

Prepared by:
Emmons & Olivier Resources, Inc.
for the Rice Creek Watershed District

Southwest Urban Lakes Study



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Appendix - Management Action Plans

1. Executive Summary

Over the past few years, the Rice Creek Watershed District has prioritized its efforts on Resource Management Plans in the developing portions of the District. The District's next focus is on more urbanized areas. Recently, RCWD has received numerous inquiries for assistance in cleaning up some fairly degraded urban lakes in the southwest portion of the watershed. These requests came from lake homeowners and/or associations on lakes that have been subjected to decades of concentrated urban runoff and are now showing the effects of that pollutant loading. The goal of this project is to assess the water quality of 24 lakes in the southwest portion of RCWD, particularly in relation to state standards, and to develop management action plans for each lake. The intent of the management action plans is to give the District a prioritized list of projects for further investigation. The prioritization exercise is NOT intended to make a final determination on the merits of a particular project. For most projects further feasibility assessments would be needed before the District proceeds with a particular project.

The phosphorus loads to each lake were estimated in order to develop lake response models and to determine the magnitude of the load reductions that are needed for the lakes to achieve water quality standards. The watershed loads were estimated using an urban runoff model (P8), and the internal loads were modeled using sediment data, in-lake nutrient concentrations, and basic lake morphometry to predict internal loads due to anoxic release. Lake response models were developed for each lake in order to integrate the watershed loading with the internal loading into a predictive model.

The Lake Management Action Plans (MAPs) presented here summarize lake characteristics and existing lake data, provide a diagnostic assessment of the data, summarize public input, identify water quality issues, and recommend remedial strategies on a lake-watershed basis. As such, each MAP provides a concise summary of the known issues and recommended management approaches for each lake. It is envisioned that the MAPs will be used to further define management strategies, guide development of the District's Third Generation Plan, and serve as the basis for seeking project partners and grant funding for retrofit water quality improvements.

Over 200 potential retrofit BMPs are identified in the MAPs. In order to prioritize further assessment and implementation feasibility, a simplified cost/benefit assessment was performed to assign each BMP as a Tier 1, 2 or 3 BMP (Tier 1 having the best cost-benefit ratio). Based on this prioritization, the recommended implementation strategy for 2009 includes:

- Initiation of feasibility studies on three Tier 1 BMPs
- Coordination with parks departments on six Tier 1 BMPs within community parks
- Solicitation of private party interest in potential cost share on nineteen Tier 1 BMPs
- Landowner notification of needed maintenance at three Tier 1 BMPs

2. Introduction

A. RCWD, RMPs, URBAN LAKES

Over the past few years, the Rice Creek Watershed District has prioritized its efforts on Resource Management Plans (RMPs) in the developing portions of the District. The RMP projects to date include topics such as wetland management, water quality to meet TMDL goals, and ditch repairs. Since RMPs are either approved or in the process of being written for the developing areas, RCWD's next focus is on more urbanized areas.

Recently, RCWD has received numerous inquiries for assistance in cleaning up some fairly degraded urban lakes in the southwest portion of the watershed. These requests come from lake homeowners and/or associations on lakes that have been subjected to decades of concentrated urban runoff and are now showing the effects of that pollutant loading. Some of the lakes in question include Little Johanna, Pike, Long, and Spring.

The goal of this project is to assess the water quality of 24 lakes (Figure 1, Table 1) in the southwest portion of RCWD, particularly in relation to state standards, and to develop management action plans for each lake:

Table 1. Study Lakes

Lake Name	DNR Lake ID
Hart	02-0081
Island	62-0075
Johanna	62-0078
Jones	62-0076
Josephine	62-0057
Karth	62-0072
Langton	62-0049
Little Johanna	62-0058
Little Josephine	62-0201
Locke	02-0077
Long	62-0067
Marsden	62-0059
Martha	62-0064
Moore	02-0075
Pike	62-0069
Poplar	62-0077
Round	62-0070
Rush	62-0068
Spring	02-0071
Sunfish	62-0065
Turtle	62-0061
Valentine	62-0071
Walsh	62-0214
Zimmerman	62-0053

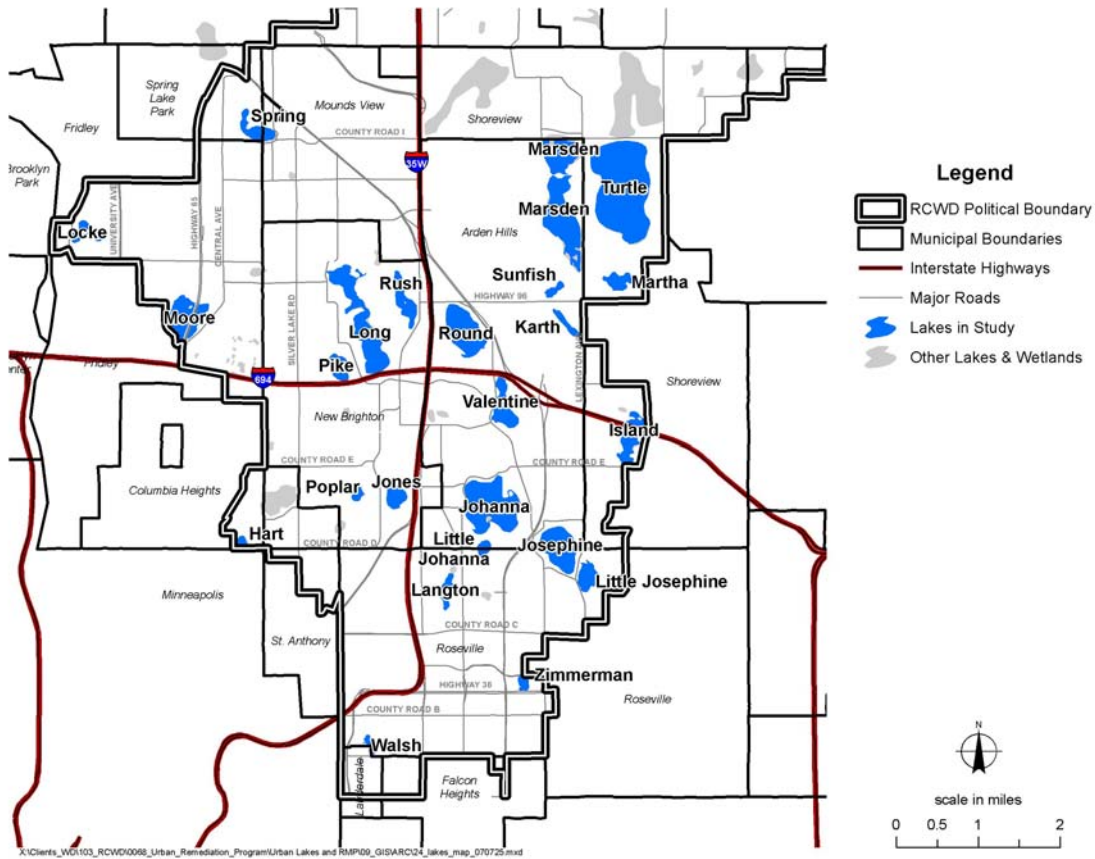


Figure 1. Location of Study Lakes

B. LAKE EUTROPHICATION STANDARDS

Water quality standards are established to protect the designated uses of the state's waters. Amendments to Minnesota's Rule 7050, approved in May 2008, include eutrophication standards for lakes (Table 2). *Eutrophication* is defined as "a process whereby water bodies receive excess nutrients that stimulate excessive plant growth" (USGS). "Excessive plant growth" often refers to algae blooms that can result in decreased water clarity (green, soupy appearance) or surface scums. Excessive algae growth can lead to a loss of native aquatic plants, decreased recreational use, unpleasant odors and appearance, and altered fish communities favoring undesirable species (rough fish). Eutrophication standards were developed for lakes in general, and for shallow lakes in particular. Standards are less stringent for shallow lakes, due to naturally higher levels of phosphorus in shallow lakes and different ecological characteristics.

