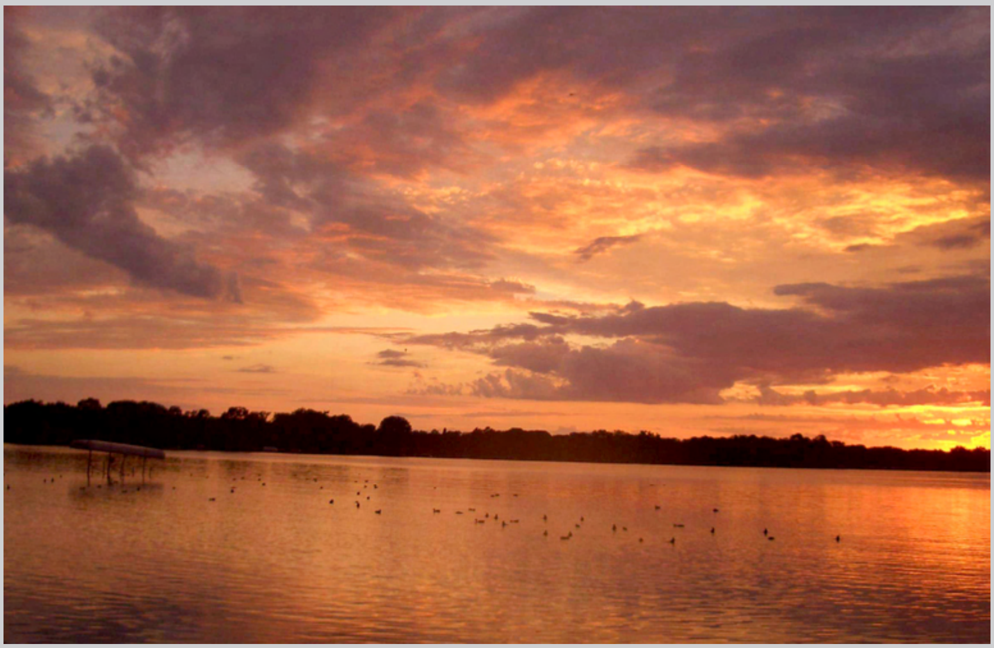
Medicine Lake Excess Nutrients Total Maximum Daily Load Implementation Plan



Prepared for:

Minnesota Pollution Control Agency
and the
Bassett Creek Watershed Management Commission

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LimnoTech
Water | Environment | Scientists | Engineers

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1. INTRODUCTION

1.1 PURPOSE

This document presents the Implementation Plan for the Medicine Lake Total Maximum Daily Load (TMDL). Medicine Lake is listed on the 2008 Minnesota Section 303(d) List of Impaired Waters due to impairment of aquatic recreation by excess nutrients (phosphorus) and a TMDL has been developed by the Minnesota Pollution Control Agency (MPCA) and the Bassett Creek Watershed Management Commission (BCWMC) (MPCA, 2010). It was originally listed in 2004.

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop TMDLs for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources.

Once a TMDL is established, an Implementation Plan must be developed. The Implementation Plan is designed to ensure that the management actions identified by the TMDL will be carried out. The Implementation Plan provides information on management measures and regulatory controls; timelines for implementation of management measures and attainment of water quality standards; a monitoring plan designed to determine the effectiveness of implementation actions; and description of adaptive management procedures should water quality standards not be met.

1.2 GEOGRAPHICAL EXTENT

Medicine Lake (Lake Assessment Unit ID: 27-0104-00) is located within the City of Plymouth, Hennepin County, Minnesota (Figure 1-1). The Medicine Lake watershed (nearly 12,000 acres) drains land from six different municipalities (Plymouth, City of Medicine Lake, New Hope, Golden Valley, Minnetonka, and Medina) and two transportation agencies (Hennepin County and Minnesota Department of Transportation) that are served by Municipal Separate Storm Sewer Systems (MS4). The outlet of Medicine Lake is the headwater of Bassett Creek.

Medicine Lake is approximately 900 surface acres in size, with a maximum depth of 11 meters (Table 1-1 and Figure 1-2). The lake littoral area (< 15 ft in depth) comprises approximately 33% of the entire surface acreage. Medicine Lake meets the State's deep lake criteria. The lake typically stratifies during the summer at approximately 5 meters in depth (Vlach et al., 2007). However, prolonged winds from the north and/or south often initiate complete or partial turnover events (in addition to the spring and fall turnover) that potentially exacerbate the internal loading of phosphorus.

