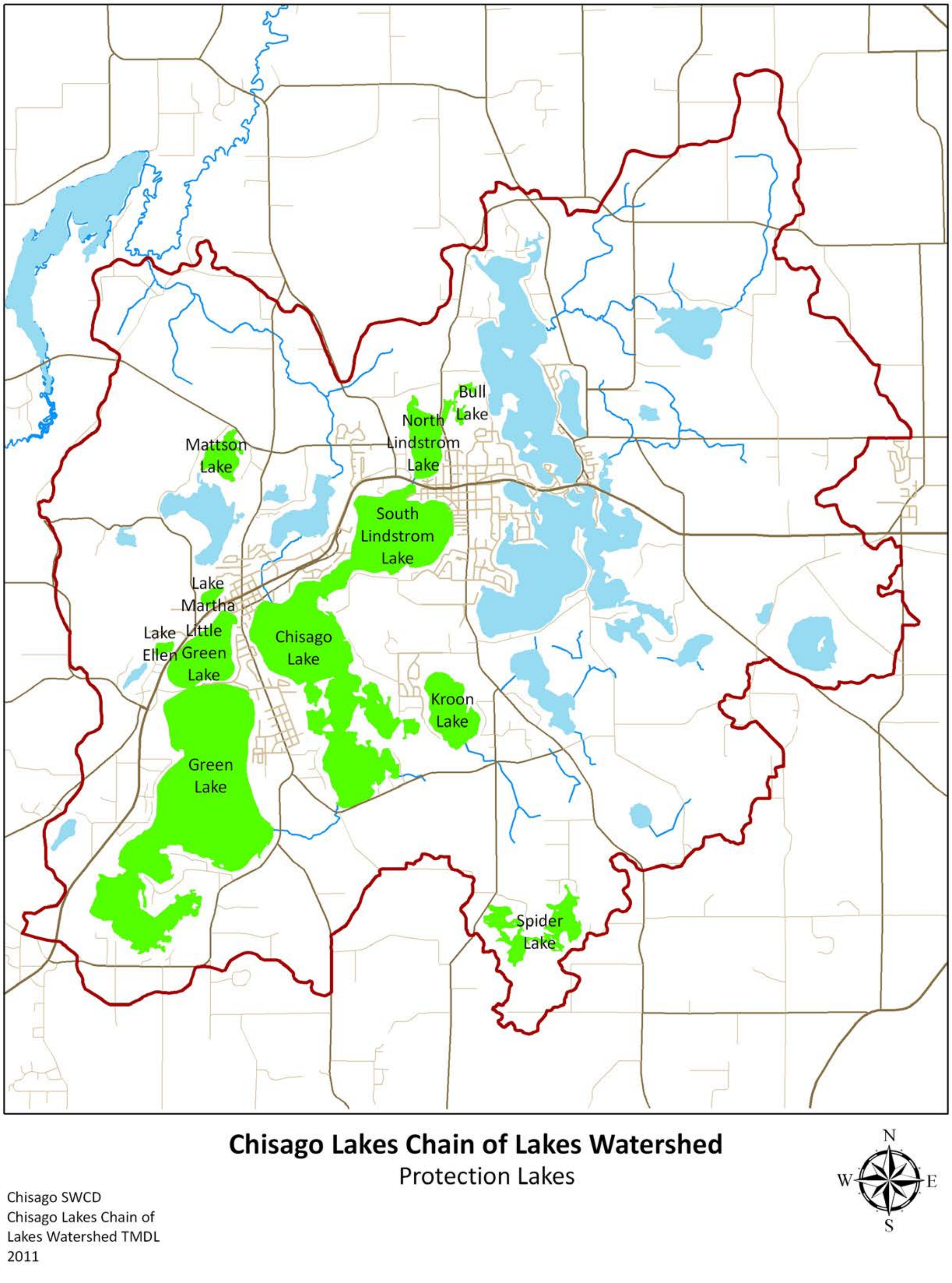
# 4 WATERSHED LAKE PROTECTION PLAN

Many lakes within the Chisago Lakes Chain of Lakes Watershed are currently meeting water quality standards set by the State of Minnesota. These waters will require protection measures to keep these unimpaired and unassessed waters off the Impaired Waters List. Protection measures include, but are not limited to, best management practices, ordinances, and education. These waters are shown in Figure 13. Waters for Protection.

**Table 29 - Waters for Protection**

| Lake Name | DNR Lake ID |
|---|---|
| Chisago Lake | 13-0012 |
| Lake Ellen | 13-0047 |
| Green Lake | 13-0041-02 |
| Little Green Lake | 13-0041-01 |
| Kroon Lake | 13-0013 |
| North Lindstrom Lake | 13-0035 |
| South Lindstrom Lake | 13-0028 |
| Lake Martha | 13-0040 |
| Mattson Lake | 13-0043 |
| Spider Lake | 13-0019 |
| **Waters Included within other Lake Watersheds** | |
| Bloom Lake | Swamp Lake (South) |
| Bull Lake | Swamp Lake (North) |
| Tributaries | |

**Figure 13. Waters for Protection**



## 4.1 Overall Approach

Identification of potential implementation activities and their phosphorus load reductions for the protection lakes followed the same method described in the Impaired Lakes Restoration Plan (See Section 3.3 for implementation activity descriptions, and methods for identification of implementation opportunities, phosphorus removal, and cost-benefits.)

## 4.2 Implementation Activities

Implementation activities identified in the protection lake watersheds are summarized in Table 30. The objective of this table is to guide selection of implementation activities appropriate for each lake watershed. Included in the table is:

1. Lake setting information to provide context for the load reductions that can be achieved by implementation activities, including: current in-lake TP concentrations relative to water quality standards, drainage and lake surface areas, and dominant land use.
2. Load reductions achieved by individual implementation activities:
    - Biofilters
    - Lawn management
    - Septic system upgrades
    - Bioretention & infiltration features
    - Sedimentation ponds and wetlands
    - Agricultural BMPs

Implementation activities with the largest load reductions are highlighted in yellow for each lake. This table is a summary of the individual protection lake implementation tables found in the Section 4.2 subsections below.

## Table 30. Implementation Activity and Load Reduction Summary for Protection Lakes.

| | PROTECTION LAKES | | | CHISAGO | ELLEN | Little GREEN | GREEN | KROON | N LINDSTROM | S LINDSTROM | MARTHA | MATTSON | SPIDER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SETTING | Lake Type | | | **Lake** | **Shallow** | **Shallow** | **Lake** | **Lake** | **Lake** | **Lake** | **Shallow** | **Shallow** | **Shallow** |
| | In-lake TP Concentration | | [µg/L] | **37** | **58** | **40** | **41** | **36** | **25** | **35** | **---** | **27** | **55** |
| | TP Standard | | [µg/L] | **40** | **60** | **60** | **40** | **40** | **40** | **40** | **60** | **60** | **60** |
| | Lake Surface Area | | [ac] | 897 | 28 | 225 | 1,587 | 181 | 142 | 548 | 35 | 69 | 122 |
| | Drainage Area‡ | | [ac] | 2,033 | 93 | 190 | 3,025 | 960 | 415 | 565 | 76 | 533 | 932 |
| | Direct Drainage Dominant Land Covers | Developed | | 19% | 33% | 40% | 26% | 18% | 25% | 31% | 38% | 23% | 12% |
| | | Cropland | | 13% | 33% | 0% | 18% | 18% | 8% | 2% | 17% | 7% | 19% |
| | | Woodland | | 19% | 9% | 0% | 6% | 10% | 26% | 10% | 2% | 25% | 30% |
| | | Grassland | | 7% | 0% | 0% | 7% | 22% | 6% | 5% | 11% | 11% | 16% |
| | | Aquatic | | 43% | 25% | 60% | 43% | 32% | 36% | 53% | 32% | 34% | 24% |
| WATERSHED | **Estimated Total Load** | | [lb/yr] | 433 | 12 | 58 | 563 | 143 | 99 | 262 | 16 | 59 | 98 |
| | | Biofilters | | 3 | | 3 | 8 | 2 | 2 | 5 | 0.1 | | 0.3 |
| | | Lawn management | | 5 | 0.04 | 1 | 3 | 1 | 2 | 6 | 0.2 | 0.2 | 0.2 |
| | | Septic upgrades | | 48 | 3.5 | 3 | 115 | 29 | 9 | 18 | 0.8 | 8 | 20 |
| | | Bioretention & infiltration | | 37 | 0.7 | 19 | 41 | 7 | 18 | 81 | 5.8 | 3 | 4 |
| | | Sedimentation | | | 1.0 | 2 | 10 | 2 | | | | | |
| | | Agricultral BMPs | | 6 | 0.2 | | 5 | 1 | 0.4 | 0.3 | 0.1 | 0.2 | 1 |
| | **Load Reduction** | | [lb/yr] | **98** | **5** | **28** | **181** | **42** | **30** | **111** | **7** | **12** | **25** |
| | | | [% of Total] | 23% | 46% | 49% | 32% | 29% | 31% | 43% | 45% | 20% | 26% |

‡excluding upstream lake watersheds

### 4.2.1 Chisago Lake

Chisago Lake (MN DNR Lake ID 13-0012) is a deep lake located between the cities of Lindstrom and Chisago City. Developed area and woodland make up the majority of the immediate drainage area to Chisago Lake. In the contributing area, cropland also makes up a large portion of the watershed. The lake currently meets water quality standards. The northern portion of the lake is deep and relatively clear, while the southern end of the lake is much shallower and is dominated by aquatic vegetation.

#### Priority Implementation Activities

Implementation activities identified in the Chisago Lake watershed can reduce the total phosphorus load by 98 lb TP/yr, or 23% of the total estimated watershed load. Phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Septic system upgrades (48 lb TP/yr)
- Rain gardens and infiltration BMPs (37 lb TP/yr)
- Agricultural BMPs (6 lb TP/yr)
- Lawn management practices (5 lb TP/yr)
- Buffer strips (3 lb TP/yr)

Refer to Table 31 and Figure 14 for detailed information on and the locations of implementation activities identified in the Chisago Lake watershed.