According to the MPCA definition of shallow lakes, a lake is considered shallow if its maximum depth is less than 15 ft, or if the littoral zone (area where depth is less than 15 ft) covers at least 80% of the lake's surface area.

Table 2. MN Eutrophication Standards, North Central Hardwood Forests Ecoregion

Parameter	Eutrophication Standard, General	Eutrophication Standard, Shallow Lakes
Total Phosphorus (µg/l)	TP < 40	TP < 60
Chlorophyll-a (algae) (µg/l)	chl < 14	chl < 20
Secchi depth (clarity) (m)	SD > 1.4	SD > 1.0

C. IMPAIRED WATERS PROGRAM

Section 303(d) of the Federal Clean Water Act requires that states establish total maximum daily loads of pollutants to water bodies that do not meet water quality standards. The loading limits are to be calculated such that, if achieved, the water body would meet the applicable water quality standard. To comply with the Clean Water Act, the Minnesota Pollution Control Agency (MPCA) assesses the state's waters, lists those water bodies that are impaired (i.e. do not meet water quality standards), and conducts studies to determine the pollutant loading limits for the impaired water bodies. These studies are known as TMDL studies, or total maximum daily load studies. In Minnesota, the pollutant that is often the cause of eutrophication is phosphorus.

The MPCA sets target start and completion dates for individual TMDL studies. Studies are usually funded by either the MPCA or by local units of government. Each TMDL study describes the impairment, identifies the relevant pollutant(s), inventories the pollutant sources, calculates the capacity of the water body (i.e. the amount of pollutant the lake can process in its natural cycle), allocates the allowable loads to the different sources, and prescribes an implementation strategy to restore the water body to meet water quality standards.

Within a year of completing the TMDL study, the MPCA requires the completion of an implementation plan, which provides more specific management details than are provided in the initial TMDL study.

Several waters that are listed on the 303(d) list of impaired waters are located within the project area (Table 3).

Table 3. Impaired Lakes

Lake Name	DNR Lake ID	Year First Listed	Impairment	Target start/ completion dates
Island Lake	62-0075	2002	Nutrient/Eutrophication Biological Indicators	2010 / 2014
Jones Lake	62-0076	2008	Aquatic macroinvertebrate bioassessments	2010 / 2014
Little Lake Johanna	62-0058	2004	Nutrient/Eutrophication Biological Indicators	2010 / 2014
Long Lake	62-0067	2002	Nutrient/Eutrophication Biological Indicators	2010 / 2014
Moore Lake, East	02-0075	2002	Nutrient/Eutrophication Biological Indicators	2009 / 2013
Pike Lake	62-0069	2002	Nutrient/Eutrophication Biological Indicators	2010 / 2014
Lake Valentine	62-0071	2002	Nutrient/Eutrophication Biological Indicators	2010 / 2014

3. Phosphorus Analysis

A. NUTRIENT LOADING TO LAKES

Purpose of analysis

Phosphorus is the nutrient that, in excessive amounts, leads to eutrophication in lakes in Minnesota, and it is the nutrient that is used by the MPCA to set numeric standards for lakes. As such, phosphorus is the pollutant focused on in this report.

The phosphorus loads to each lake were estimated in order to develop lake response models and to determine the magnitude of the load reductions that are needed for the lakes to achieve water quality standards. The watershed loads and the internal loads were estimated independently.

Watershed loading

Approach

The general approach for determining the total phosphorus (TP) load entering each of the lakes in the study area was to estimate the load generated from each lake's direct watershed and to account for all additional loads coming from upstream lakes, ponds, or watersheds. Watershed TP loading was determined using a reconnaissance level P8 Urban Catchment Model. The model predicts loads generated from urban watersheds based primarily on their size and level of imperviousness. The P8 model allows the user to account for the degree to which impervious surfaces are connected throughout the watershed and, ultimately, to the receiving water body. The portion of the impervious surfaces directly connected to the receiving water body was set at 85% for each of the watersheds in the study area. The other 15% of the area is indirectly connected to the receiving water body through pervious areas such as lawns or natural areas. No attempt was made to characterize the water quality treatment being provided by small ponds or other BMPs, such as street sweeping, throughout the watersheds.

The P8 model was run using the 1995 water year (October 1994 through September 1995). This water year represents an average year for the Minneapolis-St. Paul area in terms of total precipitation and distribution of storm events. The NURP50 particle file was used in the P8 model. It represents the 50th percentile particle size distribution based on all NURP data and is recognized as the standard file for use in this type of analysis. General model parameters were established for all of the watersheds within the study area (Table 4).

Table 4. P8 Model input parameters

P8 model parameter		Setting
Pervious	Curve Number	61
	Load Factor	1
Impervious	Depression Storage	0.02 inches
	Runoff Coefficient	0.9
	Load Factor	1

Subwatersheds for the lakes were delineated from existing resources, based on best available data for the area. Data sources included:

- Ramsey County 2-foot topographic data
- USGS 10-foot topographic data (for Anoka and Hennepin County)
- 1998 RCWD Calibration Study subwatersheds
- City Local Plan subwatershed and stormsewer maps
- Institutional knowledge of the system

It was originally envisioned that these preliminary subwatersheds would be refined with the District-wide SWMM modeling effort originally scheduled for the southwest lobe of the District in 2008. Because this modeling effort was postponed, it is recommended that, when the District pursues detailed modeling of the southwest area of the District, the watersheds should be refined utilizing LIDAR and field survey data.

