Lake Sarah Nutrient TMDL

Implementation Plan

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Prepared for:

Pioneer-Sarah Creek
Watershed Management Commission

and

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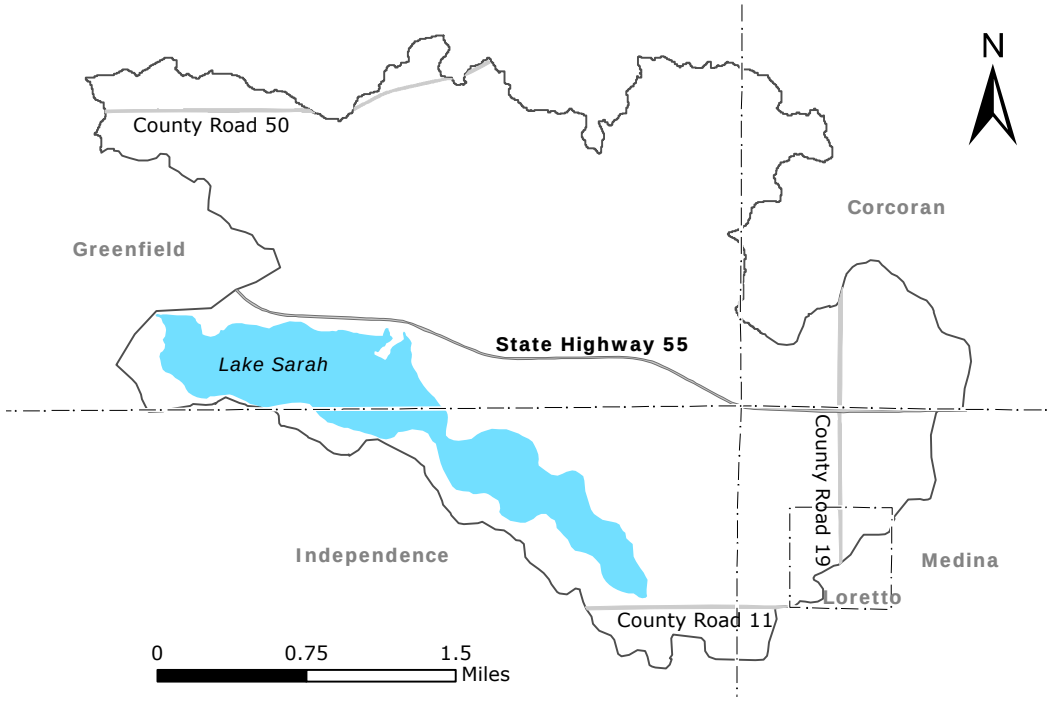
1.0 Introduction

1.1 BACKGROUND

The Lake Sarah Nutrient Total Maximum Daily Load (TMDL) Implementation Plan addresses nutrient impairments in the lake. Lake Sarah is located in the cities of Greenfield and Independence, Hennepin County, Minnesota, in the Pioneer Sarah Creek Watershed of the Upper Mississippi River Basin. Figure 1.1 shows the lake and its watershed.

Figure 1.1 – Lake Sarah, Watershed Boundaries, Municipal Boundaries and Key Roadway Features



Lake Sarah is a deep (maximum depth of 59 feet and a median depth of 9.7 feet), elongated lake of glacial origin with two bays: a west bay and an east bay. The outlet for the lake is located at the western end of the west bay (Figure 1.1). In 2004, the lake outlet was set at 978.8 feet. Information about the lake's morphometry and watershed is found in Table 1.1.

Table 1.1. Lake Sarah Physical Characteristics.

Morphometry and Watershed	
Lake area (acre)	553
Maximum depth - (feet)	59
Median depth (feet)	9.7
% Littoral (% of basin 15 feet or less in depth)	65
Drainage area (total acre)	4,454
Watershed: lake area ratio	8 to 1
Water residence time (years)	1.95
Thermally stratified in summer?	Yes
Does lake have surface outlet?	Yes
Is the lake a "created" lake?	No
Is the lake managed as a reservoir?	No

Lake Sarah receives runoff from a 4454-acre mixed-use watershed which drains land from portions of five municipalities – Greenfield, Independence, Corcoran, Loretto, and Medina (Figure 1.2). The primary land uses are agriculture (23%), rural residential (22%), medium density residential (7%), wetland (21%) and commercial (3%). Approximately 3% of the land in the watershed is dedicated to pasture and feedlots for horses and cattle. Most of the shoreline land is occupied by single family residential homes, but the shoreline also includes a horse farm, a cattle farm, wetland areas, and parkland. Property along the western shoreline of the lake is within the Lake Sarah Regional Park, operated by Three Rivers Park District.

In recent years, agricultural land has been increasingly converted into residential and commercial developments in the Lake Sarah watershed. Development of agricultural land into low density residential, medium density residential and commercial land uses is expected to continue. The Metropolitan Council's 2030 land use plan includes substantial areas that will be zoned for residential and commercial development.