**Table 31. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Chisago Lake Watershed**

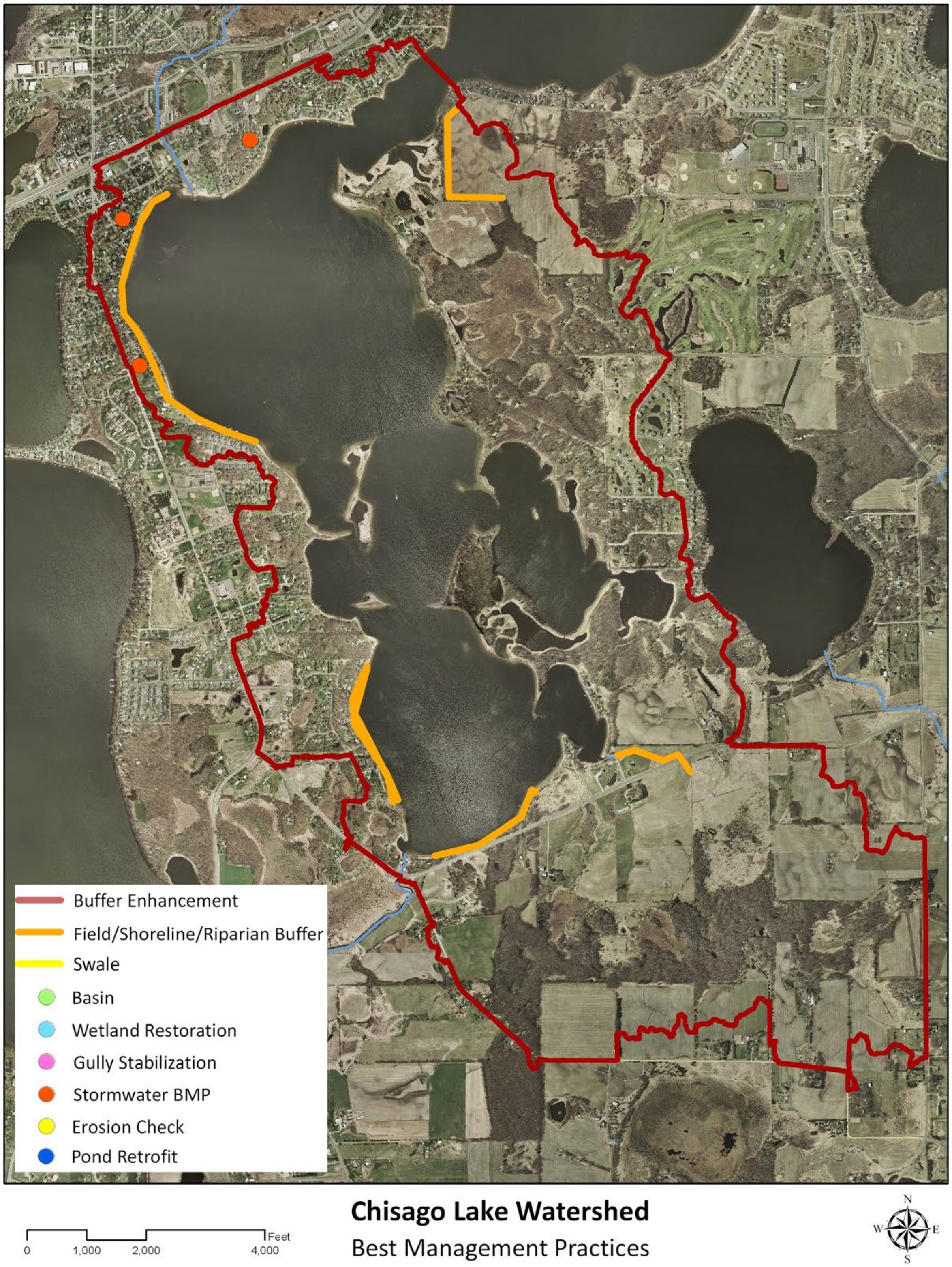
| CHISAGO LAKE IMPLEMENTATION ACTIVITES<br>CURRENT TP = 37 - 61 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Load] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| WATERSHED | Total Load Reduction Achieved: | | | 98 | 23% | | | |
| Biofilters | Buffer strips | 13 | 0.7% | 3 | 0.7% | NRCS; CWF; CWP | NRCS; LID; SWCD; LA; LO | $-$$ |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 60 | 3.0% | 5 | 1.2% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 40 | 9.3% | Ag BMP; CWF; CWP | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 7 | 1.7% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 24 | 5.6% | CWF; LID; CWP | SWCD; LID; LA; LO | $$-$$$ |
| | Infiltration BMPs (Chisago City) | 36 | 1.8% | 13 | 2.9% | | SWCD; LID; City; LA; LO | $$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 26 | 1.3% | 6 | 1.3% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |

Symbol key

- Ag BMP MDA Agricultural BMP Loan Program
- CWF Clean Water Fund
- CWP Clean Water Partnerships/ 319 Grants
- LA Lake Associations
- LID Lake Improvement District
- LO Landowners
- NRCS Natural Resources Conservation Service
- SWCD Soil and Water Conservation District

$ < $500/lb TP removed/yr
$$ = $500-$1500/lb TP removed/yr
$$$ > $1500 lb TP removed/yr

**Figure 14. Proposed Implementation Activity Locations for Chisago Lake Watershed**



### 4.2.2 Lake Ellen

Lake Ellen (MN DNR Lake ID 13-0047) is a shallow lake located northwest of Chisago City. Developed area and cropland make up the majority of the immediate drainage area to Lake Ellen. This lake houses the structure that serves as the outlet of the Lake Improvement District. Ellen is connected to Little Green Lake by a culvert under Highway 8. During the summer most of the lake surface is covered with aquatic plants. Locals say that large numbers of game fish spawn in Lake Ellen in the spring, then retreat to Little Green Lake. The lake currently meets shallow lake water quality standards.

#### Priority Implementation Activities

Implementation activities identified in the Lake Ellen watershed can reduce the total phosphorus load by 5.5 lb TP/yr, or 46% of the total estimated watershed load. Phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Septic system upgrades (3.5 lb TP/yr)
- Sedimentation ponds and gully stabilization (1 lb TP/yr)
- Rain gardens (0.7 lb TP/yr)
- Agricultural BMPs (0.2 lb TP/yr)
- Lawn management practices (0.04 lb TP/yr)

Refer to Table 32 and Figure 15 for detailed information on and the locations of the implementation activities identified in the Lake Ellen watershed.

**Table 32. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Lake Ellen Watershed**

| LAKE ELLEN IMPLEMENTATION ACTIVITES<br>CURRENT TP = 58 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Load] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| WATERSHED | Total Load Reduction Achieved: | | | 5.5 | 46% | | | |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 1.8 | 1.9% | 0.04 | 0.4% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 3.5 | 29.7% | Ag BMP; CWF; CWP | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 0.0 | 0.0% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 0.7 | 5.9% | CWF; LID; CWP | SWCD; LID; LA; LO | $$-$$$ |
| Sedimentation | Sedimentation ponds | | | 1.0 | 8.4% | NRCS; CWF; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Gully stabilization | | | | | | | $-$$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 3 | 3.3% | 0.2 | 1.7% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |

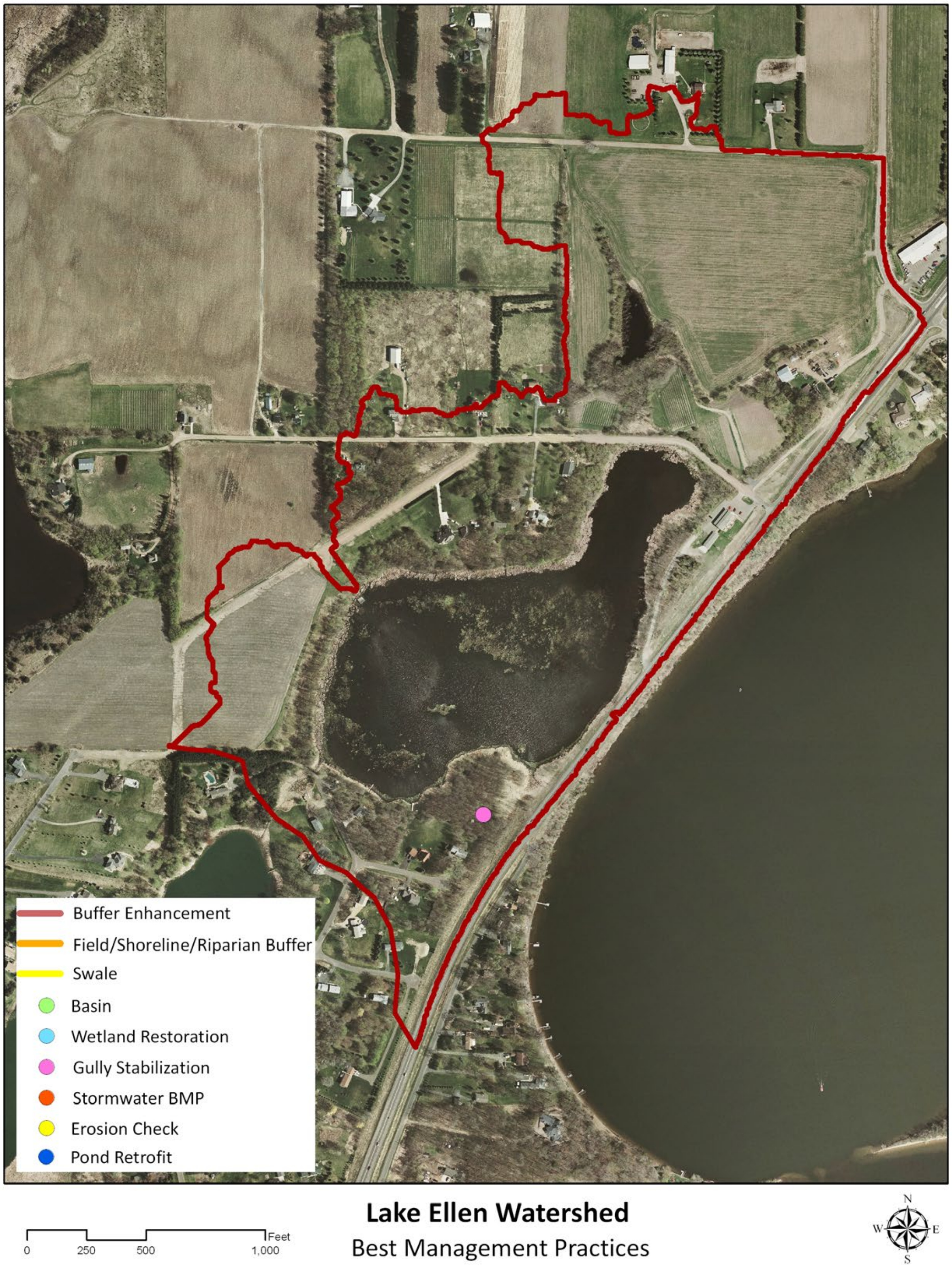
Symbol key

Ag BMP MDA Agricultural BMP Loan Program
CWF Clean Water Fund
CWP Clean Water Partnerships/ 319 Grants
LA Lake Associations

LID Lake Improvement District
LO Landowners
NRCS Natural Resources Conservation Service
SWCD Soil and Water Conservation District

$ < $500/lb TP removed/yr
$$ = $500-$1500/lb TP removed/yr
$$$ > $1500 lb TP removed/yr

**Figure 15. Proposed Implementation Activity Locations for Lake Ellen Watershed**



### 4.2.3 Green Lake

Green Lake (MN DNR Lake ID 13-0041-02) is a deep lake located west of Chisago City. Developed area and cropland make up the majority of the watershed area. The long term average of the water quality meets standards – but the in-lake phosphorus concentrations are nearing Minnesota standards.