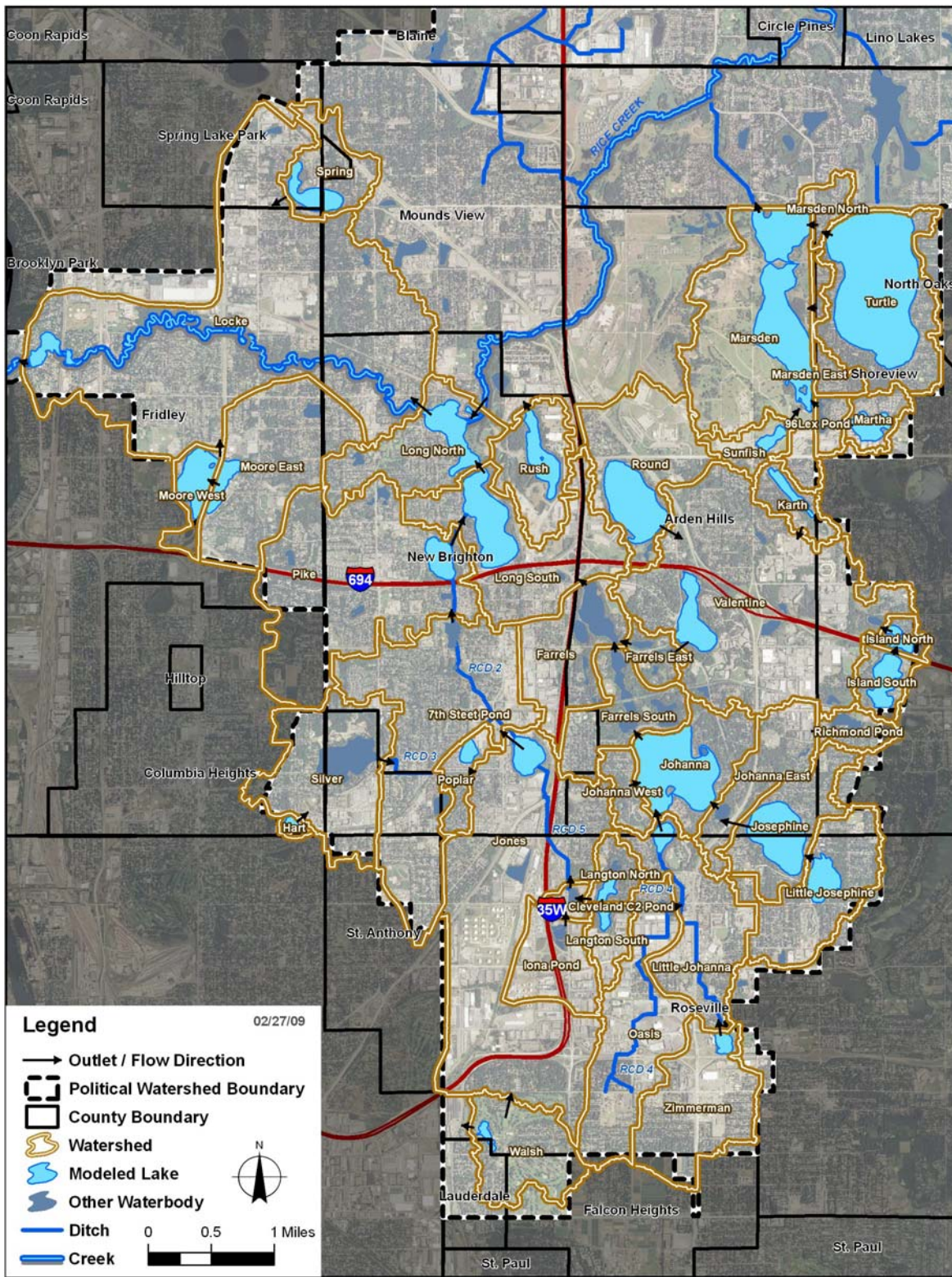


Figure 2. Subwatershed Boundaries and Drainage Direction

Impervious surface estimates for each watershed were extracted from QuickBird satellite imagery using digital image processing techniques. A supervised maximum likelihood classification using a sample priori probability was performed using 79 training samples representing urban, urban shadow, vegetation, vegetation shadow, and open water land cover types. Some urban and water features were burned into the classification manually to obtain a higher accuracy classification. Burned-in water features included modeled lake outlines as well as polygon areas representing open water MLCCS codes. Some areas classified as urban were also manually burned into the classification using polygons created by heads up digitizing. After manual edits were finished, the final classification consisted of urban (100% impervious), vegetation (0% impervious), and water (100% impervious) land cover types. Percent impervious weighted averages per subwatershed were then extracted using a zonal statistics routine.

The acreage and percent impervious for each lake's direct watershed are listed in Table 5 (see also Figure 2 for subwatershed boundaries). In some cases, additional areas drain to the lakes in the study area and these areas were modeled separately from the direct watershed area. These additional areas were separated from the direct lake watershed because they are either large, distinct areas or contain a significant water body that provides water quality treatment. The acreage and impervious percentage for these areas are also listed in Table 5.

Table 5. Watershed specific P8 Model input parameters

Direct Lake Watersheds		
Watershed Name	Area (acres)	Percent Impervious
Hart	15.9	55%
Island North	47.95	30%
Island South	91.58	32%
Johanna	207.21	22%
Jones	1699.73	50%
Josephine	279.76	27%
Karth	117.74	35%
Langton North	98.54	27%
Langton South	109.45	69%
Little Johanna	535.85	45%
Little Josephine	449.77	31%
Locke	2679.06	40%
Long North	400.62	27%
Long South	618.32	45%
Marsden	790.38	18%
Martha	76.76	43%
Moore East	701.19	36%
Moore West	47.27	40%
Pike	1228.12	38%
Poplar	108.49	43%
Round	465.07	36%
Rush	276.63	47%
Spring	302.88	35%
Sunfish	111.74	39%
Turtle	287.58	18%
Valentine	1655.41	38%
Walsh	372.2	18%
Zimmerman	531.23	46%
Additional drainage areas - no treatment		
Watershed Name	Area (acres)	Percent Impervious
Johanna East	325.45	35%
Johanna West	114.52	28%
Marsden East	116.41	26%
Marsden North	86.38	30%
Farrels	433.4	45%
Farrels East	104.59	24%
Farrels South	348.08	22%

Additional drainage areas - with treatment		
Watershed Name	Area (acres)	Percent Impervious
7th Street	1156.66	41%
96 & Lexington	71.86	47%
Cleveland & C2	53.7	63%
Iona	280.93	71%
Oasis	663.97	59%
Richmond	96.03	36%

The P8 Model was used to calculate the volume of stormwater and the total phosphorus loading from each lake's direct watershed as well as the additional areas that drain to the lakes. The model was also used to calculate the reduction in total phosphorus loading provided by the ponds located in the drainage areas with treatment shown in Table 5. Ponds in these drainage areas were modeled using configuration assumptions derived from their surface area shown in Table 6.

Table 6. Pond Configuration Assumptions

Pond	Permanent Pool		Flood Pool		Bottom
	Surface Area (known)	Volume Surface Area x 2 feet deep	Area 110% of the permanent pool area	Volume Flood Pool area ½ foot deep	Area ~ 1/2 Permanent Pool
	Acres	Acre-feet	Acres	Acre-feet	Acres
Oasis	6.94	13.88	7.63	3.82	3
Richmond Pond	11.59	23.18	12.75	6.37	6
Iona Pond	4.15	8.3	4.57	2.28	2
7th Street Pond	5.37	10.74	5.91	2.95	2.5
Cleveland C2 Pond	3.18	6.36	3.5	1.75	1.6
96Lex Pond	10.68	21.36	11.75	5.87	5.5

The volume of stormwater and the loading of total phosphorus to each lake were calculated as indicated in Table 7. In many cases, the direct drainage area was the only source of stormwater and TP loading. Other lakes have more complex drainage systems (see Figure 2 for subwatershed boundaries and drainage directions) and receive loading from upstream lakes, ponds, or drainage areas. The outflow volume and TP concentrations from upstream lakes were calculated using the Bathtub in-lake model as described in *Section B: Lake Response Modeling, Modeling Approach (#2)*. Volume and TP loads from upstream ponds were calculated using the P8 model as described above.