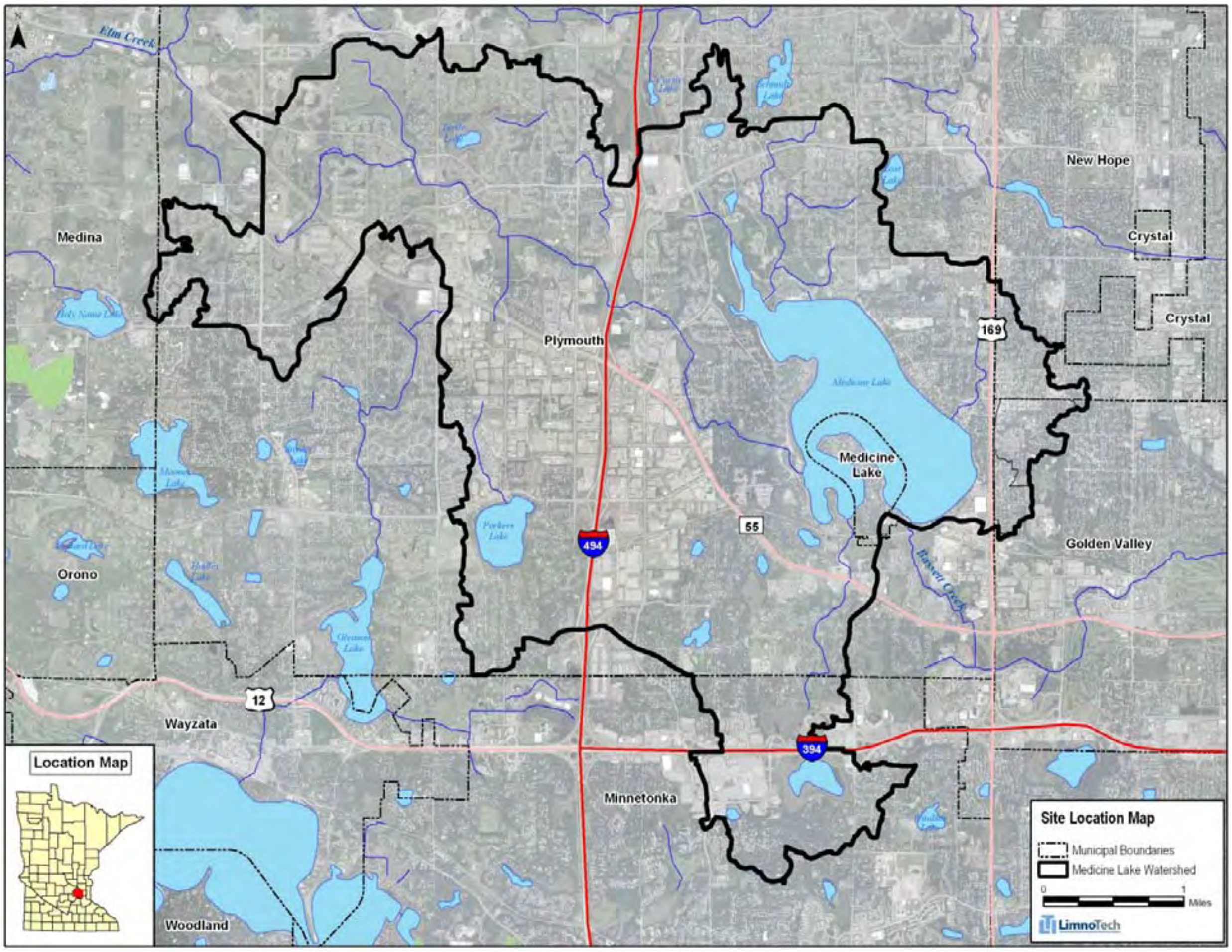


Figure 1-1. Site Location.

Table 1-1. Medicine Lake Bathymetry.

Morphometry Characteristics	
Surface Area	3.83 km^2
Mean Depth	5.3 m
Length	3 km
Mixed Layer Depth	5 m
Hypolimnetic Depth	7 m

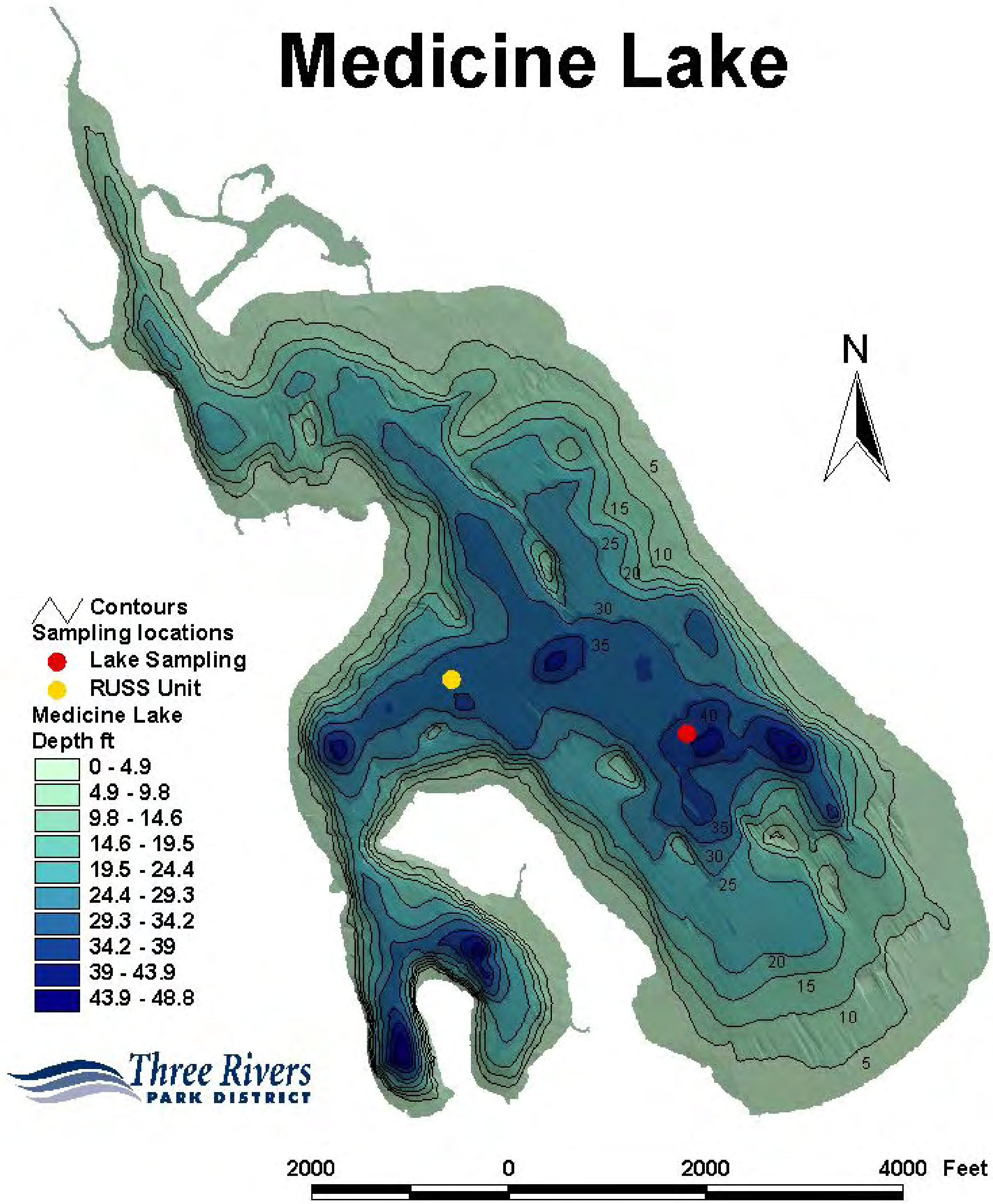


Figure 1-2. Medicine Lake Bathymetry.