#### Priority Implementation Activities

Implementation activities identified in the Green Lake watershed can reduce the total phosphorus load by 181 lb TP/yr, or 32% of the total estimated watershed load. Phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Septic system upgrades (115 lb TP/yr)
- Rain gardens and infiltration BMPs (41 lb TP/yr)
- Sedimentation ponds, wetland restorations, and gully stabilization (10 lb TP/yr)
- Buffer strips and vegetated swales (8 lb TP/yr)
- Agricultural BMPs (5 lb TP/yr)
- Lawn management practices (3 lb TP/yr)

Refer to Table 33 and Figure 16 for detailed information on and the locations of the implementation activities identified in the Green Lake watershed.

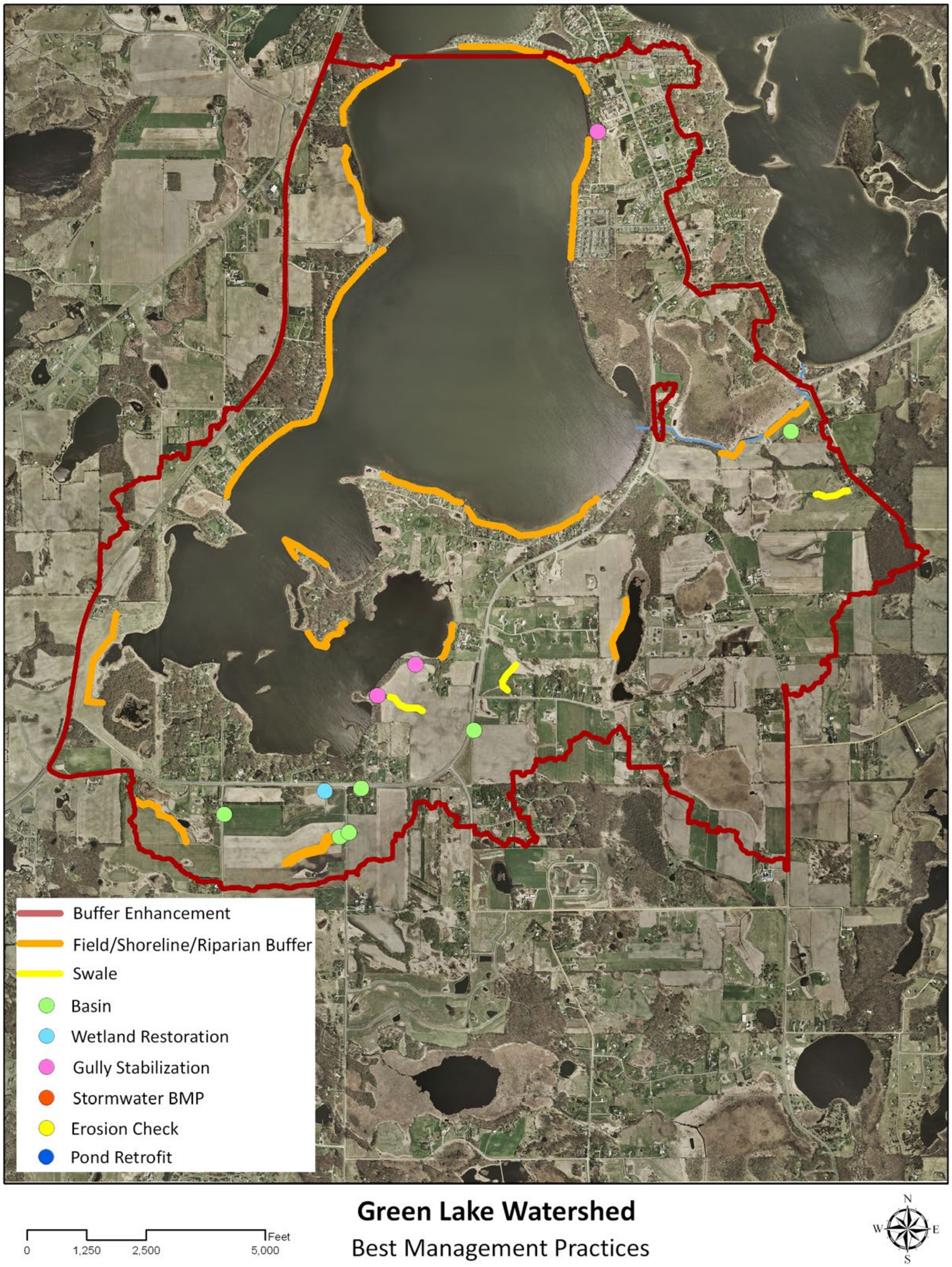
**Table 33. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Green Lake Watershed**

| GREEN LAKE IMPLEMENTATION ACTIVITES<br>CURRENT TP = 41 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Load] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| WATERSHED | Total Load Reduction Achieved: | | | 181 | 32% | | | |
| Biofilters | Buffer strips | 78 | 2.6% | 7 | 1.3% | NRCS; CWF; CWP | NRCS; LID; SWCD; LA; LO | $-$$ |
| | Vegetated swales | 5 | 0.2% | 0.5 | 0.1% | | | |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 91 | 3.0% | 3 | 0.6% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 108 | 19.2% | Ag BMP; CWF; CWP | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 6 | 1.1% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 36 | 6.4% | CWF; LID; CWP | SWCD; LID; LA; LO | $$-$$$ |
| | Infiltration BMPs (Chisago City) | 7 | 0.2% | 5 | 0.8% | | SWCD; LID; City; LA; LO | $$ |
| Sedimentation | Sedimentation ponds | 60 | 2.0% | 10 | 1.7% | NRCS; CWF; CWP; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Wetland restorations | 10 | 0.3% | | | | | |
| | Gully stabilization | | | | | | | $-$$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 54 | 1.8% | 5 | 0.9% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 16. Proposed Implementation Activity Locations for Green Lake Watershed**



### 4.2.4 Little Green Lake

Little Green Lake (MN DNR Lake ID 13-0041-01) is a shallow lake located west of Chisago City. Developed area makes up the majority of the watershed area. The lake currently meets water quality standards.

#### Priority Implementation Activities

Implementation activities identified in the Little Green Lake watershed can reduce the total phosphorus load by 28 lb TP/yr, or 49% of the total estimated watershed load. Phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Rain gardens and infiltration BMPs (19 lb TP/yr)
- Septic system upgrades (3 lb TP/yr)
- Buffer strips (3 lb TP/yr)
- Sedimentation ponds and gully stabilization (2 lb TP/yr)
- Lawn management practices (1 lb TP/yr)

Refer to Table 34 and Figure 17 for detailed information on and the locations of the implementation activities identified in the Little Green Lake watershed.

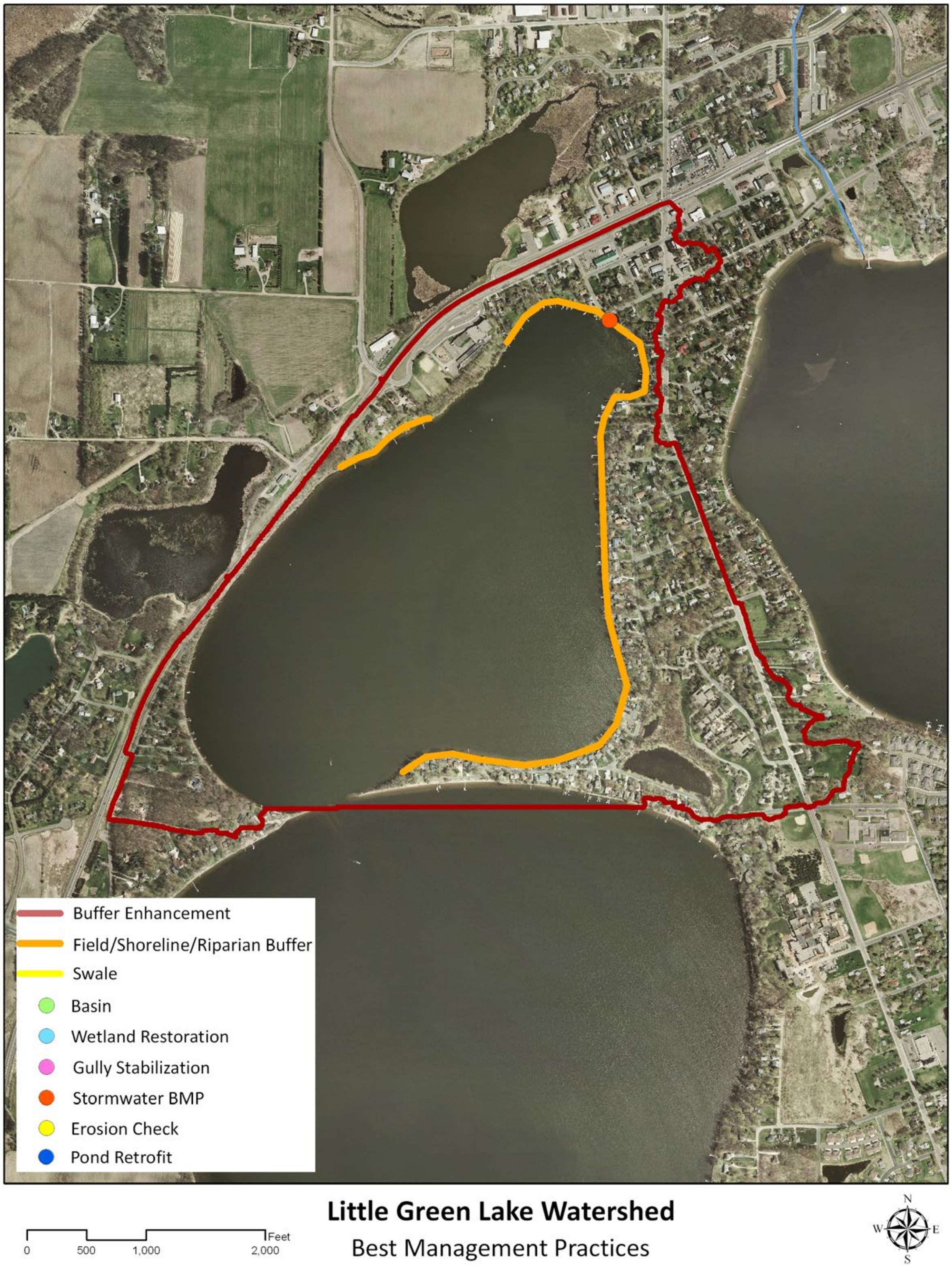
**Table 34. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Little Green Lake Watershed**