Table 7. Source of TP Load Estimates to Lakes

Lake	TP Load Calculation Approach
Hart	Direct drainage area only
Island North	Direct drainage area only
Island South	Direct drainage area only
Johanna	Direct drainage area, Johanna West drainage area, Johanna East outflow, Little Johanna Lake outflow
Jones	Direct drainage area, Poplar Lake outflow, Cleveland C2 Pond outflow, Walsh Lake outflow
Josephine	Direct drainage area, Little Josephine Lake outflow
Karth	Direct drainage area only
Langton North	Direct drainage area only
Langton South	Direct drainage area only
Little Johanna	Direct drainage area, Oasis Lake outflow, Zimmerman Lake outflow
Little Josephine	Direct drainage area only
Locke	Direct drainage area, Rice Creek inflow (drainage area x 6 in. runoff x monitored Rice Creek TP conc of 117 µg/L)
Long North	Direct drainage area, Long Lake South outflow, Rice Creek inflow (drainage area x 6 in. runoff x monitored Rice Creek TP conc of 153 µg/L)
Long South	Direct drainage area, Pike Lake outflow, Farrels drainage area
Marsden	Direct drainage area, Marsden East drainage area, Marsden North drainage area, 96Lex Pond outflow, Turtle Lake outflow, Sunfish Lake outflow
Martha	Direct drainage area only
Moore East	Direct drainage area only
Moore West	Direct drainage area only
Pike	Direct drainage area, 7th Street Pond outflow
Poplar	Direct drainage area only
Round	Direct drainage area only
Rush	Direct drainage area only
Spring	Direct drainage area only
Sunfish	Direct drainage area only
Turtle	Direct drainage area only
Valentine	Direct drainage area, Karth Lake outflow, Round Lake outflow, North Island Lake outflow
Walsh	Direct drainage area only
Zimmerman	Direct drainage area only

Results

Results from the P8 watershed modeling are presented as part of the lake modeling discussion, *Section 2B. Lake Response Modeling*.

Internal loading

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:

- Anoxic (lack of oxygen) conditions in the overlying waters. Water at the sediment-water interface may remain anoxic for a portion of the growing season, and low oxygen concentrations result in phosphorus release from the sediments. If a lake's hypolimnion (bottom area) remains anoxic for a portion of the growing season, the phosphorus released due to anoxia will be mixed throughout the water column when the lake loses its stratification at the time of fall mixing. Alternatively, in shallow lakes, the periods of anoxia can last for short periods of time; wind mixing can then destabilize the temporary stratification, thus releasing the phosphorus into the water column.
- Physical disturbance by bottom-feeding fish such as carp and bullhead. This is exacerbated in shallow lakes since bottom-feeding fish inhabit a greater portion of the lake bottom than in deeper lakes.
- Physical disturbance due to wind mixing. This is more common in shallow lakes than in deeper lakes. In shallower depths, wind energy can vertically mix the lake at numerous instances throughout the growing season.
- Phosphorus release from decaying curly-leaf pondweed (*Potamogeton crispus*). This is more common in shallow lakes since shallow lakes are more likely to have nuisance levels of curly-leaf pondweed.

Internal loading due to the anoxic release in the epilimnion of each lake was estimated in this study. Internal loading due to physical disturbance and decaying curly-leaf pondweed is difficult to estimate reliably and was therefore not included in the lake phosphorus analyses. In lakes where internal loading due to these sources is believed to be substantial, the internal load estimates presented here are likely an underestimate of the actual internal load.

Approach

Internal loads due to anoxic release in the hypolimnion were calculated based on an approach developed by Nürnberg (1988, 1995) in which an anoxic factor is calculated based on in-lake TP concentrations, lake surface area, and lake mean depth, and a sediment phosphorus release rate is calculated based on sediment phosphorus concentrations.

The internal load of a lake can be estimated by the following equation:

$$\text{Internal P loading rate} = \text{AF} \times \text{RR}$$

Where AF = anoxic factor, and RR = release rate (Nürnberg 1987). These two parameters were calculated as follows.

Anoxic Factor

The anoxic factor describes the length of time (in days) that a sediment area equal to the lake's surface area is anoxic (Nürnberg 1995). The correction for lake surface area makes the anoxic factor comparable among lakes of different sizes. The anoxic factor can be calculated by knowing the spatial extent and duration of anoxia. Nürnberg (1996) estimated the anoxic factor with the following equation, developed from a data set of lakes in central Ontario and eastern North America:

$$AF_{\text{summer}} = -36.2 + 50.1 \log(\text{TP}) + 0.762z / A^{0.5},$$

where AF_{summer} = summer anoxic factor (days/yr), TP = average summer in-lake TP concentration ($\mu\text{g/L}$), z = lake mean depth (m), and A = lake surface area (km^2).

Release Rate

The release rate of phosphorus from lake sediments can be predicted by the phosphorus concentrations within the sediments (Nürnberg 1988) with the following equation:

$$RR = -0.58 + 13.72(\text{BD-P}),$$

where RR = release rate ($\text{mg/m}^2\text{-day}$), and BD-P = bicarbonate dithionite extractable phosphorus (mg/g dry weight). BD-P analyzes iron-bound phosphorus, and has a better predictive ability than the total phosphorus in the sediment.

Sediment collection

Lake sediment samples were collected at each lake using a WaterMark Universal Core Head sediment corer.

At the lakes that had a well-defined deep hole, two to three locations in the vicinity of the deep hole were sampled. At each location, two to three replicates were taken. All of the samples taken from these lakes were composited before preserving on ice. The deep hole samples were composited since lake sediments tend to be concentrated over time in the deepest part of the lake.

At some of the more shallow lakes that did not have a well-defined deep hole, multiple samples were taken in different locations in the lake and were not composited, but rather were analyzed individually. This was done to examine spatial variability in the sediment phosphorus concentrations, since there is not one single location within the lake where the sediments tend to concentrate. At the remaining shallow lakes, sediment was sampled in only one location. When there was more than one sample analyzed per lake, the results were averaged for purposes of estimating the internal loading in the lake.

Sediment samples were analyzed for total phosphorus, aluminum-adsorbed phosphorus, calcium-adsorbed phosphorus, iron-adsorbed phosphorus, labile phosphorus, percent organic matter, and percent solids. The iron-adsorbed phosphorus fraction (also known as BD-P, or bicarbonate dithionite extractable phosphorus) was used to predict the phosphorus release rate of the sediments.

Results

The iron-adsorbed phosphorus ranged from 17 to 1400 mg P/kg sediment (dry weight), and was positively correlated with total phosphorus ($R^2 = 0.91$, Figure 3). The highest internal loading rates (anoxic factor x release rate) were in Little Lake Johanna, Little Lake Josephine, Long Lake North, and Pike Lake (Table 9). The lowest rates were in Langton Lake, Martha Lake, Moore Lake West, Spring Lake, and Turtle Lake.