1.3 WATER QUALITY GOALS

Water quality standards for Medicine Lake are specified in Minnesota Rule 7050.0222 Subp 4 for Lakes and Reservoirs in the North Central Hardwood Forest Ecoregion. The criteria for deep lakes include:

- Phosphorus, total: 40 μg/L
- Chlorophyll-a: 14 μg/L
- Secchi disc transparency: not less than 1.4 m

The primary numerical water quality target for the Medicine Lake is the average growing season total phosphorus concentration of 40 μg/L. The City of Plymouth established a goal of 38 μg/L in their Medicine Lake Watershed Implementation and Management Plan (City of Plymouth, 2004). The TMDL has been developed to meet the 38 μg/L target. The more conservative target of 38 μg/L is considered an explicit Margin of Safety (MOS) for the TMDL.

The secondary numerical water quality target for this TMDL is the average growing season secchi depth criterion of 1.4 m. Historical water quality data indicate that this criterion is generally being met currently. Compliance with the total phosphorus target and the secchi depth target would constitute compliance with the applicable water quality standards and attainment of the beneficial uses.

While attainment of the chlorophyll-*a* criterion of 14 μg/L is not a numerical target for this TMDL, making progress towards the attainment of the total phosphorus target is expected to contribute to lower chlorophyll-*a* levels in Medicine Lake. Continued monitoring will track progress towards all three parameters.

1.4 SOURCE IDENTIFICATION

All known sources of phosphorus to Medicine Lake were considered in the development of the TMDL and Implementation Plan. These sources include:

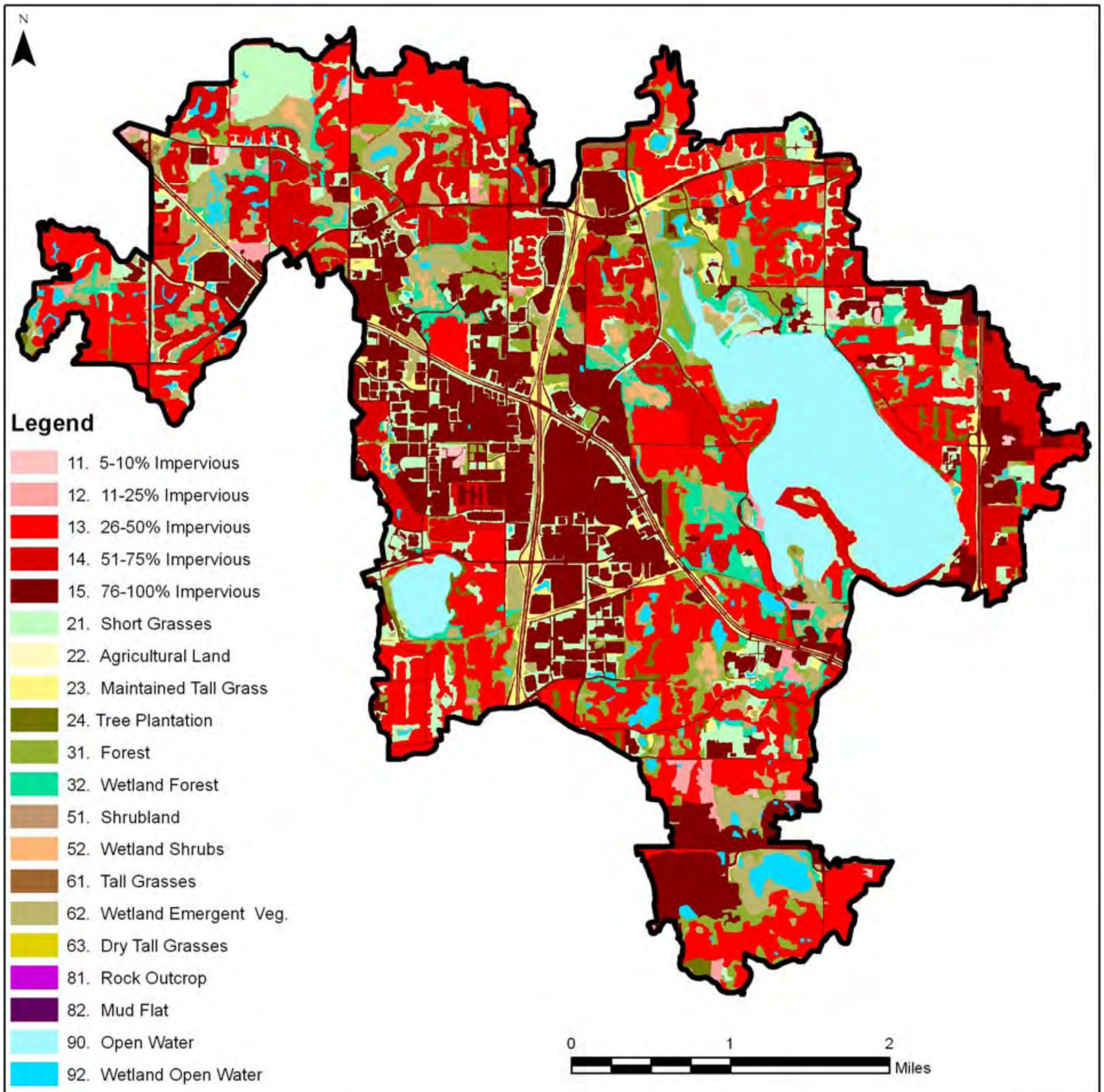
- Stormwater runoff from MS4s;
- Permitted point sources other than MS4s;
- Atmospheric deposition; and
- Internal loading.

The watershed is largely developed. Nearly 60% of the watershed is assigned a land cover of 25% impervious area or greater (Figure 1-3). Runoff from the watershed enters the lake from creeks, storm sewer outfalls, and culverts at various points along the lakeshore. Stormwater from approximately 90 percent of the Medicine Lake watershed currently drains through some form of wet detention before it enters Medicine Lake. The volume and pollutant levels of storm water runoff from the watershed, combined with internal sources of phosphorus, are the primary sources of phosphorus to Medicine Lake.

There are no permitted discharges directly to Medicine Lake other than the MS4s. There are two known permitted wastewater discharges within the watershed but were determined to be insignificant contributors of phosphorus to Medicine Lake in the TMDL and are not required to reduce their loads.

Atmospheric deposition is a significant contributor of phosphorus to Medicine Lake and was accounted for in the TMDL. However, the Implementation Plan does not call for any reductions in this load because of the limited ability to control the source.