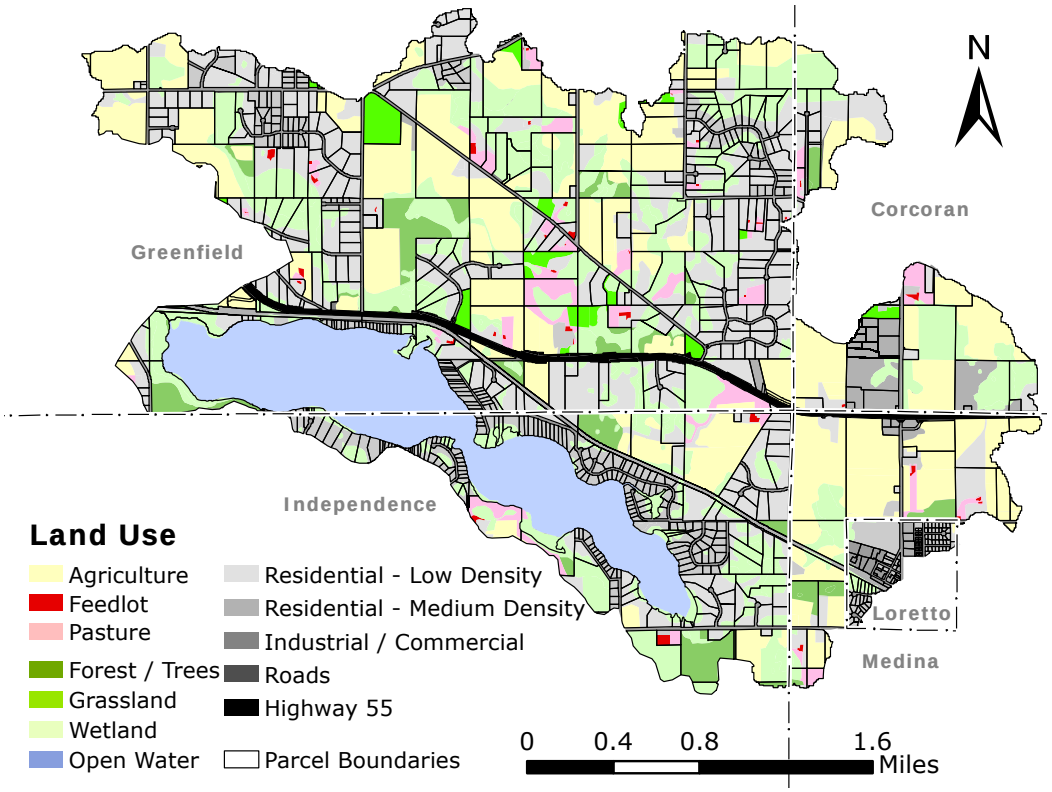


Figure 1.2. Land Use throughout the Lake Sarah Watershed for 2008.

The Pioneer Sarah Creek Watershed Management Commission (PSCWMC), in partnership with the Minnesota Pollution Control Agency (MPCA) and Three Rivers Park District (TRPD), has completed a Total Maximum Daily Load (TMDL) analysis to quantify the phosphorus reductions needed to meet state water quality standards for nutrients in Lake Sarah (DNR ID# 27-0191-01 for the West Bay and 27-0191-02 for the East Bay) in accordance with Section 303(d) of the Clean Water Act. The TMDL was prepared by the PSCWMC utilizing the TRPD staff for technical services.

The final step in the TMDL process is development of an Implementation Plan that sets forth the activities that will be undertaken to reduce phosphorus loading to Lake Sarah. This Implementation Plan provides a brief overview of the TMDL findings; describes the principles guiding development of this Implementation Plan; describes the proposed implementation activities/elements; and identifies the proposed sequencing, timing, and lead organizations for execution of those elements/activities. The specific projects, estimated costs, and timelines are summarized in Section 3 of this report.

1.2 STAKEHOLDER DIRECTION ON IMPLEMENTATION PLAN

The stakeholder group that guided development of the TMDL devoted considerable time to considering how the load reductions in the TMDL could be cost-effectively achieved. They chose to approach the issue as follows. Once the phosphorus load reduction targets were quantified, the stakeholder group requested that technical

staff assemble an array of best management practices (BMPs) that could be applied in the watershed of Lake Sarah. Locations in the watershed that could be suitable for application of certain practices were identified using GIS. The area or linear feet of land to which those practices could be applied was calculated and a unit cost for installing those practices was derived from reference information (much of the agricultural information came from the agricultural extension services in the Upper Midwest). This information was used to calculate a cost estimate for application of the particular practice. The stakeholder committee was also interested in the effectiveness of each practice in reducing phosphorus export from the land served by the BMP. This was expressed as a percent reduction (or range of percent reductions) in phosphorus loading based on literature values from studies conducted elsewhere. Again, most of this information came from studies conducted in the Upper Midwest.

The majority of the practices addressed in the evaluation could be characterized as relatively small-scale land treatment practices that would need to be done at numerous locations in the watershed to achieve the desired load reduction. These treatment practices generally fell into the following categories:

- Row crop management
- Feedlot/manure management
- Residential/commercial land management
- Shoreland management

Another set of watershed load reduction alternatives involved constructing one or more large stormwater ponds at the bottom of each of the two major drainages. These options were labeled as "instream" management options in the TMDL report. For the purposes of this Implementation Plan, they will be identified as regional treatment ponds.

Appendix D of the TMDL report presents the information on BMP options by individual community in the Lake Sarah watershed and by general source category (row crop management, feedlot/manure management, residential/commercial land management, shoreland management and "instream" management, known as regional treatment ponds in this Plan). Citations for the studies that provided the basis for both the cost and effectiveness estimates for each practice are presented in Appendix E of the TMDL report.

It was from this information that the stakeholder group established a general direction for implementation of the TMDL. The feeling of the stakeholder group was that a load reduction approach emphasizing application of small-scale practices at many different locations in the watershed was likely to be more cost-effective than one involving construction of few large and expensive end-of- the-drainage treatment ponds. However, it was also recognized that pursuing the former approach was likely to require a longer time (perhaps 10-15 years) to reach load reduction targets, due in part to the need to interact with numerous land owners.

With this mind-set and with the information on potential BMPs in Appendix D of the TMDL report, the stakeholder committee chose to recommend the following direction for watershed phosphorus load reduction:

1. Providing manure application guidance
2. Promoting nutrient management for cropland based on soil tests
3. Installing edge-of- field buffer strips
4. Barnyard management (including improvements in manure handling, storage, and disposal)
5. Shoreline buffers (along Lake Sarah)

6. Urban rainwater garden installation (mostly in developed areas around Lake Sarah and in highly impervious areas elsewhere in the watershed)

In addition, the stakeholder committee also included a joint project requested by the cities of Loretto and Medina involving construction of a smaller pond treatment system along their border that could provide load reduction benefits to both communities. Cost and benefit information was taken from preliminary engineering studies conducted on the project by those communities.

PSCWMC and Three Rivers Park District staff presented these recommendations to the Greenfield Planning Commission and City Council, the Independence City Council, the Medina City Council and the Corcoran City Council. Discussion following the presentations indicated support for the stakeholder recommendations.

1.3 RELATIVE COST-EFFECTIVENESS COMPARISON BETWEEN BMPS

Table 1.2 presents a comparison of the relative cost-effectiveness of the various management options using information presented in Appendix D of the Lake Sarah TMDL report. The information is intended to show the relative cost-effectiveness for the BMPs within each major BMP category. The second column of the table shows the phosphorus load reduction estimates at the source for the BMP's in that category, the third column shows the range of estimated costs for BMP installation to achieve those reductions, and the fourth column shows the range in the cost to achieve a one pound reduction in phosphorus loading using the BMPs within each major BMP category. The comparison is very simplistic in that it does not account for differences in project life or maintenance costs nor express information as a present value. Rather, it provides rough information to do a very basic comparison of the relative cost to achieve a one pound reduction in phosphorus loading based on the various management approaches. The information in Table 1.2 shows the high relative cost-effectiveness (i.e. lower cost per pound of phosphorus reduction) of instituting agricultural and shoreland BMPs, especially as compared to the regional pond management options (i.e., referred to as "instream" management option in the TMDL report). Note however, that a one pound phosphorus reduction from row crop management may not translate to a one pound reduction in loading to Lake Sarah since the activity may occur a mile or more from the lake. Conversely, a one pound reduction from residential runoff management is quite likely to translate to a one pound loading reduction since most of that work would be done immediately adjacent to the lake where the majority of residential development lies.