Table 8. Sediment Laboratory Results

Lake Name	TP (mg/kg dry)	P, Aluminum Adsorbed (mg/kg dry)	P, Calcium Adsorbed (mg/kg dry)	P, Iron Adsorbed (mg/kg dry)	P, Labile (mg/kg dry)	Percent Organic (%)	% Solids
Hart	770	180	280	120	<19	7.7	20
Island N	670	300	89	120	<17	13.3	20
Island S	680	370	61	120	<30	18.5	13
Johanna	950	30	180	250	<30	16.5	12
Jones	1200	390	130	420	<36	27.3	11
Josephine	1600	370	160	560	<59	32.6	6.3
Karth	750	240	150	130	<20	9.7	19
Langton N	560	360	42	86	<15	14	24
Langton S	88	33	23	17	<5.9	1	64
Little Johanna	2700	780	230	1200	<24	18	16
Little Josephine	2100	550	220	1400	<41	23.2	9.7
Locke	770	120	330	300	<13	8.7	30
Long N	2300	450	90	1300	74	32.6	7.8
Long S	2500	700	240	1300	<30	16	13
Marsden	690	180	38	310	<61	56.6	6.4
Martha	610	160	23	72	<53	63.9	7.4
Moore E	870	290	280	220	<16	10.8	24
Moore W	610	190	53	66	<37	46.5	11
Moore W	540	220	42	48	<37	53.2	10
Moore W	680	270	56	69	<35	49.7	11
Pike	2400	540	280	1200	<22	14.3	17
Poplar	790	150	290	140	<23	8.7	17
Poplar	870	170	270	150	<21	7.4	18
Poplar	640	150	210	100	<20	10.1	20
Round	850	230	81	170	<47	33.7	8.2
Rush	1500	560	75	460	<69	40.7	5.3
Spring	470	260	23	55	<110	34.2	16
Sunfish	630	260	110	130	<18	9.5	21
Turtle	1100	200	59	85	<90	28.5	4.1
Valentine	1100	140	320	360	<62	33.6	6.3
Walsh	1000	370	130	290	<29	15.0	13
Walsh	840	99	22	300	<13	9.1	28
Zimmerman	920	310	280	190	<19	11.0	20

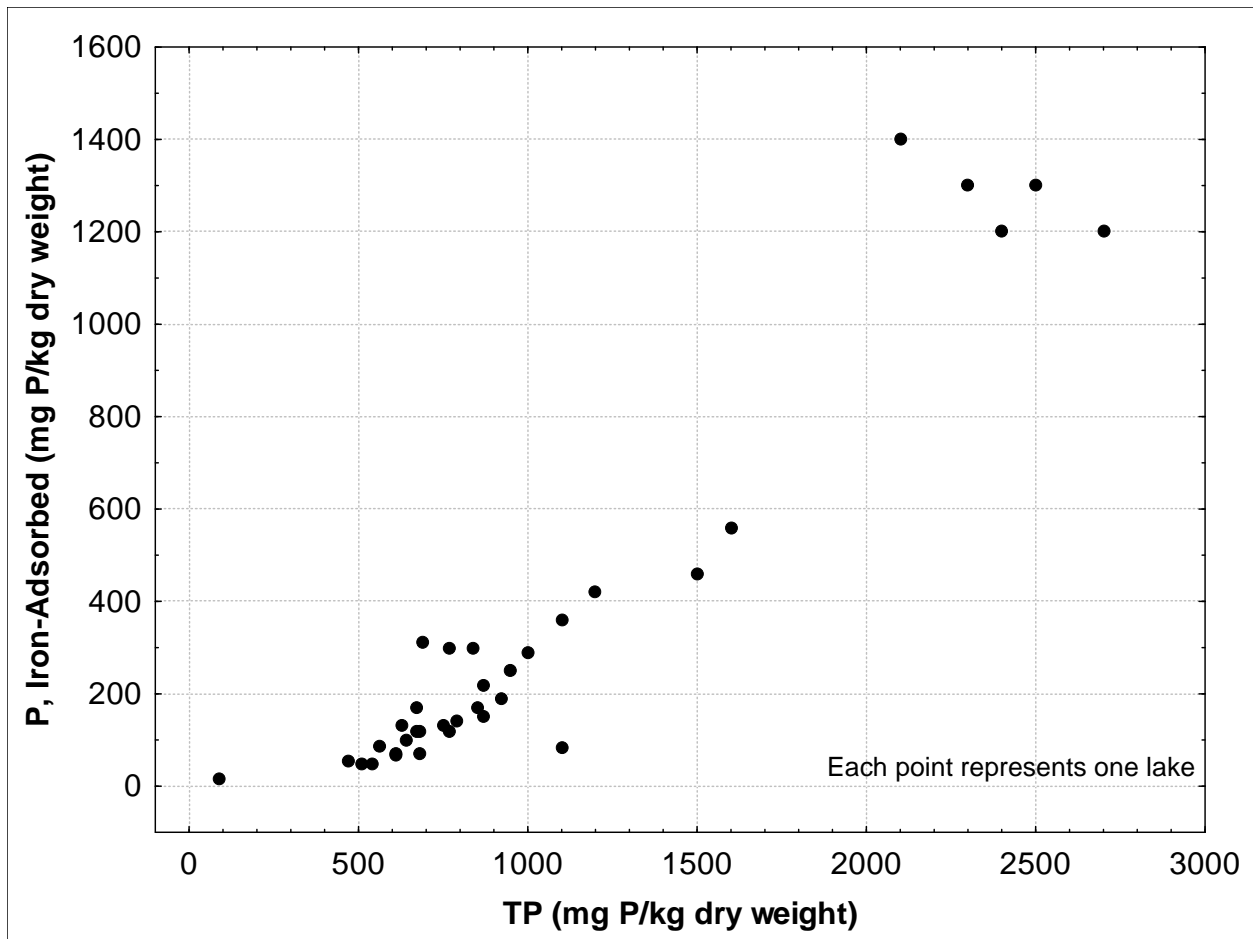


Figure 3. TP and Iron-Adsorbed Phosphorus Relationship.