There are two primary sources of internal loading of phosphorus in Medicine Lake - sediment release of phosphorus and curlyleaf pondweed senescence. These have been considered in the TMDL and Implementation Plan.



	City Land Cover (acres)							City Land Cover percentage						
Land Cover Type	Golden Valley	Medicine Lake	Medina	Minnetonka	New Hope	Plymouth	Grand Total	Golden Valley	Medicine Lake	Medina	Minnetonka	New Hope	Plymouth	Grand Total
5-10% Impervious	0.5	0.0	0.0	7.9	2.4	33.5	44.3	0.22%	0.00%	0.00%	0.88%	1.46%	0.33%	0.38%
11-25% Impervious	0.1	0.0	0.4	39.4	0.0	67.4	107.3	0.05%	0.00%	3.75%	4.37%	0.00%	0.67%	0.92%
26-50% Impervious	53.1	12.2	0.0	331.9	0.0	2,319.0	2,716.1	24.39%	5.31%	0.00%	36.81%	0.00%	22.97%	23.38%
51-75% Impervious	67.2	48.6	0.0	1.7	111.3	1,209.5	1,438.4	30.89%	21.20%	0.00%	0.19%	69.24%	11.98%	12.38%
76-100% Impervious	56.5	0.5	0.0	258.4	42.2	2,122.8	2,480.4	25.96%	0.24%	0.00%	28.66%	26.28%	21.03%	21.35%
Short Grasses	16.2	17.1	0.6	2.1	3.5	1,001.6	1,041.2	7.46%	7.46%	5.01%	0.23%	2.18%	9.92%	8.96%
Agricultural Land	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.00%	0.00%	0.62%	0.00%	0.00%	0.00%	0.00%
Maintained Tall Grass	4.4	0.0	0.0	2.3	1.4	342.1	350.1	2.02%	0.00%	0.00%	0.26%	0.84%	3.39%	3.01%
Tree Plantation	0.0	0.0	3.0	11.2	0.0	141.6	155.9	0.00%	0.00%	25.30%	1.24%	0.00%	1.40%	1.34%
Forest	8.8	0.0	4.9	75.4	0.0	644.1	733.2	4.06%	0.00%	41.05%	8.36%	0.00%	6.38%	6.31%
Wetland Forest	2.2	10.9	0.0	3.2	0.0	301.9	318.2	0.99%	4.76%	0.00%	0.36%	0.00%	2.99%	2.74%
Shrubland	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%
Wetland Shrubs	0.0	0.0	0.0	0.0	0.0	57.1	57.1	0.00%	0.00%	0.00%	0.00%	0.00%	0.57%	0.49%
Tall Grasses	1.4	0.0	0.0	0.0	0.0	11.4	12.8	0.62%	0.00%	0.00%	0.00%	0.00%	0.11%	0.11%
Wetland Emergent Veg.	4.6	8.7	2.3	106.9	0.0	743.0	865.4	2.11%	3.81%	18.93%	11.86%	0.00%	7.36%	7.45%
Dry Tall Grasses	0.7	0.0	0.0	0.0	0.0	0.0	0.7	0.31%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
Open Water	0.0	131.2	0.0	0.0	0.0	915.2	1,046.5	0.00%	57.22%	0.00%	0.00%	0.00%	9.07%	9.01%
Wetland Open Water	2.0	0.0	0.6	61.2	0.0	184.1	248.0	0.94%	0.00%	5.35%	6.79%	0.00%	1.82%	2.13%
Grand Total	217.6	229.3	12.0	901.6	160.7	10,095.1	11,616.3							

Figure 1-3. Medicine Lake Watershed Land Use.

1.5 REQUIRED LOAD REDUCTIONS

The TMDL represents the total mass of phosphorus that can be assimilated into Medicine Lake while continuing to meet the state water quality standards. For purposes of implementation, the TMDL equation is described as four different components: Wasteload Allocation (WLA); Load Allocation (LA); Margin of Safety (MOS); and Reserve Capacity (RC). The WLA represents phosphorus loading from point sources such as permitted stormwater discharge from the various MS4s. The LA represents phosphorus from nonpoint sources such as atmospheric deposition and internal loading. A portion of the TMDL is allocated to the MOS to account for uncertainty associated with modeling estimates and environmental variation. The RC represents the portion of the load that is set aside to account for future development.

$$TMDL = \sum WLA + \sum LA + MOS + RC$$

WLA = Wasteload Allocations

LA = Load Allocations

MOS = Margin of Safety

RC = Reserve Capacity

The BATHTUB model load-response function was used to evaluate the in-lake water quality response to varying phosphorus loads from the watershed and establish the TMDL. The TMDL and its components are presented as:

	TMDL	=	∑WLA	+	∑LA	+	MOS	+	RC
(lbs/day)	10.3	=	8.84	+	0.69	+	0.74	+	0
(lbs/year)	3,753	=	3,230	+	253	+	270	+	0

The annual loading rate is the relevant time scale for considering the water quality impacts of excess phosphorus loads to Medicine Lake and compliance with applicable water quality standards. However, EPA requires TMDLs be written with daily loads. Therefore, both time scales will be presented. Table 1-2 presents a summary of the TMDL components and percent reductions needed from watershed conditions existing in 2007. BMPs implemented following 2007 have not been accounted for in the assessment of reductions needed to meet the WLA. If monitoring or modeling of BMPs implemented since 2007 can demonstrate reduced loadings, those should be considered in the required reductions needed to meet the WLA. A complete description of the BATHTUB application and assumptions used to arrive at these values is presented in the TMDL report (MPCA, 2010).

Table 1-2. Medicine Lake TMDL, Components and Percent Reductions.

TP Source	TP Load			% Reduction
	Current	TMDL	Reduction	
Watershed (WLA) **(lbs/day)** **(lbs/year)**	12.4 4,517	8.84 3,230	3.56 1,287	28%
Atmospheric (LA) **(lbs/day)** **(lbs/year)**	0.69 253	0.69 253	0 0	0%
Internal (LA) **(lbs/day)** **(lbs/year)**	0*	0*	0	0%
Margin of Safety (MOS) **(lbs/day)** **(lbs/year)**	- -	0.74 270	- -	-
Reserve Capacity (RC) **(lbs/day)** **(lbs/year)**	-	0	-	-
Total (lbs/day) **(lbs/year)**	13.1 4,770	10.3 3,753	3.53 1,287	27%

* Represents background levels of internal loading implicitly accounted for in the BATHTUB model for 2006 conditions. See TMDL report Sections 4.1 and 4.3 and Appendix B for further discussion (MPCA, 2010).