| LITTLE GREEN LAKE IMPLEMENTATION ACTIVITES<br>CURRENT TP = 40 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Load] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| WATERSHED | Total Load Reduction Achieved: | | | 28 | 49% | | | |
| Biofilters | Buffer strips | 18 | 9.3% | 3 | 4.6% | NRCS; CWF; CWP | NRCS; LID; SWCD; LA; LO | $-$$ |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 24 | 12.4% | 1 | 2.5% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 3 | 5.3% | Ag BMP; CWF; CWP | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 0 | 0.0% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 9 | 16.2% | CWF; LID; CWP | SWCD; LID; LA; LO | $$-$$$ |
| | Infiltration BMPs (Chisago City) | 31 | 16.5% | 10 | 16.9% | | SWCD; LID; City; LA; LO | $$ |
| Sedimentation | Sedimentation ponds | 10 | 5.3% | 2 | 3.2% | NRCS; CWF; CWP; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Gully stabilization | | | | | | | $-$$ |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 17. Proposed Implementation Activity Locations for Little Green Lake Watershed**



### 4.2.5 Kroon Lake

Kroon Lake (MN DNR Lake ID 13-0013) is a deep lake located south of Lindstrom. Developed area and grassland are the top two land covers that make up the majority of the immediate drainage area to Kroon Lake. In the contributing area, cropland, grassland, and wetland share the majority. The lake currently meets water quality standards. Kroon Lake is of special concern as it was listed on the Impaired Waters List in 2008. Water quality data from the most recent 10 years is used to calculate water quality means. In the most recent 10-year period Kroon Lake meets water quality standards and is, therefore, proposed to be taken off the Impaired Waters List.

#### Priority Implementation Activities

Implementation activities identified in the Kroon Lake watershed can reduce the total phosphorus load by 42 lb TP/yr, or 29% of the total estimated watershed load. Phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Septic system upgrades (29 lb TP/yr)
- Rain gardens (7 lb TP/yr)
- Sedimentation ponds and gully stabilization (2 lb TP/yr)
- Buffer strips and vegetated swales (2 lb TP/yr)
- Agricultural BMPs (1 lb TP/yr)
- Lawn management practices (1 lb TP/yr)

Refer to Table 35 and Figure 18 for detailed information on and the locations of the implementation activities identified in the Kroon Lake watershed.

**Table 35. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Kroon Lake Watershed**

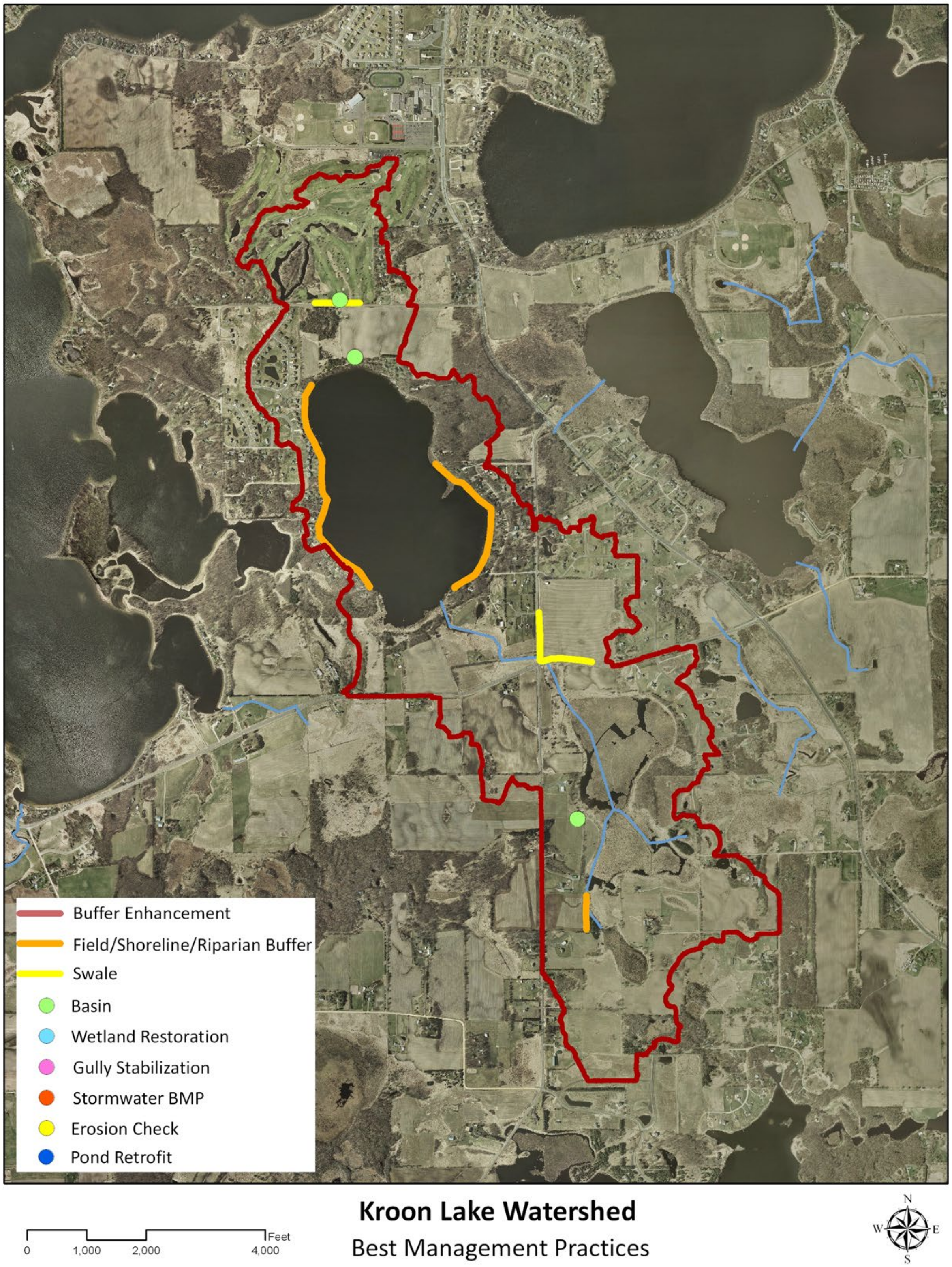
| KROON LAKE IMPLEMENTATION ACTIVITES<br>CURRENT TP = 36 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Load] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| WATERSHED | Total Load Reduction Achieved: | | | 42 | 29% | | | |
| Biofilters | Buffer strips | 18 | 1.9% | 1 | 0.9% | NRCS; CWF; CWP | NRCS; LID; SWCD; LA; LO | $-$$ |
| | Vegetated swales | 6 | 0.6% | 0.4 | 0.3% | | | |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 17 | 1.8% | 1 | 0.4% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 21 | 14.9% | Ag BMP; CWF; CWP | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 8 | 5.6% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 7 | 4.9% | CWF; LID; CWP | SWCD; LID; LA; LO | $$-$$$ |
| Sedimentation | Sedimentation ponds | 20 | 2.1% | 2 | 1.3% | NRCS; CWF; CWP; City; LID | NRCS; SWCD; LID; City; LO | $$ |
| | Gully stabilization | | | | | | | $-$$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 17 | 1.8% | 1 | 0.9% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |

Symbol key

Ag BMP MDA Agricultural BMP Loan Program
CWF Clean Water Fund
CWP Clean Water Partnerships/ 319 Grants
LA Lake Associations
LID Lake Improvement District
LO Landowners
NRCS Natural Resources Conservation Service
SWCD Soil and Water Conservation District

$ < $500/lb TP removed/yr
$$ = $500-$1500/lb TP removed/yr
$$$ > $1500 lb TP removed/yr

**Figure 18. Proposed Implementation Activity Locations for Kroon Lake Watershed**



### 4.2.6 North Lindstrom Lake

North Lindstrom Lake (MN DNR Lake ID 13-0035) is a deep lake located north of Lindstrom. Developed area makes up the majority of the immediate drainage area to North Lindstrom Lake. In the contributing area, woodland makes up a large portion of the watershed. The lake currently meets water quality standards and has the best average water quality of the entire chain of lakes.

#### Priority Implementation Activities

Implementation activities identified in the North Lindstrom Lake watershed can reduce the total phosphorus load by 30 lb TP/yr, or 31% of the total estimated watershed load. Phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Rain gardens and infiltration BMPs (18 lb TP/yr)
- Septic system upgrades (9 lb TP/yr)
- Buffer strips and vegetated swales (2 lb TP/yr)
- Lawn management practices (2 lb TP/yr)
- Agricultural BMPs (0.4 lb TP/yr)

Refer to Table 36 and Figure 19 for detailed information on and the locations of the implementation activities identified in the North Lindstrom Lake watershed.