Table 9. Internal Load Calculations

Lake Name	Release Rate Calculations		Anoxic Factor Calculations				AF x RR (mg/m ² -yr)	Internal load (lbs/yr)
	Iron-Adsorbed Phosphorus (mg/kg)	P Release Rate, RR (mg/m ² -day)	Lake Area (ac)	Mean depth (m)	TP mean, GS (µg/L)	AF (days/summer)		
Hart	120	1.07	8.1	0.61	168	77.9	83	6.
Island N	120	1.07	18.6	0.86	100	66.4	71	12
Island S	120	1.07	43.6	1.43	84	62.9	67	26
Johanna	250	2.85	213.5	4.92	33	44.0	125	239
Jones ¹	420	5.18	37.5	0.24	207	80.3	416	139
Josephine	560	7.10	116.4	3.22	36	45.3	322	334
Karth	130	1.20	20.5	1.50	54	54.6	66	12
Langton N	86	0.60	13.3	1.20	66	58.9	35	4
Langton S	17	-0.35	10.3	1.20	55	55.5	-19	-2 ²
Little Johanna	1,200	15.88	17.3	3.04	80	68.0	1,080	166
Little Josephine ¹	1,400	18.63	44.2	0.68	84	61.4	1,144	452
Locke ¹	300	3.54	22.4	1.20	117	70.5	249	50
Long N	1,300	17.26	73.1	1.65	145	74.4	1,284	838
Long S	1,300	17.26	118.9	3.44	54	54.4	938	995
Marsden ¹	310	3.67	271.5	0.50	61	53.6	197	477
Martha ¹	72	0.41	34.0	0.50	59	53.5	22	7
Moore E	220	2.44	29.5	1.66	44	49.9	122	32
Moore W	61	0.26	70.3	0.61	58	53.2	14	9
Pike	1,200	15.88	37.2	1.87	88	65.0	1,032	342
Poplar ¹	130	1.20	12.6	0.50	101	65.9	79	9
Round ¹	170	1.75	130.5	0.79	55	51.8	91	106
Rush ¹	460	5.73	54.7	0.50	85	61.3	351	172
Spring	55	0.17	46.4	1.50	29	39.4	7	3
Sunfish ¹	130	1.20	14.3	0.50	95	64.5	78	10
Turtle	85	0.59	447.7	3.21	21	31.9	19	75
Valentine	360	4.36	63.9	1.05	70	57.8	252	144
Walsh ¹	295	3.47	8.5	1.00	102	68.5	238	18
Zimmerman ¹	190	2.03	13.2	1.00	143	75.1	152	18

¹In-lake phosphorus data not available and TP based on lake modeling; therefore internal loads should be considered preliminary.

²Low iron-adsorbed P lead to negative internal loading rate, assumed to be zero

B. LAKE RESPONSE MODELING

Purpose of modeling

Lake response models were developed for each lake in order to integrate the watershed loading with the internal loading into a predictive model. For those lakes that do not have in-lake monitoring data, the model was used to estimate the in-lake phosphorus concentrations. The model can also be used to predict the effect of phosphorus loading changes on the lakes' water quality.

Modeling approach

In-lake water quality models were developed using Bathtub (Version 6.1), an empirical model of reservoir eutrophication developed by the U.S. Army Corps of Engineers. The following steps were taken to calibrate the models. Table 10 indicates the lakes that followed the different types of calibration approaches described under step 4 below.

- 1) Summarize available monitoring data: The 1998-2007 averages of total phosphorus (TP), chlorophyll-*a*, and Secchi depth were used for model calibration.
- 2) Input watershed load: For those lakes that do not have another modeled lake in their watershed, the watershed load was determined from the P8 watershed model. For those lakes *with* another modeled lake in the watershed, the load from the direct drainage area was determined from the P8 watershed model. The load from the upstream lake and its watershed was determined by multiplying the volume of runoff draining to the lake (from the P8 model) by the observed in-lake phosphorus concentration. If there were no in-lake monitoring data, the volume was multiplied by the in-lake phosphorus concentration predicted by the Bathtub model of the upstream lake.
- 3) Select phosphorus sedimentation model: The phosphorus model that best predicted the in-lake TP concentration was selected. The models most frequently used were the following: Second Order, Available P; Second Order, Fixed; and Canfield & Bachmann, General.
- 4) Calibrate phosphorus model:
 - If the T-statistic (absolute value) was < 2.0, no changes were made to the phosphorus calibration coefficient (Approach A in Table 10). In some cases the predicted TP was quite different from the observed TP; this is acceptable for model calibration due the amount of variability in the monitoring data and the level of error in the models. However, if the observed TP was above the lake TP standard and therefore it was necessary to calculate the phosphorus load reductions needed to meet the standard, a closer match of observed and predicted values was needed:
 - If the predicted TP concentration was greater than the observed concentration, the inflow TP concentration (estimated in P8) was lowered (Approach B in Table 10).
 - If the observed TP concentration was greater than the predicted concentration, an additional internal load was added to the model (Approach C in Table 10).

- If the T-statistic (absolute value) was > 2.0, the phosphorus calibration coefficient was adjusted so that T < 2.0 (Approach D in Table 10). In one case it was still necessary to lower the inflow TP concentration in order to obtain a closer match of observed and predicted values to estimate the load reductions needed to attain the standard (Approach E in Table 10).
- If there were no in-lake monitoring data for model calibration, the phosphorus model most common in the lake set (Second Order, Fixed) was used and further adjustments were not made (Approach F in Table 10).

Table 10. Model Calibration Approaches

Approach*	Lakes
A	Island S, Johanna, Josephine, Karth, Long N, Moore W, Turtle
B	Langton, Little Johanna, Long S, Pike, Valentine
C	Island N
D	Spring
E	Moore E
F	Hart, Jones, Little Josephine, Locke, Martha, Marsden, Poplar, Round, Rush, Sunfish, Walsh, Zimmerman

*Approaches outlined in above modeling discussion

- 5) Incorporate internal loading: An average rate of internal loading is implicit in Bathtub since the model is based on empirical data. In the majority of the lake models, adjustments to internal loading were not necessary for model calibration. The internal loading estimate calculated from the lake sediment data was therefore not directly entered into the model, but was used to represent internal loading in the overall lake nutrient balance. In the case of Island N, an additional rate of internal loading was needed (Approach C above); this internal load was assumed to be in addition to the internal load calculated from the sediment data.
- 6) Calibrate chlorophyll and Secchi depth models: The chlorophyll and Secchi depth models that best predicted the observed concentrations were selected for each model. If there were no in-lake monitoring data for model calibration, the models most common in the lake set (chlorophyll: P, Linear; Secchi: vs. chl-a & turbidity) were used and further adjustments were not made.
- 7) Estimate watershed load reductions for lakes not currently meeting standards: After the model was calibrated to all parameters (TP, chlorophyll-*a*, and Secchi depth), the TP standard was then used as an endpoint, and the TP loads were adjusted until the model predicted that the in-lake TP standard would be reached. The model output also includes predictions of chlorophyll-*a* concentration and Secchi depth at the TP standard, in addition to predicted algal bloom frequencies, which are based on chlorophyll-*a* concentration.
- 8) Estimate internal load reductions for lakes not currently meeting standards: Since the internal loads were not directly incorporated into the lake response models, the internal load reductions weren't based on the lake response model but rather were based on a target phosphorus release rate, set to 7 mg/m²-day for each lake. This rate is derived from the range of release rates in lakes of varying trophic state reported in Nürnberg (1988). The median release rate for mesotrophic lakes was approximately 5 mg/m²-day, and the median release rate for eutrophic lakes was approximately 10 mg/m²-day (Nürnberg 1988). The release rate goal of 7 mg/m²-day was selected to be fall in

between the two medians. If the calculated release rate was less than 7 mg/m²-day, then there were no recommended internal load reductions. If the rate was greater than 7 mg/m²-day, the internal loading goal was estimated based on the difference between the calculated rate and 7 mg/m²-day.