Table 1.2 - Relative Cost-Effectiveness of BMP Options by Major BMP Category[1]

BMP Category	***Potential P Reduction Estimate (lbs.)***	***Cost Estimate***	***Cost Effectiveness (dollars/lb. P reduction)***
Row Crop Management	4433- 6590	$1,279,354- $1,379,914	$194 - $311/lb
Feedlot/Manure Management	651	$366,539 - $375,577	$563-$577/lb.
Residential/Commercial Land Management	697	$5,253,250- $17,372,500	$7,537 - $24,925/lb.
Shoreland Management	49	$4,014- $5,734	$82 - $117/lb.
Regional treatment ponds[2]	962-1806	$3,000,000	$1,661 - $3,118/lb.

1 Information presented is only for relative cost comparison among general types of BMPs.

2 The term "Regional treatment ponds" is used here instead of the term "instream management options" in the TMDL report

2.0 Lake Sarah TMDL Summary

A key aspect of the TMDL is the development of an analytical link between loading sources and receiving water quality. To establish the link between phosphorus loading and the quality of the water in the lake, monitoring data extending back to the early 1990's was reviewed to better understand conditions and trends. In addition, extensive watershed monitoring and modeling efforts were undertaken as part of the TMDL to better understand the linkage between pollutant loading and in-lake water quality.

2.1 CURRENT WATER QUALITY AND APPLICABLE STATE STANDARDS

Lake Sarah is listed as an "impaired water" because it has excess levels of nutrients that cause blooms of algae. Nutrient loads in this TMDL are set for phosphorus, since this is typically the limiting nutrient for algae. The State of Minnesota has adopted eutrophication standards for lakes as part of a larger rule-making process that differentiates between shallow and deep lakes by ecoregion (Minnesota Rules Chapter 7050-Standards for Protection of Waters of the State as amended-May 2008). Lake Sarah is located in the North Central Hardwood Forest (NCHF) ecoregion and is classified as a "deep" lake, having more than 80% of its surface area greater than 15 feet deep. As such, the in-lake phosphorus standard applicable to Lake Sarah is 40 µg/l as a June-September mean. The standards also set numerical limits for chlorophyll-a and water clarity.

Historical monitoring data indicate that Lake Sarah is degraded mainly due to nutrient enrichment. Table 2.1 summarizes historical water quality data for the lake. The bottom row in Table 2.1 includes the numerical standards for all three parameters.

Table 2.1 – Water Quality in Lake Sarah and Target End Points (Lake Sarah Data from 1996-1998, 2000, 2002, and 2003-2008)

Summer (June-September) Average			
Lake	Total Phosphorus (µg/l)	Chlorophyll a (µg/l)	Secchi Depth (m)
Lake Sarah	101	41.9	1.5
State Standard	<40	<14	>1.4

Source: 2011 Lake Sarah Nutrient TMDL Report

Lake Sarah will be considered to meet the overall eutrophication standard when measured in-lake water quality is equal to or better than all three of the numeric standards for total phosphorus, chlorophyll a, and water clarity.

2.2 REQUIRED PHOSPHORUS LOAD REDUCTIONS

The TMDL prepared for Lake Sarah indicates that to consistently meet the state's in-lake water quality standards under average annual precipitation conditions, nutrient loads from watershed and in-lake sources need to be reduced by 4,330 pounds of total phosphorus per year (79% of the existing combined internal and external phosphorus loads to the lake). Approximately 1,108 pounds per year of phosphorus

reduction (about 26% of the overall load reduction target) will come from reductions in watershed loadings. The remaining 3,222 pounds per year of reduction in phosphorus loading (or 74% of the load reduction target) will come from control of internal loading in the form of curlyleaf pondweed control and reductions in sediment phosphorus release. This Implementation Plan provides guidance on the specific activities the stakeholders in the watershed plan to undertake to attain these reductions.

2.2.1 Waste Load Allocations

Stormwater discharges are regulated under the National Pollutant Discharge Elimination System (NPDES) program, and nutrient reductions assigned to permittees must be divided among permit holders. In the Lake Sarah Watershed, there are four municipalities regulated by the Municipal Separate Storm Sewer System (MS4) General Permit. In addition, construction activities disturbing one acre or more of land or those construction activities that are part of a common plan of development or sale are regulated under a Construction General Permit. There are no known industrial stormwater dischargers in the Lake Sarah watershed. Known permit holders are listed in Table 2.2

Table 2.2 – NPDES Permitted Facilities in the Watershed

Permitted Source	Identifier Number[1]
City of Corcoran	MS400081
City of Independence	MS400095
City of Medina	MS400105
City of Loretto	MS400030
Construction[2]	MNR100001

[1] The number listed for the cities is an identifier number. The permit number for these municipalities is MNR040000.

[2] The number shown for Construction is the permit number

As part of their NPDES permit to discharge municipal stormwater, the cities of Corcoran, Independence, Medina, and Loretto are required to meet the wasteload allocation (WLA) for phosphorus as designated in Table 2.3. The focus in implementation will be on reducing the annual phosphorus load to Lake Sarah from the portion of the watershed that falls within the respective municipalities through structural and nonstructural Best Management Practices (BMPs). A summary of the assigned wasteload allocations by source along with the existing phosphorus loads are provided in Table 2.3 for average precipitation conditions.

Table 2.3-Wasteload Allocations by Source for Lake Sarah

Assigned Source	Existing Phosphorus Loading		Phosphorus Wasteload Allocation		Wasteload Reduction	% Reduction
	(lbs./yr.)	(lbs./day)	(lbs./yr.)	(lbs./day)	(lbs./yr.)	
Corcoran	210.40	0.576	101.04	0.277	109	51.8%
Independence	316.90	0.868	173.49	0.475	143	45.1%
Medina	341.90	0.937	92.92	0.255	249	72.8%
Loretto	56.60	0.155	19.37	0.053	37	65.4%

2.2.2 Load Allocations

A Load allocations (LA) is assigned to each non-permitted entity. For the Lake Sarah TMDL, these included the City of Greenfield (which is not part of the urbanized area as defined by the 2000 census). Also included are MnDOT and Hennepin County Highways, both of which are road authorities that in the Lake Sarah watershed lie outside the Twin Cities urbanized area and, as such, are non-regulated stormwater dischargers at this time. In the event that the Twin Cities urban area were to expand to include any Mn/DOT or Hennepin County roads, those areas would then be considered regulated and a transfer of load from the LA to the WLA would occur. Finally, internal loading and atmospheric phosphorus loading are also included in the load allocations.