## Table 36. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for North Lindstrom Lake Watershed

| NORTH LINDSTROM L. IMPLEMENTATION ACTIVITES CURRENT TP = 25 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Load] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| WATERSHED | Total Load Reduction Achieved: | | | 30 | 31% | | | |
| Biofilters | Buffer strips | 13 | 3.1% | 2 | 1.5% | NRCS; CWF; CWP | NRCS; LID; SWCD; LA; LO | $-$$ |
| | Vegetated swales | 1 | 0.2% | 0 | 0.1% | | | |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 32 | 7.7% | 2 | 1.5% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 6 | 6.0% | Ag BMP; CWF; CWP | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 3 | 2.9% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 13 | 12.9% | CWF; LID; CWP | SWCD; LID; LA; LO | $$-$$$ |
| | Infiltration BMPs (City of Lindstrom) | 34 | 8.2% | 5 | 5.4% | | SWCD; LID; City; LA; LO | $$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 3 | 0.8% | 0.4 | 0.4% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |

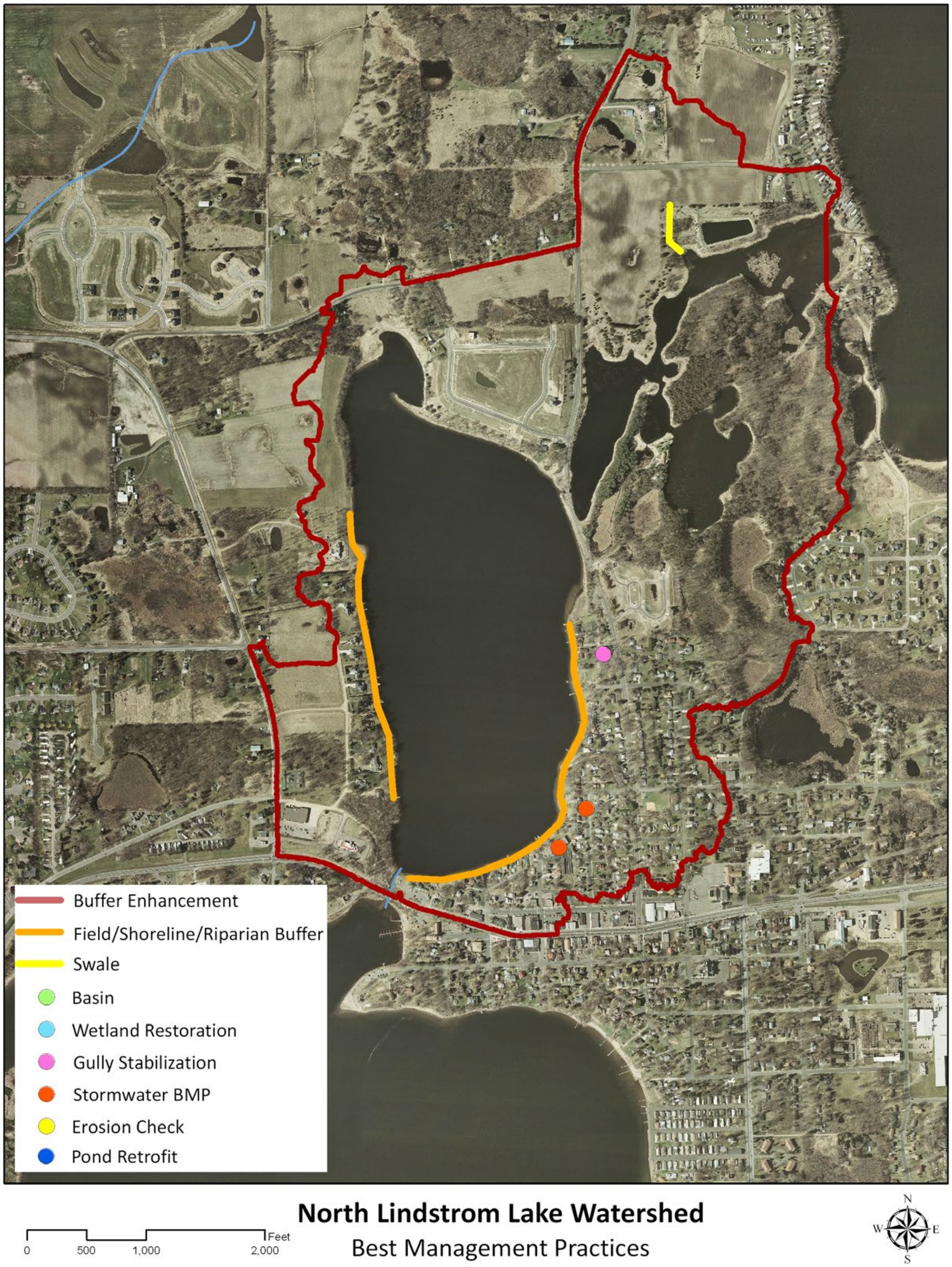
Symbol key

Ag BMP MDA Agricultural BMP Loan Program
CWF Clean Water Fund
CWP Clean Water Partnerships/ 319 Grants
LA Lake Associations

LID Lake Improvement District
LO Landowners
NRCS Natural Resources Conservation Service
SWCD Soil and Water Conservation District

$ < $500/lb TP removed/yr
$$ = $500-$1500/lb TP removed/yr
$$$ > $1500 lb TP removed/yr

**Figure 19. Proposed Implementation Activity Locations for North Lindstrom Lake Watershed**



### 4.2.7 South Lindstrom Lake

South Lindstrom Lake (MN DNR Lake ID 13-0028) is a deep lake located between the cities of Lindstrom and Chisago City. Developed area makes up the majority of the immediate drainage area to South Lindstrom Lake. The water quality of South Lindstrom Lake is very good and currently meets all water quality standards.

#### Priority Implementation Activities

Implementation activities identified in the South Lindstrom Lake watershed can reduce the total phosphorus load by 111 lb TP/yr, or 43% of the total estimated watershed load. Phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Rain gardens and infiltration BMPs (81 lb TP/yr)
- Septic system upgrades (18 lb TP/yr)
- Lawn management practices (6 lb TP/yr)
- Buffer strips (5 lb TP/yr)
- Agricultural BMPs (0.3 lb TP/yr)

Refer to Table 37 and Figure 20 for detailed information on and the locations of the implementation activities identified in the South Lindstrom Lake watershed.

**Table 37. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for South Lindstrom Lake Watershed**

| SOUTH LINDSTROM L. IMPLEMENTATION ACTIVITES CURRENT TP = 35 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Load] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| WATERSHED | Total Load Reduction Achieved: | | | 111 | 43% | | | |
| Biofilters | Buffer strips | 23 | 4.1% | 5 | 2.0% | NRCS; CWF; CWP | NRCS; LID; SWCD; LA; LO | $-$$ |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 64 | 11.4% | 6 | 2.3% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 17 | 6.7% | Ag BMP; CWF; CWP | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 1 | 0.4% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 26 | 9.8% | CWF; LID; CWP | SWCD; LID; LA; LO | $$-$$$ |
| | Infiltration BMPs (Chisago City) | 47 | 8.4% | 13 | 4.9% | | SWCD; LID; City; LA; LO | $$ |
| | Infiltration BMPs (City of Lindstrom) | 157 | 27.8% | 43 | 16.3% | | | |
| Agricultural BMPs | 10% of cropland with conservation tillage | 1 | 0.2% | 0.3 | 0.1% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |

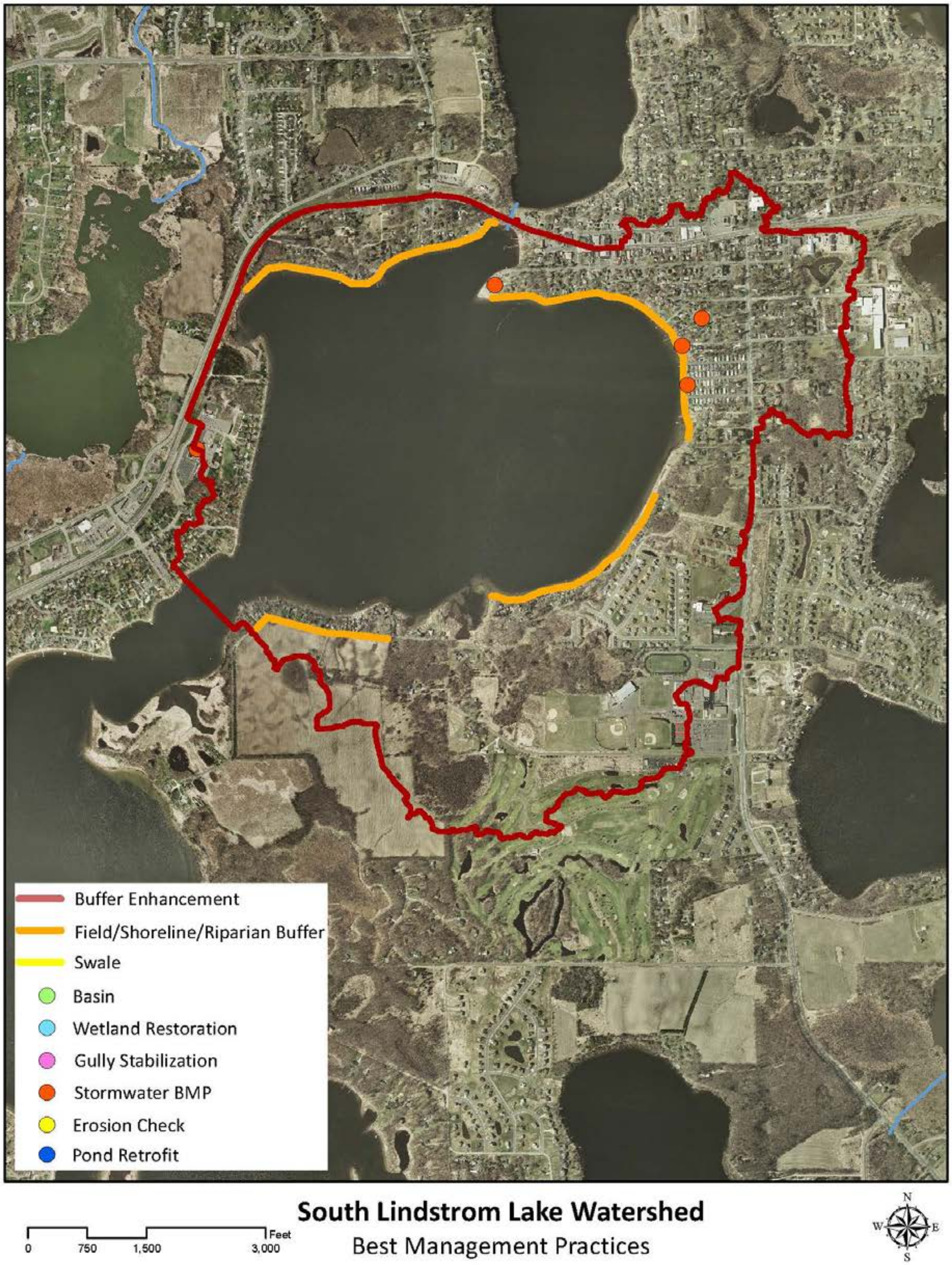
Symbol key

Ag BMP MDA Agricultural BMP Loan Program
CWF Clean Water Fund
CWP Clean Water Partnerships/ 319 Grants
LA Lake Associations