Results

Table 11. Lake Water Quality Data and Standard Summary

TP = total phosphorus, chl-a = chlorophyll-a (a measure of algae), Secchi = clarity or transparency

Lake	Water Quality Data Means, 1998-2007			Water Quality Standards			Meeting Standards		
	TP (µg/L)	Chl-a (µg/L)	Secchi (m)	TP (µg/L)	Chl-a (µg/L)	Secchi (m)	TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Hart*	168	75	0.4	*	*	*	N	N	N
Island N	102	25	1.3	< 60	< 20	> 1.0	N	N	N
Island S	86	34	1.1	< 60	< 20	> 1.0	N	N	Y
Johanna	31	12	2.0	< 40	< 14	> 1.4	Y	Y	Y
Jones	ND	ND	ND	< 60	< 20	> 1.0	ND	ND	ND
Josephine	36	11	2.0	< 40	< 14	> 1.4	Y	Y	Y
Karth	54	18	1.0	< 60	< 20	> 1.0	Y	Y	Y
Langton N	60	17	1.1	< 60	< 20	> 1.0	Y	Y	Y
Langton S	60	14	1.2	< 60	< 20	> 1.0	Y	Y	Y
Little Johanna	80	25	1.5	< 40	< 14	> 1.4	N	N	Y
Little Josephine	ND	ND	ND	< 60	< 20	> 1.0	ND	ND	ND
Locke*	ND	ND	ND	*	*	*	ND	ND	ND
Long N	145	57	0.6	< 40	< 14	> 1.4	N	N	N
Long S	54	25	1.4	< 40	< 14	> 1.4	N	N	Y
Marsden	ND	ND	ND	< 60	< 20	> 1.0	ND	ND	ND
Martha	ND	ND	ND	< 60	< 20	> 1.0	ND	ND	ND
Moore E	44	18	1.7	< 40	< 14	> 1.4	N	N	Y
Moore W	58	11	1.3	< 60	< 20	> 1.0	Y	Y	Y
Pike	91	53	0.8	< 60	< 20	> 1.0	N	N	N
Poplar	ND	ND	ND	< 60	< 20	> 1.0	ND	ND	ND
Round	ND	ND	ND	< 60	< 20	> 1.0	ND	ND	ND
Rush	ND	ND	ND	< 60	< 20	> 1.0	ND	ND	ND
Spring	29	2.9	2.4	< 60	< 20	> 1.0	Y	Y	Y
Sunfish	37	ND	ND	< 60	< 20	> 1.0	Y	ND	ND
Turtle	20	4.9	2.4	< 40	< 14	> 1.4	Y	Y	Y
Valentine	70	18	1.7	< 60	< 20	> 1.0	N	Y	Y
Walsh*	ND	ND	ND	*	*	*	ND	ND	ND
Zimmerman*	ND	ND	ND	*	*	*	ND	ND	ND

*No bathymetric data available. Since water quality standards are based on depths, the standards are undefined at this time.

ND = No data available

Table 12. Existing Load and Load Goal Summary

Lake	Watershed TP load (lbs/yr)	Internal load (lbs/yr)	Total load (lbs/yr)	% Watershed Load	% Internal Load	Watershed Load Goal (lbs/yr)	Internal Load Goal (lbs/yr)	Watershed Load Percent Reduction	Internal Load Percent Reduction	Total Load Percent Reduction
Hart	13	6	19	68%	32%	2	6	88%	0%	60%
Island S	47	26	73	64%	36%	47	26	0%	0%	0%
Island N	23	96	120	20%	80%	23	18	0%	82%	66%
Island	70	122	193	36%	64%	70	44	0%	64%	41%
Johanna	670	239	908	74%	26%	lake meeting WQ standards				
Jones*	1,647	139	1,786	92%	8%	396	139	76%	0%	70%
Josephine	178	334	513	35%	65%	lake meeting WQ standards				
Karth	66	12	79	85%	15%	lake meeting WQ standards				
Langton N	21	4	25	84%	16%	lake meeting WQ standards				
Langton S	46	0	46	100%	0%	lake meeting WQ standards				
Langton	68	4	72	94%	6%	lake meeting WQ standards				
Little Johanna	625	166	791	79%	21%	226	73	64%	56%	62%
Little Josephine*	228	452	679	34%	66%	122	170	46%	62%	57%
Locke*	17,364	50	17,414	100%	0%	9,053	50	48%	0%	48%
Long N	19,129	836	19,966	96%	4%	6,832	340	64%	59%	64%
Long S	476	996	1,472	32%	68%	476	404	0%	59%	40%
Long	19,606	1,832	21,438	91%	9%	7,308	743	63%	59%	62%
Marsden*	509	477	986	52%	48%					
Martha*	53	7	59	89%	11%					
Moore E	173	32	205	84%	16%	121	32	30%	0%	25%
Moore W	39	9	47	82%	18%	lake meeting WQ standards				
Moore	212	41	252	84%	16%	160	41	24%	0%	21%
Pike	1,605	342	1,947	82%	18%	951	151	41%	56%	43%
Poplar*	75	10	85	88%	12%	30	10	61%	0%	53%
Round*	268	106	374	72%	28%					
Rush*	210	172	381	55%	45%	108	172	48%	0%	27%
Spring	171	3	174	98%	2%	lake meeting WQ standards				
Sunfish*	69	10	79	88%	12%	lake meeting WQ standards				
Turtle	84	75	159	53%	47%	lake meeting WQ standards				
Valentine	575	144	719	80%	20%	429	144	25%	0%	20%
Walsh*	108	18	126	86%	14%	44	18	59%	0%	51%
Zimmerman*	394	18	412	96%	4%	105	18	73%	0%	70%

*Limited or no monitoring data available, loads are based on modeling only and should be considered preliminary.

Watershed loading values are summarized from Bathtub modeling output. Values may be slightly different from P8 output due to rounding in several unit conversion steps.

4. Lake Management Action Plans

A. PURPOSE

Lake Management Action Plans (MAPs) summarize lake characteristics and existing lake data, provide a diagnostic assessment of the data, summarize public input, identify water quality issues, and recommend remedial strategies on a lake-watershed basis. As such, each MAP provides a concise summary of the known issues and recommended management approaches for each lake. It is envisioned that the MAPs will be used to further define management strategies, guide development of the District's Third Generation Plan, and serve as the basis for seeking project partners and grant funding for retrofit water quality improvements.

B. PUBLIC MEETINGS

Two public input meetings for each lake were conducted during the development of the MAPs. The first series of meetings, held in the summer of 2008, solicited input from citizens and LGU staff and officials regarding water quality concerns to further define impairments. At the second series of public meetings, held in January 2009, draft MAPs were reviewed, impairments described, and in-lake and watershed management strategies were summarized. Input received during the meetings as well as comments from LGU in response to draft MAPs were incorporated into the final MAPs.