A summary of the assigned load allocations by source along with their existing phosphorus loads are provided in Table 2.4 for average precipitation conditions.

Table 2.4-Load Allocations by Source for Lake Sarah

Assigned Source	Existing Phosphorus Loading		Phosphorus Load Allocation		Load Reduction
	(lbs./yr.)	(lbs./day)	(lbs./yr.)	(lbs./day)	(lbs./yr.)
Greenfield	1114.20	3.053	586.08	1.606	528
MnDOT Metro	45.1	0.124	17.11	0.047	28
Hennepin County	21.30	0.058	8.56	0.023	13
Watershed LA	***1180.60***	***3.235***	***611.75***	***1.676***	***569***
Internal Load	3222.00	8.827	0.00	0.00	3222
Atmosphere	148.00	0.405	148.0	0.405	0
Non-watershed LA	***3370.00***	***9.233***	***148.00***	***0.405***	***3222***
TOTAL	**4550.60**	**12.467**	**759.75**	**2.082**	**3791**

As described in the TMDL report, setting the internal load in the TMDL equation to zero does not imply there is no internal load. Instead, the zero value indicates that the internal load that will allow Lake Sarah to meet water quality standards can be no higher than the background levels of internal loading already represented in the lake response model (BATHTUB) used for the TMDL.

3.0 Lake Sarah Implementation Plan

The activities and Best Management Practices (BMPs) identified in this Implementation Plan are the result of a series of stakeholder meetings led by the Pioneer Sarah Creek Watershed Management Commission (PSCWMC). As described in Section 1, the stakeholder group met numerous times to discuss the TMDL requirements, TMDL results, and the quantification of watershed-derived and internal loads affecting the lake, as well as identify reasonably cost-effective BMPs to reduce those loads to the levels called for in the TMDL.

3.1 RECOMMENDED PHOSPHORUS MANAGEMENT STRATEGIES

This TMDL Implementation Plan focuses on reducing the movement of phosphorus from the watershed into Lake Sarah as well as working within the lake itself to reduce phosphorus recycling, decrease algal production as defined by chlorophyll a, and improve water clarity to meet the NCHF Ecoregion deep lake standard adopted by MPCA. Consistent with the philosophy of adaptive management outlined in the TMDL report, there will be an emphasis on assessing the impacts of the management actions and applying lessons learned to guide future actions toward achieving the goals for in-lake water quality.

3.1.1 Watershed Load Reduction Strategies

To achieve the Wasteload Allocation (WLA) and Load Allocation (LA) goals (as described in the TMDL Allocation section), a decrease in average annual watershed phosphorus loading of 1108 lbs must be achieved. As described in the Loading Capacity and SWAT modeling sections of the TMDL report, the majority of the phosphorus load from the watershed is delivered to the lake as a result of overland surface flow – primarily from spring snow-melt and early season precipitation. As a result, BMPs that focus on reducing surface runoff and/or erosion - especially during these seasonal time periods – should be pursued.

Based on input from the stakeholder group and communities, a lower cost approach emphasizing land treatment BMP's at numerous locations in the affected subwatersheds was preferable to a higher cost approach involving a few large, capital intensive treatment projects near the bottom of major watersheds. It was also recognized that taking the former approach might require more time – up to 10-15 years – for full implementation. The preferred strategy for achieving the requisite reductions in the watershed load involves implementing a series of BMPs related to row crop agriculture, feedlot and manure management, and residential and commercial development, supplemented with restoration of stream, wetland and shoreline habitat. To facilitate flexibility during implementation, the total acreages available for implementation, relative cost, and removal efficiencies of different BMPs for each watershed community have been summarized (Appendix D of the TMDL report). Anticipated costs and phosphorus reductions are based on estimates from a range of sources (e.g., Devlin, et al. 2003; MSSC, 2008; Rehm, et al. 2002; Wortmann, et al. 2005). For further detail on BMP references see Appendix E in the TMDL report. Potential costs were calculated by multiplying the number of acres available for different BMPs by anticipated cost per acre estimates (estimates were rounded to the nearest $10 increment).

The following will guide efforts to move ahead with implementing phosphorus load reduction actions for the Lake Sarah watershed. They are as follows:

- **The responsibility for meeting individual watershed load reductions assigned through the TMDL lies with the governmental unit assigned those load reductions**. This means the municipalities, MnDOT and Hennepin County are responsible for meeting the allocations as outlined in the following sections and summarized in Tables 2.3 and 2.4. Achieving consistent progress toward meeting assigned watershed load reductions for the regulated MS4's – Corcoran, Medina, Loretto, and Independence – will be enforced through the MS4 permit program.
- The interim goal is that each municipality will achieve at least 40% of the load reduction assigned it within 6 years after the official approval of this Implementation Plan by MPCA. If that goal is not achieved, the PSCWMC will amend its watershed plan to require such additional regulations as the PSCWMC deems necessary so that the entire load reduction targets from the watershed are achieved within 12 years of the date of approval of this plan.
- Once an estimated watershed load reduction of 50% is achieved, the PSCWMC should institute a watershed runoff monitoring effort for 1-2 years to help assess actual progress in reducing loads to the lake (see Section 3.2 - Monitoring). Those organizations having responsibility for achieving specific watershed load reductions are expected to use generally accepted load estimation tools to estimate the reduction associated with each additional BMP they employ and track the cumulative reduction so overall progress can be monitored by the PSCWMC.