A 1,287 lbs/yr TP reduction in watershed loads is required to meet the WLA. This is a 28% reduction from watershed conditions in 2007. The required reduction may be less as a result of BMPs implemented since 2007. The wasteload allocation (WLA) component of the TMDL addresses all point sources. Two permitted wastewater discharges are located within the watershed. These include Minntech Corporation and Honeywell, Inc. However, as described in the TMDL, these discharges were determined to be insignificant contributors of phosphorus to Medicine Lake and are not required to reduce their loads (0 lbs/year from Minntech and 6 lbs/year from Honeywell). Therefore, the required reduction will come from stormwater sources under the jurisdiction of MS4s. However, monitoring of TP in the Honeywell discharge may be included in the NPDES permit upon permit renewal. Should additional monitoring of the discharge and assessment of its transport and fate indicate greater than 6 lbs/year of total phosphorus is contributed to Medicine Lake from the facility, mitigation may be required.

No reductions are being called for from atmospheric deposition because of the inability to control this load.

A background internal load from the sediment bed in Medicine Lake was accounted for in the TMDL. Reductions below this background level are not required by the TMDL. Continued reductions in watershed loads of phosphorus can be expected to reduce release of phosphorus from the sediment bed below the background conditions. However, the magnitude of reductions and the timeframe for recovery of the sediment bed phosphorus levels have not been evaluated. Curlyleaf pondweed controls have been implemented and are required to continue to be implemented to maintain curlyleaf pondweed densities at those experienced in 2006.

Conditions may be experienced in any given year that lead to higher levels of internal loading than what was experienced in 2006 and accounted for in the TMDL. Such conditions include multiple wind-driven mixing events and increased curlyleaf pondweed densities. Compliance with water quality standards, even if the external loading capacity of 3,753 lbs TP/year is met, may not be achieved during years of internal loading at levels above that experienced in 2006. Should long-term monitoring demonstrate continued impairment even with reductions in the external loads, adaptive management will be required to assess and identify additional actions that will result in attainment of water quality standards.

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2. DESCRIPTION OF MANAGEMENT MEASURES

The required reduction in the WLA is assigned to MS4s. The municipal MS4s have decided to approach this in a coordinated fashion and have agreed to a categorical WLA. These municipal MS4s include the City of Plymouth, City of Medicine Lake, City of Minnetonka, City of Golden Valley, and the City of New Hope. The Bassett Creek Watershed Management Commission (BCWMC) will serve as the convener of action for the categorical WLA, but not as a responsible entity. Additional MS4 entities which have individual wasteload allocations include Hennepin County and Mn/DOT. The MS4s boundaries are presented in Figure 2-1. Table 2-1 presents a summary of the land area of each MS4. Note that municipal MS4s have transportation right-of-ways subtracted from their total area. Areas for the transportation right-of-ways for Hennepin County and Mn/DOT were calculated from GIS coverage using roadway lengths and right-of-way widths for each road in the respective jurisdiction.

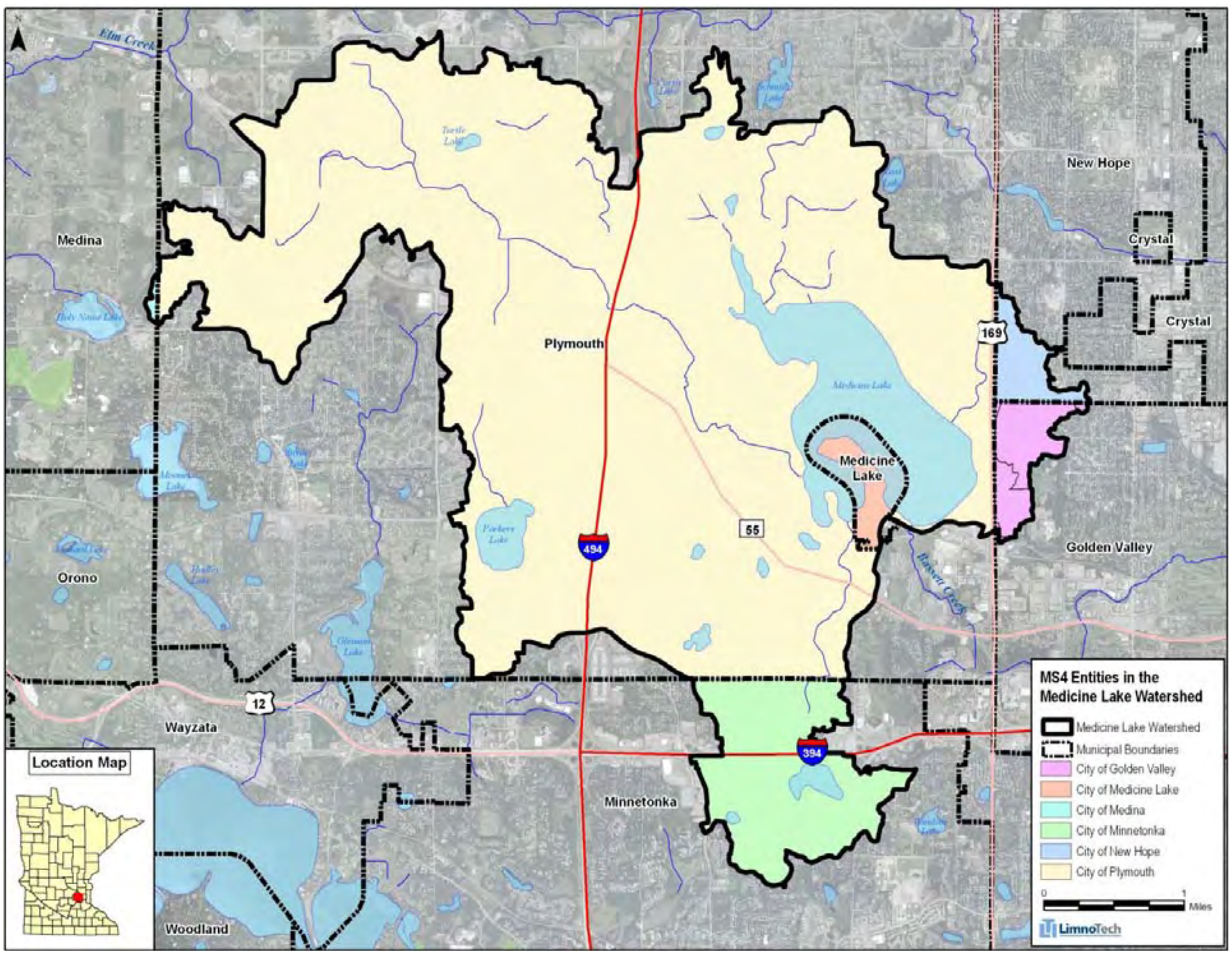

Figure 2-1. MS4 Boundaries.