LID Lake Improvement District
LO Landowners
NRCS Natural Resources Conservation Service
SWCD Soil and Water Conservation District

$ < $500/lb TP removed/yr
$$ = $500-$1500/lb TP removed/yr
$$$ > $1500 lb TP removed/yr

**Figure 20. Proposed Implementation Activity Locations for South Lindstrom Lake Watershed**



### 4.2.8 Lake Martha

Lake Martha (MN DNR Lake ID 13-0040) is a shallow lake in Chisago City. Developed area, cropland, and grassland make up the majority of the watershed to Lake Martha. There is currently no water quality monitoring data for Lake Martha, but it has been noted that there are algae blooms in the summer months.

#### Priority Implementation Activities

Implementation activities identified in the Lake Martha watershed can reduce the total phosphorus load by 7 lb TP/yr, or 45% of the total estimated watershed load. Phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Rain gardens and infiltration BMPs (5.8 lb TP/yr)
- Septic system upgrades (0.8 lb TP/yr)
- Lawn management practices (0.2 lb TP/yr)
- Buffer strips (0.1 lb TP/yr)
- Agricultural BMPs (0.1 lb TP/yr)

Refer to Table 38 and Figure 21 for detailed information on and the locations of the implementation activities identified in the Lake Martha watershed.

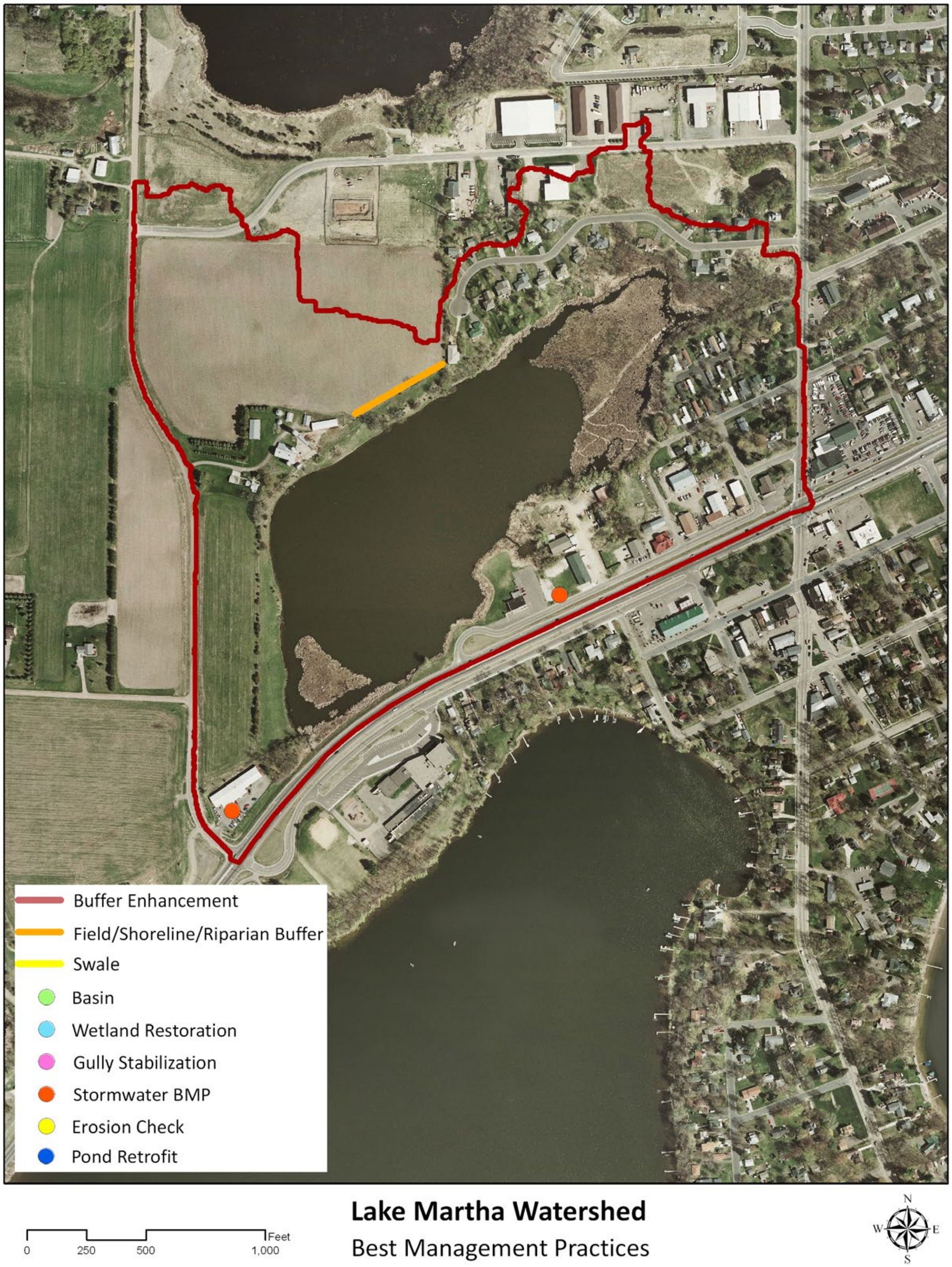
**Table 38. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Lake Martha Watershed**

| LAKE MARTHA IMPLEMENTATION ACTIVITES<br>CURRENT TP = N/A | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Load] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| WATERSHED | Total Load Reduction Achieved: | | | 7.0 | 45% | | | |
| Biofilters | Buffer strips | 1 | 1.3% | 0.1 | 0.6% | NRCS; CWF; CWP | NRCS; LID; SWCD; LA; LO | $-$$ |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 6 | 7.7% | 0.2 | 1.5% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 0.8 | 5.0% | Ag BMP; CWF; CWP | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 0.0 | 0.0% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 2.4 | 15.2% | CWF; LID; CWP | SWCD; LID; LA; LO | $$-$$$ |
| | Infiltration BMPs (Chisago City) | 11 | 14.2% | 3.4 | 21.9% | | SWCD; LID; City; LA; LO | $$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 1 | 1.7% | 0.1 | 0.9% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 21. Proposed Implementation Activity Locations for Lake Martha Watershed**



### 4.2.9 Mattson Lake

Mattson Lake (MN DNR Lake ID 13-00143) is a shallow lake located north of Chisago City. Wetland, woodland, and developed area make up the majority of the drainage area to Mattson Lake. Mattson Lake is connected to School Lake through a channel that is navigable in normal water levels. The lake currently meets water quality standards, and is well below both the shallow and deep lake standards. Implementing activities to keep the water quality of this lake below the standard will be very important in the future. The majority of the lake has populations of native aquatic vegetation. Curly-leaf pondweed is in School Lake and it poses a potential threat to Mattson Lake.

#### Priority Implementation Activities

Implementation activities identified in the Mattson Lake watershed can reduce the total phosphorus load by 12 lb TP/yr, or 20% of the total estimated watershed load. Phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Septic system upgrades (8 lb TP/yr)
- Rain gardens (3 lb TP/yr)
- Agricultural BMPs (0.2 lb TP/yr)
- Lawn management practices (0.2 lb TP/yr)

Refer to Table 39 and Figure 22 for detailed information on and the locations of the implementation activities identified in the Mattson Lake watershed.

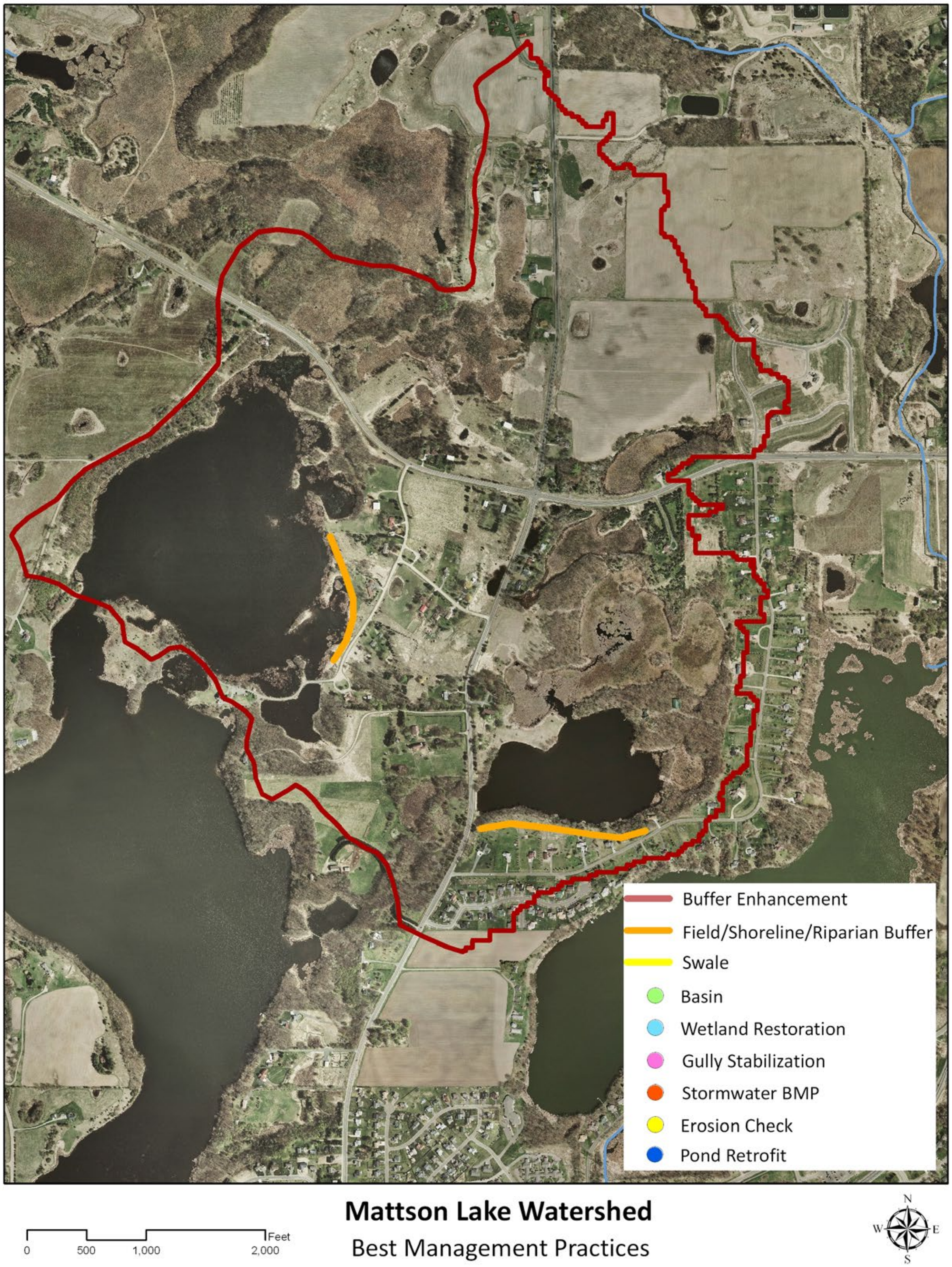
**Table 39. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Mattson Lake Watershed**