The watershed load reduction recommendations described below are based on a combination of a cost-benefit comparisons and direction from local city councils, planning commissions, and stakeholders on which BMP's are most appropriate for their communities. Costs and associated pounds of phosphorus reduction are presented below assuming the identified BMPs will be applied everywhere that was identified as a potential location. Realistically, more detailed on-the-ground assessments will be needed as part of an early phase of implementation to identify which areas are most cost-effective for the application of a given BMP, whether the owner of the land is willing to cooperate in the installation of the BMP, etc. Since this step has not happened yet, the cumulative estimated load reduction in the following section is significantly greater than the load reduction required of each of the entities listed. This excess is intended to account for partial implementation of different BMP types, overlap of BMP effectiveness, and possible joint projects where adjacent communities share the benefits and costs of a project. BMPs described are intended for existing conditions and do not address changes in land use. However, stormwater management rules and policies of the Pioneer-Sarah Creek Watershed Management Commission as well as state and federal anti-degradation policies require mitigation to achieve, at a minimum, nondegradation when undeveloped land is converted to a developed land use.

A summary of phosphorus reduction strategies for each entity receiving an allocation is presented below.

<u>Medina (Phosphorus load reduction of 249 lbs. P/yr needed to reach WLA)</u>
The most cost-effective options for phosphorus load reduction in the City of Medina are BMPs related to row crop management and instream/wetland restoration. Specific projects/activities recommended in Medina are:

1) nutrient management based on soil tests (up to 115 lbs P/yr; $2,880);
2) edge-of-field filter strips (buffers; up to 172 lbs P/yr; $8,600);
3) barnyard management* (up to 31 lbs P/yr; $35,000) **note: for details, see Appendix D in Lake Sarah TMDL Report*
4) instream/wetland restoration of channelized reaches (up to 100 lbs P/yr; $260,000*). **note: based on possible joint project between Medina and Loretto; projected phosphorus reduction and cost based on general project plan, split of benefits and costs are assumed and will be revised/updated as part of preliminary engineering/design.*

Total potential phosphorus removal resulting from BMP implementation in Medina is up to **418 lbs P/yr**.

Independence (Phosphorus load reduction of 143 lbs. P/yr needed to reach WLA)
The most cost-effective options for phosphorus load reduction in the City of Independence are BMPs related to row crop management, feedlot and manure management and shoreline restoration. Specific projects/activities recommended in Independence are:

1) manure application guidance (up to 19 lbs P/yr; $530);
2) nutrient management based on soil tests (up to 38 lbs P/yr; $950);
3) edge-of-field filter strips (buffers; up to 38 lbs; $1,890);
4) shoreline buffering (up to 25 lbs P/yr; $2,900);
5) barnyard management* (up to 76 lbs P/yr; $45,000) **note: for details, see Appendix D in Lake Sarah TMDL Report*
6) urban raingarden installation (up to 64 lbs P/yr; $1,162,500)

Total potential phosphorus removal resulting from BMP implementation in Independence is up to **260 lbs P/yr**.

Greenfield (Phosphorus load reduction of 528 lbs. P/yr needed to reach LA)
The most cost-effective options for phosphorus load reduction in the City of Greenfield are BMPs related to row crop and feedlot/manure management. Specific projects/activities recommended in Greenfield are:

1) manure application guidance (up to 27 lbs P/yr; $740);
2) nutrient management based on soil tests (up to 264 lbs P/yr; $950/yr);
3) edge-of-field filter strips (buffers; up to 519 lbs; $25,970);
4) barnyard management* (up to 162 lbs P/yr; $215,000) **note: for details, see Appendix D in Lake Sarah TMDL Report.*

Total potential phosphorus removal resulting from BMP implementation in Greenfield is up to **972 lbs P/yr**.

Corcoran (Phosphorus load reduction of 109 lbs. P/yr needed to reach WLA)
The most cost-effective options for phosphorus load reduction in the City of Corcoran are BMPs related to row crop, feedlot/manure and commercial runoff management. Specific projects/activities recommended in Corcoran are:

1) nutrient management based on soil tests (up to 64 lbs P/yr; $1,600/yr);
2) edge-of-field filter strips (buffers; up to 140 lbs; $7,000);
3) barnyard management* (up to 28 lbs P/yr; $25,000) **note: for details, see Appendix D in Lake Sarah TMDL Report*
4) filtration of commercial runoff (up to 35 lbs P/yr; $1,027,500)

Total potential phosphorus removal resulting from BMP implementation in Corcoran is up to **267 lbs P/yr**.

Loretto (Phosphorus load reduction of 37 lbs. P/yr needed to reach WLA)
The most cost-effective options for phosphorus load reduction in the City of Loretto are BMPs related to urban and residential stormwater management and instream/wetland restoration. Specific, projects/activities recommended in Loretto are:

1) instream/wetland restoration of channelized reaches (up to 54 lbs P/yr; $140,000*) **note: based on possible joint project between Medina and Loretto; projected phosphorus reduction and cost based on general project plan, split of benefits and costs are assumed and will be revised/ updated as part of preliminary engineering/design.*

Total potential phosphorus removal resulting from BMP implementation in Loretto is **54 lbs P/yr**.

Minnesota Department of Transportation (Mn/DOT) (Phosphorus load reduction of 28 lbs. P/yr needed to reach LA)
The most cost-effective options for phosphorus load reduction by Mn/DOT are the implementation of stormwater BMPs during roadway construction or reconstruction projects.

Hennepin County (Phosphorus load reduction of 13 lbs. P/yr needed to reach LA)
The most cost-effective options for phosphorus load reduction by Hennepin County is the implementation of stormwater BMPs during roadway development/redevelopment projects and/or cost-sharing with local municipalities during BMP implementation.

Additional Direction from Current Commission. The current members of the PSCWMC have offered adjustments and refinements to the implementation strategy developed by the stakeholder committee and the PSCWMC prior to January 1, 2011. They are summarized below:

1. The Commission strongly encourages MnDOT to achieve its load reduction. Further, it encourages MnDOT to cooperate in evaluating the restoration of wetlands that lie within the Highway 55 transportation corridor in the Dance Hall Creek subwatershed as a regional treatment option that could achieve load reductions in excess of that assigned MnDOT under this TMDL.
2. A more detailed evaluation of the efficacy of constructing one or more regional pond/wetland treatment systems in the Dance Hall Creek subwatershed should be pursued. While this option may not be as cost-effective as small scale land treatments at numerous sites in the watershed, it may be an easier load reduction measure to implement in a timely manner. Land treatments may still be pursued as a means of reducing the maintenance frequency for any regional treatment facility.
3. Alternative waste load reduction approaches for the City of Loretto should be developed in case the proposed joint pond project with the City of Medina is not viable. These alternative approaches could include one or more of the following:
    a. Retrofitting of large areas of impervious surface, such as areas within the industrial parks, with stormwater infiltration or filtration features.

b. Cleanout/deepening/expansion of the existing detention basin northwest of the industrial park to enhance its pollutant removal performance.
c. Re-routing a portion of Loretto Creek flows into the existing detention basin, especially if the pond performance is enhanced with physical modifications and more of the treatment of runoff from the large industrial area is handled with retro-fitted on-site infiltration/filtration features.