Table 2-1. MS4 Areas within the Medicine Lake Watershed.

MS4	Area (acres)	% of Watershed Area
Categorical Municipal MS4 (sum of cities listed below)	11,066	95.6%
City of Plymouth	9,613	83.1%
City of Medicine Lake	229	2.0%
City of Minnetonka	887	7.5%
City of Golden Valley	202	1.7%
City of New Hope	145	1.2%
Hennepin County	171	1.5%
Mn/DOT	379	2.9%

The calibrated P8 model results were compiled on a subwatershed basis to assess the TP load and unit area loading rate by subwatershed based on watershed conditions in 2007 and climatic conditions in 2006. The results are presented in Table 2-2. These values can be used to guide implementation efforts.

Table 2-2. Total Phosphorus Unit Area Loads by Subwatershed.

Subwatershed	Existing Load to Lake (based on 2007 watershed conditions and 2006 climatic conditions)	
	TP (lbs)	TP (lbs/acre/yr)
East Medicine Lake Park	84	0.71
South Bassett Creek	239	0.45
Middle Bassett Creek	88	0.63
North Bassett Creek	143	0.75
Northeast Medicine Lake	114	0.17
North Medicine Lake	261	0.53
West Medicine Lake	88	0.45
City of Medicine Lake + Direct Drainage Areas	290	0.68
Ridgedale Creek	494	0.34
Plymouth Creek	2360	0.55
18th Avenue	356	0.17
Watershed-wide	4517	0.43

2.1 EXISTING EVALUATIONS OF POTENTIAL MANAGEMENT MEASURES

The existing *Medicine Lake Watershed and Lake Management Plan* (Barr, 2000) and the City of Plymouth *Phase II: Medicine Lake Watershed Implementation and Management Plan* (City of Plymouth, 2004) examined a range of alternatives to reduce phosphorus loads to Medicine Lake. A summary of the recommended alternatives and costs per pound of TP reduced in the *Phase II: Medicine Lake Watershed Implementation and Management Plan* is presented in Table 2-3. Note that some of these controls have already been implemented.

Table 2-3. Summary of City of Plymouth 2004 Implementation Plan.

Action	Reduction	$/lb
Erosion Control & Streambanks	294	$660
Pond Maintenance	42	$224
Geese Control	63	$181
Fertilizer Restriction Implementation	84	$12
Increased Street Sweeping	168	$298
Rain gardens/etc.	21	$281
Pond Treatment	21	$160
BC-98 & BC-107 Ponds	55	$2,225
West Medicine Lake Park Pond	336	$164
Ordinances & Rules	4	$107
Total	**1,088**	**---**

2.2 WATERSHED PHOSPHORUS REDUCTION ALTERNATIVES

The calibrated P8 model was applied to assess various phosphorus loading reduction scenarios. BMPs existing in the watershed in 2007 were used to represent baseline conditions. Precipitation and temperature for water year 2006 (October 1, 2005 through September 30, 2006) were used to represent climatic conditions.

As noted in the TMDL and previously in the Implementation Plan, the required reduction in the annual total phosphorus load to Medicine Lake is 1,287 lbs, a 28% reduction from baseline loadings.

The following seven screening-level alternatives were simulated. These are screening level alternatives meant to assess the limitations of potential benefits from various BMPs if applied watershed-wide, and are not intended to portray actual projects in the watershed, with the exception of Alternative 1 which accounts for projects already in the planning, design, or construction phase. The final implementation will likely be comprised of a combination of various BMPs applied at something less than a watershed-wide basis.

- Alternative 1: Addition of proposed West Medicine Lake Water Quality Ponds in the City of Plymouth and creation of a potential pond/wetland area in Golden Valley.
    - Reductions: 489 lbs from the West Medicine Lake Water Quality Ponds and 11 lbs from the Golden Valley pond, for a total reduction of 500 lbs.
- Alternative 2: New ponds in Alternative 1 along with a 10% reduction in the runoff curve number watershed-wide. This 10% reduction is a way of generally representing reduced runoff from pervious areas within the watershed. Opportunities to reduce runoff from pervious areas may include: increasing infiltration by use of rain gardens or soil amendments; increasing storage by use of rain barrels; improving landscape design to promote storage and infiltration; and increasing tree canopy cover. These practices apply to all types of land uses and should be considered throughout the watershed. An area-weighted estimate of the existing curve number for the watershed, as represented in the P8 model, is 76. This represents a relatively tight soil.
    - Reductions: 994 lbs (in the absence of the West Medicine Lake Water Quality Ponds and the Golden Valley pond, this reduction would be 487 lbs). The 10% curve number reduction results in a 7.2% reduction in runoff from the watershed. Watershed runoff volumes for baseline conditions are approximately 13.2 hm^3/yr. Under this scenario, runoff reduces to 12.3 hm^3/yr. To put this type of reduction in context, it can be compared to the amount of reduction in runoff from demonstration studies. The Burnsville rain garden demonstration study included the creation of 17 rain gardens, totaling 6,800 square feet, in a 5.3 acre residential area. In the Burnsville study, monitoring data demonstrated that a 90% reduction in runoff was obtained. Using a rough translation from the Burnsville study, achieving the 7.2% reduction in runoff from the Medicine Lake watershed could require creation of approximately 2,600 rain gardens averaging 400 square feet in size.
- Alternative 3: New ponds in Alternative 1 along with an increase in the depression storage in impervious areas from 0.03 inch to 0.1 inch watershed-wide. The depression storage is the amount of rainfall that is initially retained on the impervious landscape before any runoff occurs. An increase to 0.1 inch of depression storage is a way of representing modifications to impervious areas to retain more rainfall on-site, either through storage, infiltration (e.g. porous pavement), or initial abstraction that might be attained by means of additional tree cover. These practices apply to impervious land uses and should be considered throughout the watershed. Directly connected impervious area is represented as 3,732 acres in the P8 model. At 0.03 inch of depression storage, the total storage capacity is 9.3 acre-ft. At 0.1 inch of depression storage, the total storage capacity is 31 acre-ft.