| MATTSON LAKE IMPLEMENTATION ACTIVITES<br>CURRENT TP = 27 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Load] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| WATERSHED | Total Load Reduction Achieved: | | | 12 | 20% | | | |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 7 | 1.4% | 0.2 | 0.3% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 8 | 13.8% | Ag BMP; CWF; CWP | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 0 | 0.0% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 3 | 5.1% | CWF; LID; CWP | SWCD; LID; LA; LO | $$-$$$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 4 | 0.7% | 0.2 | 0.4% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |

Symbol key

| | | | | |
|---|---|---|---|---|
| Ag BMP | MDA Agricultural BMP Loan Program | LID | Lake Improvement District | $ < $500/lb TP removed/yr |
| CWF | Clean Water Fund | LO | Landowners | $$ = $500-$1500/lb TP removed/yr |
| CWP | Clean Water Partnerships/ 319 Grants | NRCS | Natural Resources Conservation Service | $$$ > $1500 lb TP removed/yr |
| LA | Lake Associations | SWCD | Soil and Water Conservation District | |

**Figure 22. Proposed Implementation Activity Locations for Mattson Lake Watershed**



### 4.2.10 Spider Lake

Spider Lake (MN DNR Lake ID 13-0019) is a shallow lake located south of Lindstrom. Woodland and cropland make up the majority of the drainage area to Spider Lake. The lake currently meets water quality standards. The west portion of the lake has better water quality than the east portion.

#### Priority Implementation Activities

Implementation activities identified in the Spider Lake watershed can reduce the total phosphorus load by 25 lb TP/yr, or 26% of the total estimated watershed load. Phosphorus loads can be reduced through the following activities (in order of decreasing phosphorus reduction):

- Septic system upgrades (20 lb TP/yr)
- Rain gardens (4 lb TP/yr)
- Buffer strips (0.3 lb TP/yr)
- Agricultural BMPs (1 lb TP/yr)
- Lawn management practices (0.2 lb TP/yr)

Refer to Table 40 and Figure 23 for detailed information on and the locations of the implementation activities identified in the Spider Lake watershed.

Table 40. Identified Implementation Activities, Load Reductions, Project Partners, and Costs for Spider Lake Watershed

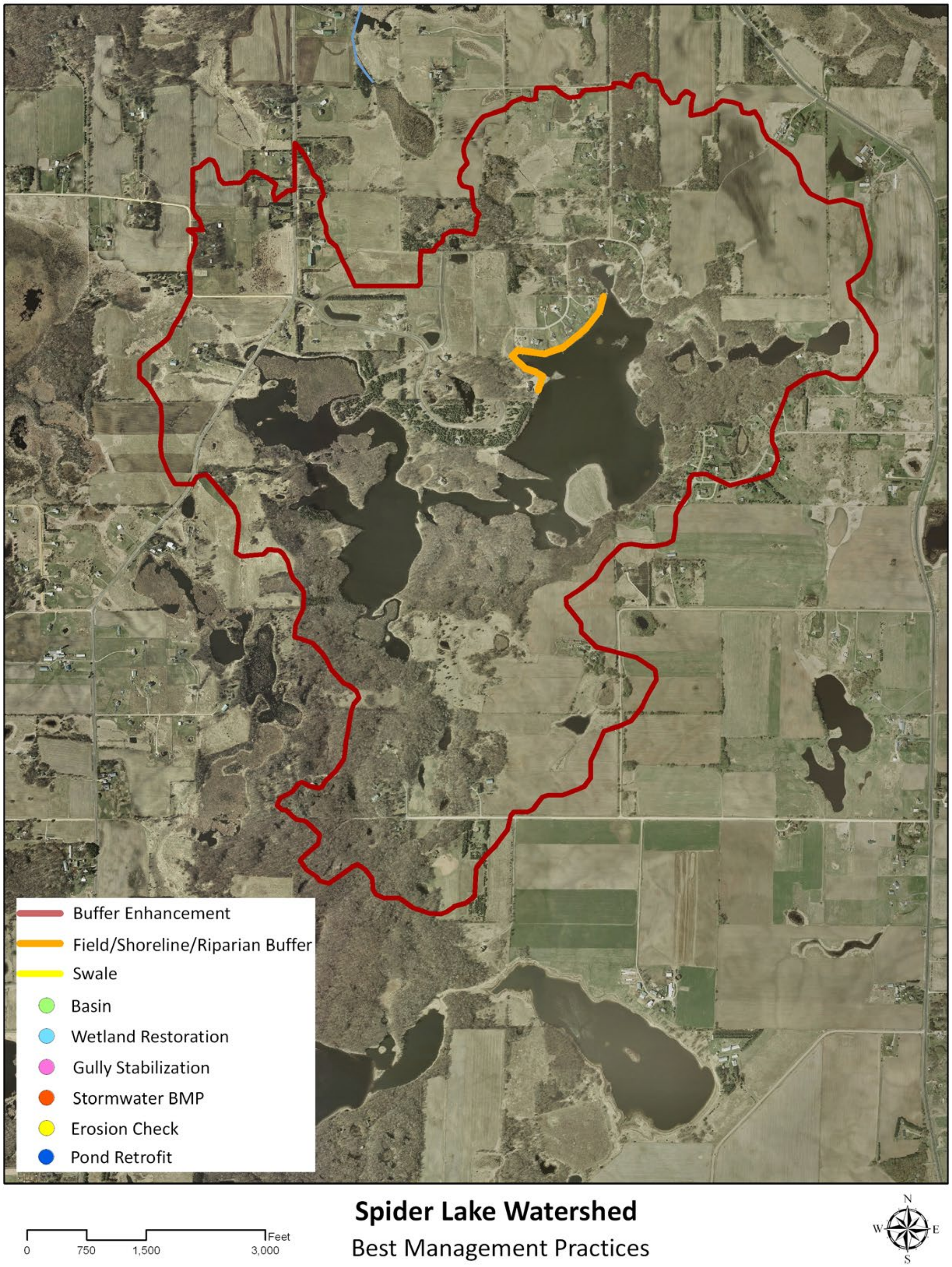
| SPIDER LAKE IMPLEMENTATION ACTIVITES<br>CURRENT TP = 55 µg/L | | Treated Area [ac] | Treated Area [% Watershed] | Estimated TP Load Reduction [lb P/yr] | Estimated TP Load Reduction [% Total Load] | Potential Granting Organization | Project Partners | Estimated 30-year Costs |
|---|---|---|---|---|---|---|---|---|
| WATERSHED | Total Load Reduction Achieved: | | | 25 | 26% | | | |
| Biofilters | Buffer strips | 5 | 0.5% | 0.3 | 0.3% | NRCS; CWF; CWP | NRCS; LID; SWCD; LA; LO | $-$$ |
| Lawn management | Maintaining turfgrass and preventing transport of leaves and clippings | 9 | 1.0% | 0.2 | 0.2% | Existing programs | City; SWCD; LA | $$ |
| Septic system upgrades | Convert failing to conforming | | | 19 | 19.5% | Ag BMP; CWF; CWP | County; Cities; LO | $ |
| | Convert ITPHSS to conforming (completed) | | | 1 | 1.0% | | County, LO | |
| Bioretention & Infiltration | Rain gardens | | | 4 | 3.8% | CWF; LID; CWP | SWCD; LID; LA; LO | $$-$$$ |
| Agricultural BMPs | 10% of cropland with conservation tillage | 18 | 1.9% | 1 | 1.0% | NRCS; Ag BMP | NRCS; SWCD; LO | Variable |

Symbol key

Ag BMP MDA Agricultural BMP Loan Program
CWF Clean Water Fund
CWP Clean Water Partnerships/ 319 Grants
LA Lake Associations
LID Lake Improvement District
LO Landowners
NRCS Natural Resources Conservation Service
SWCD Soil and Water Conservation District

$ < $500/lb TP removed/yr
$$ = $500-$1500/lb TP removed/yr
$$$ > $1500 lb TP removed/yr

**Figure 23. Proposed Implementation Activity Locations for Spider Lake Watershed**



# 5 PROJECT SCHEDULE

Implementation of phosphorus reduction activities in the Chisago Chain of Lakes watershed should prioritize impaired lakes over protection lakes to ensure that impaired lakes meet state water quality standards. In addition, a number of the lakes flow into each other in the Chisago Chain of Lakes (Figure 24) and improvements in the water quality of upstream lakes are taken into account in the water quality of downstream lakes. Therefore, impaired, upstream lakes (Little, Linn, and Ogren) should be the highest priority in the overall implementation plan to ensure that downstream, impaired lakes can attain their water quality goal. The large recreational impaired lakes (North and South Center) should be the next priority due to large stakeholder and general public interest in these lakes. After implementation activities begin on the large impaired lakes some implementation should start on the protection lakes. Five of the ten protection lakes are within 10% of the water quality standards (Green, Chisago, Kroon, Ellen, and Spider) and should be addressed first. Simultaneously or soon after the first 3 groups of lakes have implementation started, the shallow, impaired lakes (School, Wallmark, Emily, and Pioneer) should receive priority. Once implementation of phosphorus reduction activities has begun in all of the impaired lakes, the remaining five protection lakes (North and South Lindstrom, Little Green, Mattson, and Martha) should be started.