Should it become necessary to consider options like those above in lieu of the pond project, this Implementation Plan can be modified after a preliminary assessment is conducted to develop planning level cost and effectiveness information for those options.

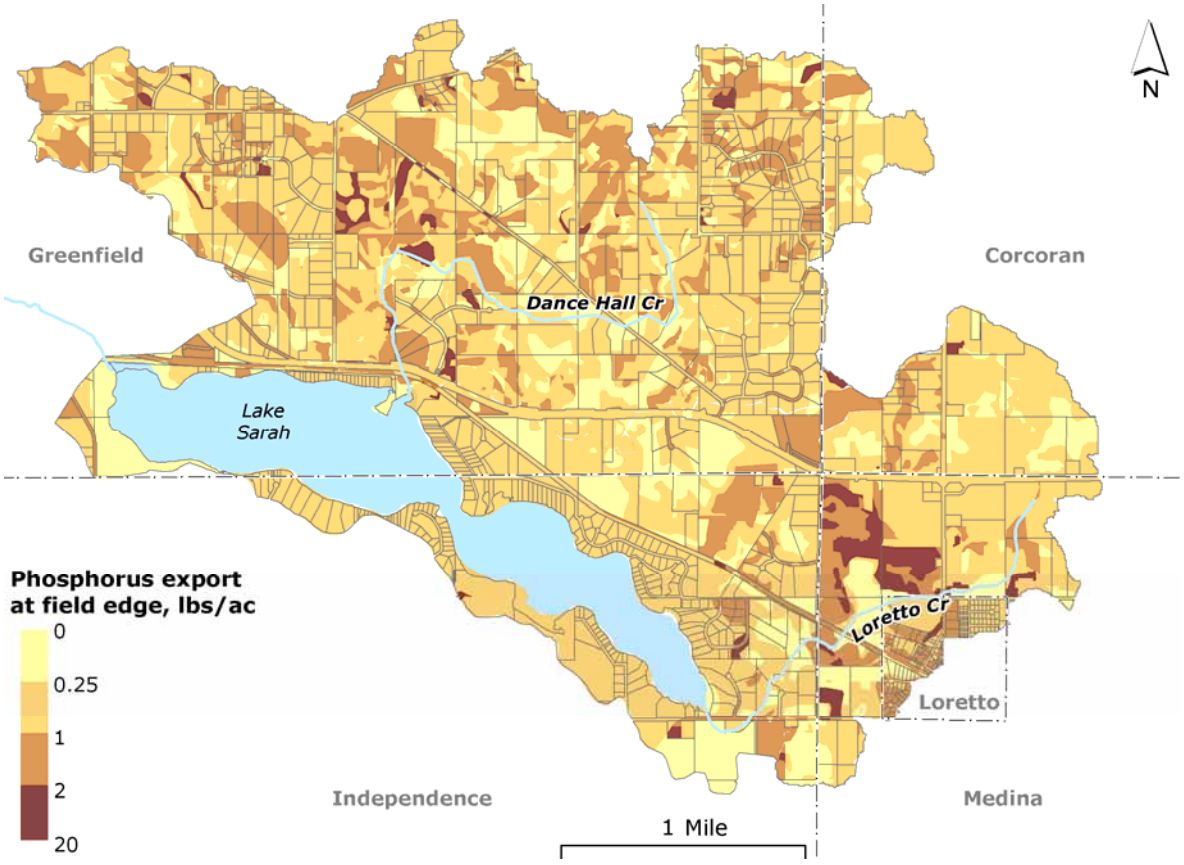
4. Shoreline buffers and infiltration/filtration features should be added to the suite of treatment practices that could be applied in Greenfield. Shoreline buffers should be targeted at lakeshore properties in Greenfield, whereas infiltration/filtration practices are appropriate for developed areas with significant impervious coverage anywhere in the watershed.
5. Future improvements in the management of manure from livestock operations in the watershed as well as declines in the number of livestock units can both result in phosphorus load reductions to Lake Sarah. The Commission will give consideration to the conditions under which these changes can count toward meeting the load and waste load reduction objectives in the TMDL. This could include the adoption and enforcement of manure management standards that would apply to existing, new, and expanded livestock operations in the watershed to assure that the decrease in loading is not just due to a temporary condition.
6. Education on sound stormwater management practices will be encouraged throughout the watershed, especially for residential properties. Education efforts should focus on:
    a. Use of no-phosphorus fertilizers for lawns unless soil tests show phosphorus is needed.
    b. Keeping vegetative debris off streets.
    c. Small scale practices such as rainwater gardens to infiltrate water from hard surfaces or maintained areas.
    d. Installing buffers to stabilize shorelines and filter overland runoff.
    e. Dis-connection of impervious areas to replacement of existing impervious areas with pervious surfaces.
    f. Native landscaping.
    g. Pet waste control.
    h. Wise use of lawn chemicals.
    i. Maintaining a healthy lawn that keeps soil in place and minimizes runoff.

Next Steps. The types of watershed BMPs recommended in this Implementation Plan have been chosen in part for their cost-effectiveness. However, the level of detail of analysis conducted is not sufficient to identify specific parcels of land nor specific projects that represent the most cost-effective individual sites for BMP installation to reduce loads to Lake Sarah. An effort to identify and screen potential sites will be needed as a follow-up activity to this plan, including on-the-ground field investigations to identify the highest priority areas for improvement, development of site-specific remedies, and development of project-specific benefits and costs. Estimating project specific benefits can utilize tools such as MinnFARM (to help

prioritize livestock feedlot problems) and soil loss and pollutant reduction worksheets from the Board of Water and Soil Resources (BWSR).

To aid in identifying high priority areas in the watershed on which to focus initial efforts, Figure 2.1 has been prepared to show potential "hotspots" in the watershed that represent the highest potential to generate phosphorus loads affecting the lake. The map is the result of an analysis which overlays soils data, slope, and land cover/land use to show the parts of the watershed most likely to generate disproportionately high source loads. This can serve as a starting point to focus field-scale review efforts to identify actual "hotspots" on the ground.