- Reductions: 794 lbs (in the absence of the West Medicine Lake Water Quality Ponds and the Golden Valley pond, this reduction would be 310 lbs). Watershed runoff volumes for baseline conditions are approximately 13.2 hm^3/yr. Under this scenario, runoff reduces to 12.1 hm^3/yr, for an 8.7% reduction in runoff.

- Alternative 4: New ponds in Alternative 1 along with a new "generic" pond at the most downstream location in each major subwatershed, just before entering Medicine Lake. The "generic" pond is intended to represent the "best case scenario" for potential particulate phosphorus removal by creation of new ponds within each subwatershed. New ponds are limited to areas where land is available. The benefits of a new pond will depend on the location within the watershed and the land use from which the pond would receive runoff. Therefore, new ponds should be considered throughout the watershed but must be evaluated on a case-by-case basis to determine cost-effectiveness. The 11 ponds were represented as 0.5 acres at permanent pool with a storage volume of 2.6 acre-ft, for a total of 5.5 acres with 28.6 acre-ft of storage volume.

  - Reductions: 761 lbs (in the absence of the West Medicine Lake Water Quality Ponds and the Golden Valley pond, this reduction would be 340 lbs).

- Alternative 5: New ponds in Alternative 1 along with a 10% reduction in the directly connected impervious area throughout the watershed. Similar to Alternative 2, this scenario represents improvements in the watershed to reduce runoff and increase infiltration and/or evapotranspiration, but focuses on the highly impervious areas, such as commercial and industrial developments and large parking structures. This scenario simulates reducing runoff by directly reducing impervious area in the watershed. Directly connected impervious area is represented as 3,732 acres in the P8 model. This scenario would restore 373 acres of impervious area to pervious area with a curve number similar to the existing pervious area.

  - Reductions: 792 lbs (in the absence of the West Medicine Lake Water Quality Ponds and the Golden Valley pond, this reduction would be 308 lbs). Watershed runoff volumes for baseline conditions are approximately 13.2 hm^3/yr. Under this scenario, runoff reduces to 12.4 hm^3/yr, for a 6.6% reduction in runoff.

- Alternative 6: New ponds in Alternative 1 along with improvements in the removal efficiency of all existing ponds. Existing ponds throughout the watershed should be evaluated to determine the potential benefit of improved maintenance or retrofits. Improved maintenance of ponds and potential retrofits to optimize phosphorus removal can be simulated in P8. All ponds were adjusted from the standard Particle Scale Factor of 1 to a value of 3 to represent increased removal efficiencies. The literature supporting the P8 model suggests values from 3 to 6 could be used to represent the potential removal efficiencies in ponds if retrofits for water quality were constructed.

- Reductions: up to 1,516 lbs (in the absence of the West Medicine Lake Water Quality Ponds and the Golden Valley pond, this reduction would be 1,377 lbs). Significant uncertainty exists in the potential benefits of water quality retrofits for existing ponds. Depending on existing construction, increased removal efficiencies may not be possible. However, retrofits should be examined to determine feasibility and cost-benefit.

- Alternative 7: New ponds in Alternative 1 along with stream bank restoration efforts along Plymouth Creek. Streambank restoration was simulated by doubling the Particle Scale Factor in devices along the mainstem of Plymouth Creek.
    - Reductions: up to 999 lbs (in the absence of the West Medicine Lake Water Quality Ponds and the Golden Valley pond, this reduction would be 711 lbs).

A summary of these simulations is presented in Table 2-4. While the potential for attaining the 1,287 lb TP/year reduction seems attainable using some combination of the alternatives, careful consideration needs to be given to the feasibility and cost of implementing any one of these alternatives at any scale. The costs associated with a management measure can vary significantly depending on site-specific characteristics and land availability. Site-specific feasibility assessments and cost-benefit evaluations should be conducted prior to proceeding with individual projects.

These reductions and costs indicate that, beyond the West Medicine Lake Water Quality Ponds, streambank restoration on Plymouth Creek is a priority. In addition, identifying the most cost-effective opportunities to implement the other measures, such as rain gardens, parking lot retrofits, new ponds, and existing pond retrofits should be explored. To attain 1,287 lbs/yr TP reduction in the watershed load, at an average cost of $2,500/lb, the total cost would be $3,217,500. At $5,000/lb, the cost doubles to $6,435,000. This cost could be less considering BMPs implemented since 2007 have not been accounted for in the 1,287 lbs/yr TP reduction estimate.

Table 2-4. Measures and Costs.

Management Measure	Estimated Reduction Potential (lbs/yr, 2006 conditions)	Approximate Costs and $/lb Reduction
West Medicine Lake Park Ponds - in construction ($1,500,000)	489	$3,000/lb
Streambank Restoration/ Erosion Control • Wood Creek – completed in 2008 ($300,000) • County Road 9/61 – completed in 2008 ($425,000) • Timber Creek – completed in 2009 ($200,000) • Plymouth – in development ($1,000,000)	Up to 711 along Plymouth Creek (510 with WMLP Pond)	$500 to $5,000/lb
Bioretention, rain gardens, soil restoration	487 (494 with WMLP and GV Ponds)	$500 to $2,500 per 400 sq. ft rain garden $2,500 to $13,500/lb
Impervious area retention and retrofits	310 (293 with WMLP and GV Ponds)	$1 to $10/sq.ft for parking lot retrofit $5,000 to $50,000/lb
Reduction in impervious area	308 (292 with WMLP and GV Ponds)	$10,000 to $20,000/acre $12,500 to $25,000/lb
New ½ acre wet pond at downstream end of watershed	341 (261 with WMLP Pond)	$100,000 to $500,000/acre $1,500 to $7,500/lb
Water Quality Retrofits to Existing Ponds	Up to 1,500	$3,000 to $10,000/impervious acre served $7,500 to $25,000/lb
Shoreline Restoration	Uncertain	$30 to $50/ft

2.3 INTERNAL LOAD REDUCTIONS

The TMDL assumes internal loads of phosphorus are maintained at levels experienced in 2006. Two key components of the internal load must be considered: 1) curlyleaf pondweed senescence; and 2) sediment phosphorus release.