A summary of the prioritization recommendations for implementation of phosphorus reduction activities in the Chisago Chain of Lakes watershed follows:

1. Impaired and contributes surface water flow to an impaired lake downstream
2. Impaired large recreational lakes
3. Unimpaired but close to the water quality standard (within 10%)
4. Impaired shallow lakes
5. Unimpaired (in order of decreasing in-lake TP concentration)

Based on these recommendations, a preliminary 10-year schedule for implementation in the Chisago Chain of Lakes is summarized in Table 41 below.

**Figure 24. TMDL and Protection Lakes with Flow Pattern**

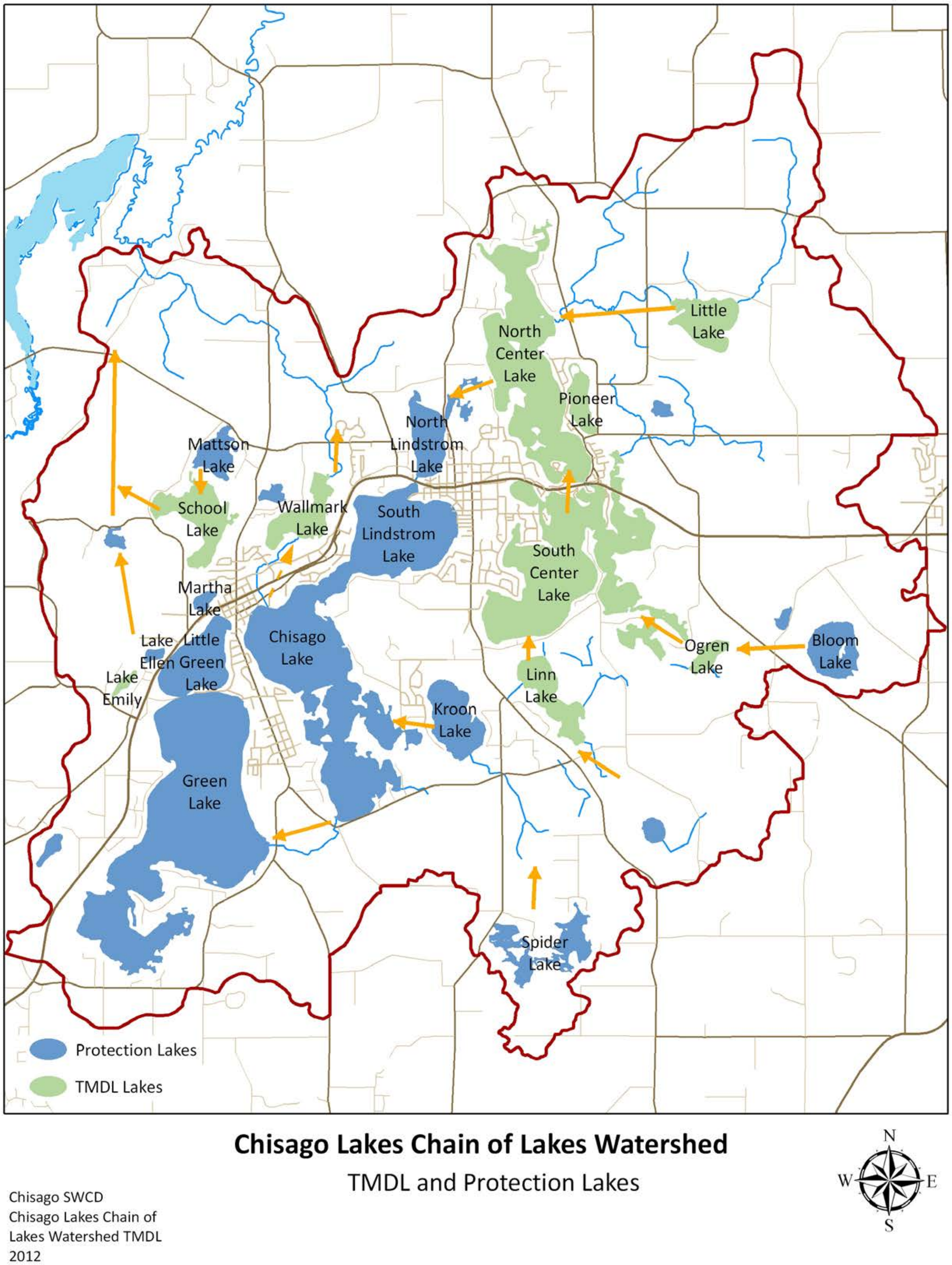


**Table 41. Preliminary Chisago Chain of Lakes implementation schedule, 2013-2022.**

| Lake | In-lake TP [ppb] | TP Standard [ppb] | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little | 173 | 40 | | | | | | | | | | |
| Linn | 217 | 60 | | | | | | | | | | |
| Ogren | 64 | 40 | | | | | | | | | | |
| North Center | 70 | 60 | | | | | | | | | | |
| South Center | 50 | 40 | | | | | | | | | | |
| Green | 41 | 40 | ‡ | ‡ | | | | | | | | |
| Chisago | 37 | 40 | ‡ | ‡ | | | | | | | | |
| Kroon | 36 | 40 | ‡ | ‡ | | | | | | | | |
| Ellen | 58 | 60 | ‡ | ‡ | | | | | | | | |
| Spider | 55 | 60 | ‡ | ‡ | | | | | | | | |
| Wallmark | 322 | 60 | | | | | | | | | | |
| School | 216 | 60 | | | | | | | | | | |
| Emily | 341 | 60 | | | | | | | | | | |
| Pioneer | 345 | 60 | | | | | | | | | | |
| South Lindstrom | 35 | 40 | | | | | | | | | | |
| North Lindstrom | 25 | 40 | | | | | | | | | | |
| Little Green | 40 | 60 | | | | | | | | | | |
| Mattson | 27 | 60 | | | | | | | | | | |
| Martha | --- | 60 | | | | | | | | | | |

‡ Initiate discussions with the local community regarding septic system upgrades and stormwater management before focused implementation begins in 2015

# 6 MONITORING PLAN

## 6.1 Lake Monitoring

Many of the lakes within the Chisago Lakes Chain of Lakes Watershed have been monitored by volunteers and staff over the years. There are more monitoring records on the lakes with a DNR public access. This monitoring is planned to continue to keep a record of the changing water quality. Lakes are generally monitored for chlorophyll-*a*, total phosphorus, and Secchi disk transparency. Currently, the monitoring schedule is once per month from May through September.

In-lake monitoring will continue as implementation activities are installed across the watershed. Some tributary monitoring has been completed on the inlets to the Chain of Lakes. Monitoring on the tributaries and stormwater inlets may be continued to measure pollutants and quantify pollutant loads entering the lakes through streams and pipes. A watershed-wide reduction of 20% phosphorus loading within 10 years may be achievable with the correct programs in place. Each lake has its own goal to achieve statewide water quality standards over time; however, a 10%-30% reduction of in-lake phosphorus within that same 10-year period in each lake would show that the BMPs being installed are working.

The MN DNR will continue to conduct macrophyte and fish surveys as allowed by their regular schedule. Ideally, these surveys will be conducted no less than every 5 years.

## 6.2 BMP Monitoring

On-site monitoring of implementation practices should also take place in order to better assess BMP effectiveness. A variety of criteria such as land use, soil type, and other watershed characteristics, as well as monitoring feasibility, will be used to determine which BMPs to monitor. Under these criteria, monitoring of a specific type of implementation practice can be accomplished at one site and can be applied to similar practices under similar criteria and scenarios. Effectiveness of other BMPs can be extrapolated based on monitoring results.

# 7 STAKEHOLDER PARTICIPATION

## 7.1 Steering Committee

On August 6, 2012, a Steering Committee meeting was held to discuss the implementation plan approach. This meeting was attended by many local and state partners. These included: Chisago County, Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, St. Croix Watershed Research Station, Chisago Lakes Lake Improvement District, Board of Water and Soil Resources, Emmons & Olivier Resources, and the Chisago SWCD. Meeting participants were given an overview of the TMD, and the approach for determining locations and nutrient reductions associated with best management practices. The group was encouraged to look at the project summary sheets handed out and return comments and suggestions to the Chisago SWCD within two weeks. Some comments came back from the group, but most comments will come when the Draft Restoration and Protection Plan is sent to the Steering Committee for review in mid-October.

## 7.2 Public Meetings

On August 6, 2012 a public meeting was held in conjunction with the regular August Chisago Lakes Lake Improvement District meeting to discuss the implementation plan approach. Six CLLID Board members, 2 CLLID employees, 8 citizens, and one member from the local paper were at the meeting to hear updates on the TMDL and the Restoration and Protection Plan. Lake Summary handouts were available for each attendee at the meeting to take home and review. The group had many questions about specific projects within the watershed and how to get more local individuals involved in the efforts to clean-up and keep our lakes clean. An article was published in the Chisago County Press that highlighted the TMDL process and where to find more information.

## 7.3 Regular Updates

Regular updates about the TMDL and Restoration and Protection plan process are given at the Chisago Lakes Lake Improvement District board meetings. These meetings are held the first Monday of each month at 6:30 p.m. in the Chisago County Government Center. Another update on the process is also given each year at the Chisago Lakes Lake Improvement District Annual Meeting held in February. Board members are also given the chance to review these documents along with the Steering Committee. The board members on the CLLID each represent different lakes and their associated watersheds. These board members are often members of their individual lake associations; in those cases, the members are asked to provide updates to the rest of the lake association members. Similar updates are also given by the SWCD to the area Lake Associations for newsletters and annual meetings.

The Steering Committee also receives frequent updates on the project and is given many opportunities to comment on the progress of the project.

# 8 REFERENCES

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