Figure 2.1 - Desk-top Watershed "Hotspot" Analysis for Potential Phosphorus Loading



To achieve the most direct benefit to the lake, highest priority should be given to projects for those "hotspot" areas that drain directly to the lake or that are immediately adjacent to (and drain to) perennial or intermittent tributaries to the lake. High loads entering a tributary stream far from the lake but that discharges to the lake without passing through any intervening wetland or pond can have as significant an impact as a problem area that is right on the lake shore. It bears repeating that there is no substitute for on-the-ground knowledge of the watershed in identifying cost-effective projects. This requires expertise in being able to

recognize a problem area or management practice, and the willingness and ability to work cooperatively with the parcel owner to resolve the problem.

The immediate next steps for initiating watershed load reduction activities are as follows:

1. Complete a detailed assessment of specific opportunities for small scale land treatment practices to achieve phosphorus load reduction. This should include on-the-ground field investigations to identify the highest priority areas for improvement, development of site-specific remedies, a determination of the willingness of the affected landowner(s) to cooperate in a remediation project, and development of project-specific benefits and costs. The PSCWMC will initiate this effort and the cost of the initial screening effort is expected to be up to $15,000. The effort will be started no later than 2013.
2. Complete a feasibility study to evaluate alternatives for constructing regional treatment facilities to reduce loadings from the Dance Hall Creek subwatershed. Again, the PSCWMC will lead this initial effort and the cost of the initial screening effort is expected to be up to $20,000. The effort will be started no later than 2013.

The results of the above assessments will be used to inform capital improvement planning and implementation for both the PSCWMC and the affected cities in meeting the watershed load reduction objectives in the TMDL.

3.1.2 Internal Load Reduction Strategies

The majority of the internal phosphorus load is considered anthropogenic from years of input from watershed loading. Implementation measures to reduce anthropogenic watershed loading will ultimately reduce the rate of accumulation of phosphorus in lake sediments that causes internal loading. Despite the required reductions in watershed load, additional management efforts will have to be implemented to control internal loading from enriched sediments presently in the lake in order to achieve in-lake water quality goals. Internal load reduction will be achieved through the implementation of a curlyleaf pondweed control program and/or in-lake phosphorus sequestration/removal. Effective control of internal loading will require the removal/sequestration of 3222 lbs P/year.

Curlyleaf Pondweed Control

As described in the introduction, curlyleaf pondweed is present in much of the approximately 373 acre littoral zone of Lake Sarah. Senescence of these plants are estimated to contribute load of approximately 914 pounds of phosphorus per year. There are two principle approaches that could be used to try to control curly-leaf pondweed. These are harvesting and early season, low dose aquatic herbicide treatments. Harvesting activities would likely need to be carried out on the lake almost every year and are estimated to cost approximately $52,500/year. Harvesting is likely to have low effectiveness in limiting turion (seed) production and in reducing phosphorus loading from senescing curlyleaf pondweed due to inherent limitations of the equipment on the depths and areas that can be harvested in a timely fashion. For example, harvesters are generally not used in water shallower than 2-3 feet and they can usually cut the plant off at a depth no greater than 5-6 feet. In addition, underwater obstructions such as rocks and woody debris can cause damage to harvesters so these areas are generally avoided. Finally, harvesting rates for a single machine in relatively heavy plant cover rarely exceed 1-2 acres per day,

meaning that the plants cannot usually be cost-effectively cut and hauled out during the relatively short period between the time they are large enough to cut effectively and the time they the release their turions (seeds) for succeeding years growth.

Herbicide treatments would likely need to be carried out on the lake for at least five consecutive years over most of the littoral area. The low dose, early season herbicide application over a multi-year period has a much greater potential for effective control of turion production, limiting phosphorus loading from curlyleaf pondweed, and enhancing the native aquatic plant community in the lake. This is because the entire littoral zone of Lake Sarah could probably be treated in under a week. Further, the herbicides would kill the curlyleaf pondweed well before viable turions would be released. Finally, the treatments would be timed to kill the plants when natives are still dormant and therefore generally not susceptible to the effects of the herbicide. Estimated costs are based on initial herbicide applications on over 300 acres of the littoral area for the first two years, 150 acres for the third year, and 75 acres each for the fourth and fifth year. Costs for a 5-year herbicide control program would total approximately $250,000 assuming a contractor is hired to apply the herbicide. Note that cost could vary based on the efficacy of treatment from year to year.

A 5-year program of low dose, early season herbicide treatments for those areas of the littoral zone supporting curlyleaf pondweed growth is recommended as the preferred alternative because the probability of achieving curlyleaf pondweed control is much higher using this method than using harvesting. Prior to any whole-lake manipulation, the Lake Sarah Lake Vegetation Management Plan (LVMP) must be completed and approved by the Minnesota Department of Natural Resources and permits will need to be obtained. The control program for curlyleaf pondweed could be started anytime the resources to support a sustained effort over five consecutive years are available. Periodic spot treatments are likely to be needed even after the initial five-year control effort, but these should be relatively low-cost (perhaps $500-$1000 every other year). This plan assumes the initial control effort is expected to start in 2012 or 2013, though a later start would not be a problem as long as curlyleaf pondweed abundance is reduced to non-nuisance levels in the lake by the time the in-lake phosphorus sequestration is executed.

Responsible Parties: The PSCWMC will lead the effort to implement this element, with the Lake Sarah Improvement Association (LSIA) providing coordinating services with lakeshore owners as well as financial support. TRPD will support the effort by providing technical guidance, conducting plant surveys to track progress, and covering a share of the cost commensurate with the percentage of the total shoreline that it owns on Lake Sarah (approximately 15% currently) and TRPD cost-sharing policy. The PSCWMC will pay up to 25% of the cost of the project and work with the LSIA, TRPD, and the affected municipalities to secure grants and other funding.

<u>In-lake Phosphorus Sequestration</u>

In addition to aquatic vegetation management, sediment release of nutrients during periods of anoxia may need to be addressed. The recommended method of reducing internal loading is through a one time, "batch" alum treatment to a portion of the lake. The appropriate dose of alum and cost of the alum treatment for Lake Sarah should be based on the chemistry of lake sediment cores taken in perhaps 5-10 locations of the lake. This work will cost approximately $10,000. While accurate costs of an alum treatment for Lake Sarah cannot be developed until this is done, the typical costs of alum treatment projects in similar lakes range between $700/acre

and $1900/acre of lake area. For the purposes of this plan, the preliminary estimate to treat the deep area of the lake (about 180 acres) plus the deep half of the littoral area of the lake (about 190 acres) with alum is $481,000 based on a per acre cost at the mid-point of the range presented above ($1,300/ac.). In-lake phosphorus control is not being proposed as a recurring management activity, but rather as a "one-time" management tool to complement watershed and aquatic plant management efforts. A treatment to sequester phosphorus in the lake would be completed toward the end of the implementation schedule (likely during or after Year 10) once curlyleaf pondweed and watershed source controls have been largely completed. Achieving substantial completion of the watershed load reduction and curly pondweed control efforts prior to the alum treatment will be important in maximizing the effectiveness and longevity of the alum treatment. Permits will need to be obtained in order to implement the alum treatment.