Curlyleaf pondweed controls in Medicine Lake were initiated in 2004 (TRPD, 2008). The initial treatment covered 300 acres at a cost of approximately $100,000/year for the first three years. Continued annual spot treatments are required to maintain control of curlyleaf pondweed such that densities observed in 2006 are not exceeded. The cost of continued spot treatments to maintain this level of control is estimated at approximately $40,000 per year to treat 55 acres.

Under climatic conditions when multiple mixing events occur during the course of the summer, internal loadings from sediment release greater than those implicitly assumed in the TMDL for 2006 conditions may be experienced. The increased level of sediment release of phosphorus may contribute to non-attainment of water quality standards. While the TMDL does not call for control of the sediment release of phosphorus, continued monitoring will be used in an adaptive management framework to assess the need for additional actions to address internal loads. The existing Medicine Lake Watershed and Lake Management (Barr, 2000) provides an assessment of in-lake alum treatment for control of sediment phosphorus release. Cost estimates developed in 2000 were approximately $1,000,000 for alum treatment.

3. INFORMATION AND EDUCATION

Continued public education and involvement will be beneficial throughout the implementation of management measures. These activities may include:

- Annual reporting of in-lake water quality data;
- Annual reporting of management measures implemented and expected phosphorus reductions;
- Maintenance of the MPCA TMDL website;
- Updates on the BCWMC, TRPD, AMLAC, and MS4 websites, newsletters, and public meetings;
- Shoreline restoration outreach and education; and
- Individual property owner outreach and education on fertilizer use, low-impact lawn care practices, and rain garden installation and maintenance.

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4. IMPLEMENTATION SCHEDULE

Implementation of management measures is a continuing process. The BCWMC and municipalities have been identifying and implementing projects that reduce phosphorus loads to Medicine Lake for many years. The TMDL has now set a specific load reduction requirement that will guide continued implementation activities. The goal for achieving the required load reduction of 1,287 lbs/yr TP is 10 years, or by 2020, with 75% of the load reduction achieved within 5 years, or 2015. Specific management measures have not been identified in this Implementation Plan with the exception of the West Medicine Lake Water Quality Ponds, which is scheduled for completion in the fall of 2010. Scheduling of additional management measures will be determined by the BCWMC and individual MS4 entities, including Mn/DOT and Hennepin County.

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5. ADAPTIVE MANAGEMENT PROCESS

Management measures to meet the Medicine Lake TMDL are focused on reducing stormwater runoff and increasing the removal of phosphorus from stormwater runoff. Implementation of these types of controls will likely include numerous projects of varying size and will be distributed throughout the watershed. Predictions of load reductions from individual projects are limited in terms of their accuracy and precision. The attainment of water quality goals in Medicine Lake under reduced loading conditions is also subject to uncertainty. Therefore, monitoring, as discussed in Section 6, will be required to assess progress towards meeting the necessary load reductions and water quality goals. Also, an adaptive management decision-making process will provide a means of continually tracking progress and informing subsequent implementation projects.

It is important that all activities or projects in the watershed that reduce phosphorus loads to Medicine Lake be documented and tracked.

Annual monitoring of in-lake water quality and intensive monitoring of watershed loads every 5 years, as described in Section 6, will also be used to track progress. Annual variability in climatic conditions and potential lag time for BMPs to achieve full load reduction potential will need to be considered in assessing the data and developing conclusions.

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6. MONITORING

To ensure effectiveness and efficiency of TMDL implementation, ongoing monitoring will be conducted. The following monitoring plan is a very comprehensive plan to aid the communities in assessing whether progress toward the TMDL is being made. While this level of monitoring will provide valuable information to utilize in watershed and lake management efforts it is not required to determine if the allocations are being met. Monitoring will assess BMP implementation, in-lake condition, watershed loading and aquatic plant community composition.

BMP implementation tracking will be coordinated by the Bassett Creek Watershed Commission, as lead entity in the categorical TMDL. Each year, member communities will submit a summary of BMP projects and the anticipated phosphorus reductions to the Bassett Creek Commission in conjunction with Stormwater Pollution Prevention Plan (SWPPP) reporting. BMPs will be cataloged to track progress toward the individual wasteload reduction goals. Mn/DOT and Hennepin County should also track BMP implementation and document it in their MS4 annual reports.

In-lake monitoring will be conducted annually following completion of the TMDL (TRPD currently conducts this monitoring and will continue doing so). Samples will be collected biweekly (April thru October) following previously described protocols for eutrophic lake assessment (Heiskary 1994 and Heiskary 2007). Based on this sampling frequency, there is a 75% probability that a 30% change in lake condition will be detected after 3 years of monitoring (90% after 6 yrs; (MPCA 2007). Monitoring will be continued at this frequency for a ten year period and/or until implementation efforts have been completed.

A detailed watershed load monitoring study should be conducted to quantify the relative load reduction associated with various BMPs. Modeling using FLUX and P8 should be conducted concurrently to assess annual loading rates. Watershed monitoring will be conducted at the current TMDL monitoring sites following protocols described by Walker (1996). The scheduling of an initial monitoring effort should consider the timing of implementation activities and occur approximately five years after approval of the TMDL. Follow-up monitoring should 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 efforts should also include upstream-downstream assessments of individual BMPs to validate the predicted phosphorus removal and facilitate an adaptive approach to the design/implementation of future BMPs.

Sediment phosphorus levels should be assessed to better evaluate the applicability and potential cost-effectiveness of additional in-lake BMPs. Sediment phosphorus monitoring will be conducted following the protocol outlined by Pettersson et al. (1988).

Aquatic macrophyte monitoring will be conducted annually to assess: 1) the natural variability of the aquatic plant community; and 2) the efficacy of any future aquatic plant management programs (TRPD currently performs this sampling and plans to continue with this effort). Monitoring will be conducted at ~200 points throughout the littoral zone using a point intercept survey (e.g., Madsen 1999). Annual monitoring will be conducted until in-lake plant management activities have been completed.

7. REFERENCES

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