Responsible Parties: The PSCWMC will lead the effort to implement this element, including developing a cost-sharing arrangement between the various parties, working with LSIA, TRPD, the affected municipalities, and others to secure financial assistance to execute the treatment, and arranging to secure a contractor to do the work. TRPD will provide a share of the cost of the treatment commensurate with the percentage of the total shoreline that it owns on Lake Sarah (approximately 15% currently) and consistent with its cost-share policy. TRPD will also provide technical guidance for the project, including assisting the PSCWMC in the determination of the appropriate alum dose.

3.2 MONITORING PLAN

To ensure effectiveness and efficiency of TMDL implementation, ongoing monitoring will be conducted. Monitoring will assess BMP implementation, in-lake condition, watershed loading and aquatic plant community composition.

BMP implementation monitoring will be conducted by the Pioneer-Sarah Creek Watershed Commission (PSCWC). Each year, member communities will submit a summary of BMP projects and the anticipated phosphorus load reductions to the PSCWC. For permitted MS4 communities, it is anticipated that this would be done in conjunction with reporting requirements under the new MS4 General Permit for 2011-2015. For non-MS4 communities (City of Greenfield), a separate summary will need to be prepared. BMPs will be cataloged to monitor progress toward the individual wasteload and load reduction goals.

In-lake monitoring will be conducted annually following completion of the TMDL. Samples will be collected biweekly (April thru October) following previously described protocols for eutrophic lake assessment by the MPCA. Lake monitoring will continue to be cooperatively implemented by the PSCWC and Three Rivers Park District. The estimated cost for this work is $3,500-$5,500/year, with the PSCWMC splitting this cost with TRPD.

Five years after approval of the TMDL, a detailed watershed load monitoring study should be conducted to quantify the relative load reduction associated with various BMPs. Watershed monitoring will be conducted at the current TMDL monitoring sites following protocols described by Walker (1996). Follow-up monitoring will be conducted for a one to two year period (depending on precipitation patterns), every five years until wasteload reduction goals have been achieved. Watershed load

monitoring should be structured to assess BMP effectiveness at a watershed scale (where applicable) to validate the predicted phosphorus removal efficiencies and facilitate an adaptive approach to the design/implementation of future BMPs. **Future watershed load monitoring efforts should include assessments of early season runoff associated with snow melt and early season rain events (particularly during seasons where rain-on-snow events are possible). Preliminary data suggests that early season runoff may be an important phosphorus source to the lake that is currently underrepresented in the model (see the modeling uncertainty section of the Lake Sarah TMDL for further discussion). Again, this monitoring could be carried out through a cooperative arrangement between PSCWMC and Three Rivers Park District. The estimated costs for this work range from $8,000-$10,000 per year assuming two monitoring stations and depending on the number of events sampled.*

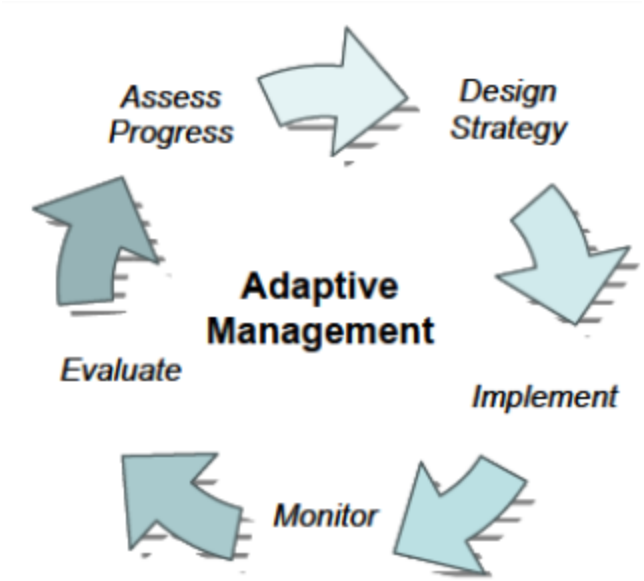
Sediment phosphorus levels should be assessed to refine the dosage and cost-effectiveness of an alum treatment to reduce internal phosphorus release and recycling from enriched lake sediments. This can be done anytime in the implementation period, but it is recommended that it be done within 1-2 years of when an alum treatment will be carried out in order to use the information to develop an appropriate dose. Sediment phosphorus monitoring will be conducted following the protocol outlined by Pettersson et al. (1988) or an equivalent methodology. The estimated cost for this work is $10,000.

Aquatic macrophyte monitoring should be conducted at least every three years to assess the natural variability of the aquatic plant community and provide current information to support a Lake Vegetation Management Plan (DNR currently requires that the plan be based on an aquatic plant survey that is no more than 3 years old). Monitoring should be conducted throughout the littoral zone using a point intercept survey (e.g., Madsen, 1999). During execution of curlyleaf pondweed control efforts, monitoring should be conducted at least annually in early spring to identify specific areas in the lake that should be treated that year. Vegetation monitoring will continue to be cooperatively implemented by PSCWC and Three Rivers Park District. The estimated cost for this work is $800 - $1,600 per year, depending on whether one or two surveys are completed that year.

4.0 Adaptive Management

The load allocations in the TMDL represent aggressive goals for nutrient reductions. Consequently, implementation will be conducted using adaptive management principles. Adaptive management is an iterative approach of implementation, evaluation, and course correction (see Figure 4.1). It is appropriate here because it is difficult to predict the lake response to the load reductions expected. Future conditions and technological advances may alter the specific course of actions detailed in this plan. Continued lake water quality monitoring and course corrections responding to monitoring results offer the best opportunity for meeting the water quality goals established in the TMDL.

Figure 4.1 – Adaptive Management



The PSCWMC will reconvene the Stakeholder Committee near the beginning of the fifth year of the initial five-year implementation period to review the monitoring data and evaluate project progress as well as determine if this Implementation Plan should be amended. The PSCWMC will act as the lead entity in this effort. If the Implementation Plan is amended, those changes will be reflected in the next five-year NPDES Phase II MS4 permit for the affected communities.

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