C. MAPs

The appendix of the report presents the finalized MAPs. For each MAP one will find:

- An overview of the lake and watershed characteristics
- A summary of existing water quality data and comparison to applicable water quality standards
- A summary of public input received
- Identification of water quality issues
- Recommended management approaches for both watershed and in-lake activities
- A listing of additional data to be collected to tailor the management recommendations

Because all 24 lakes are within fully or nearly fully developed watersheds, management of land in the watershed is a critical element in addressing the identified impairments. Therefore, the identification of opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs is a significant element of each MAP. To that end, a preliminary field reconnaissance for each watershed was conducted to identify likely regional, local, and site-specific retrofit opportunities. It should be noted that the assigned BMP classifications (regional, local or site-specific) are qualitative in nature, intended to give perspective to the relative scale of the feature and potential treatment area. Potential BMP locations identified during this field investigation are identified on Figure 1 of each MAP and detailed in the field reconnaissance supplement at the end of each MAP.

5. Long-Term Management Strategy

A. PRIORITIES

Over 200 potential retrofit BMPs are identified in the Field Reconnaissance Supplements appended to the Management Action Plans. The preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities that could be implemented to reduce watershed pollutant loading to downstream receiving waters. Again, it should be noted that the assigned BMP classifications (regional, local or site-specific) are qualitative in nature, intended to give perspective to the relative scale of the feature and potential treatment area.

In order to prioritize the projects, a simplified cost/benefit assessment was performed. The following criteria were used to prioritize the projects:

- Landownership – the ease of acquiring the needed permissions to utilize the land required to implement the proposed BMP.
- Studies/Planning – the amount of effort needed to assess the feasibility of a project and generate the requirements needed to implement.
- Construction Cost – the cost to construct the potential BMP.
- Pollutant Removal Potential – the amount of pollutants the proposed BMP would have the potential to remove.
- Pollutant Removal Potential relative to the Lake – the potential pollutant removal relative to the total subwatershed loading to the lake.

Qualitative rankings were based on the field investigations and institutional knowledge of the system. Projects within upstream lake subwatersheds were also considered as potential implementation projects for downstream lakes. The diminishing return of a potential project further upstream in the system was qualitatively taken into account when looking at upstream projects relative to a particular lake.

The intent of this exercise is to give the District a prioritized list of projects for further investigation. The prioritization exercise is NOT intended to make a final determination on the merits of a particular project. For most projects further feasibility assessments would be needed before the District proceeds with a particular project. Using the raw rankings as general guidance, projects were prioritized in three tiers by lake as described below:

Tier 1

Tier 1 projects consist of those projects that appear to have a very good cost benefit ratio based on the criteria described above. The projects included in Tier 1 for a particular lake are recommended as high priority for potential projects that could benefit that water body.

Tier 2

Tier 2 projects are projects that appear to have good cost benefit ratios; however, they either were projects that fell below other higher priority projects or are projects that are more suited to be implemented during road reconstruction or redevelopment projects.

Tier 3

Tier 3 projects are projects that appeared to have lower cost benefit ratios than Tier 1 or Tier 2 projects and would not be recommended as current priorities. However, these projects would still warrant investigation particularly during permit review related to redevelopment or road reconstruction projects. Also, should Tier 1 and Tier 2 projects be implemented or determined to be unfeasible, Tier 3 projects could then be assessed (as needed) to meet the water quality goals of a particular lake. Projects within upstream watersheds of other lakes were not considered as candidates for Tier 3 projects.

B. RECOMMENDED ACTIONS FOR 2009

1. For 2009 it is recommended that the District initiate feasibility studies on three of the projects included in Tier 1. These Tier 1 projects have the highest likely benefit, for a low level of additional feasibility.
 - Little Johanna 2
 - Moore 7 combined with Moore 10 & 11
 - Pike 2
2. Contact the Parks Departments and solicit interest in partnerships for the following Tier 1 projects:
 - Island 1 & 5
 - Langton 1
 - Long 17
 - Spring 2
 - Turtle 4
3. Solicit private party interest in cost shares through the Urban Stormwater Remediation Program for the following site-specific BMPs that were prioritized as Tier 1 projects.
 - Jones 22
 - Karth 5 & 7
 - Josephine 3
 - Little Josephine 9
 - Langton 3 & 6
 - Locke 19 & 24
 - Long 14
 - Marsden 2 & 3
 - Moore 12
 - Pike 11
 - Poplar 4
 - Valentine 11
 - Walsh 7
 - Zimmerman 5 & 8

4. Landowners should be notified of needed maintenance/attention at the following facilities.

- Karth 6
- Little Johanna 17
- Turtle 3

The following tables include all of the projects broken down by tiers for each lake. These tables can be used as a guide for future planning and implementation of CIP projects. Estimated cost ranges for Tier 1 projects were included to give a general feel for the magnitude of the projects. Further feasibility assessment and cost estimates will be needed as the District moves towards implementation of a particular project.

Lake	Tier	Project ID	Range of Probable Cost (\$)	Description / Notes
Hart	No Projects Identified			
Island	Tier 1	Island 1	5-15k	(Bio)filtration basin or swale between bituminous trail and lake
		Island 2	5-30k	Multiple (in)filtration raingardens or larger retention basin
		Island 5	2-20k	Repair existing basin skimmer and excavate 2 nd cell downstream of trail
	Tier 2	Island 3, 4, 6 & 7		
	Tier 3	No Tier 3 Projects Identified		
Jones	Tier 1	Jones 12	25-100k	Retrofit existing dry pond to provide (in)filtration or water quality storage
		Jones 21	25-50k	Retrofit (in)filtration or wetland treatment system at existing wooded depression
		Jones 22	2-5k	Retrofit (in)filtration raingarden into existing turf-grass swale
	Tier 2	Jones 7, 9, 10, 11, 14, 15, 16, 17 & 18, Poplar 1		
	Tier 3	Jones 1, 2, 3, 4, 5, 6, 8, 13, 19, 20, 23 & 24		
Johanna	Tier 1	Johanna 2	50-200k	Excavation of accumulated sediment and cattails from existing wetland basin
		Little Johanna 1	30-60k	Retrofit existing dry basin to provide (in)filtration storage, native vegetation
		Little Johanna 2	10-200k	Weir repair or major basin enhancement, excavate & reduce short-circuiting
	Tier 2	Johanna 1, 4, 5, & 7, Little Johanna 3, 6, 8, & 9, Little Josephine 1		
	Tier 3	Johanna 3 & 6		

Lake	Tier	Project ID	Range of Probable Cost (\$)	Description / Notes
Little Johanna	Tier 1	Little Johanna 1	30-60k	Retrofit existing dry basin to provide (in)filtration storage, native vegetation
		Little Johanna 2	10-200k	Weir repair or major basin enhancement, excavate & reduce short-circuiting
	Tier 2	Little Johanna 3, 4, 6, 8, 9, 12, 13, 14, 18 & 19, Zimmerman 5		
	Tier 3	Little Johanna 5, 7, 10, 11, 15, 16, & 17		
Josephine	Tier 1	Josephine 2	15-40k	(In)filtration swale or outfall basin along lot-lines
		Josephine 3	10-40k	Retrofit existing dry basin to provide (in)filtration storage
	Tier 2	Josephine 1 & 4, Little Josephine 1, 3 & 6		
	Tier 3	No Tier 3 Projects Identified		
Little Josephine	Tier 1	Little Josephine 1	50-200k	Sediment forebay, energy dissipation and wetland treatment ponding
		Little Josephine 4	10-25k	Convert swale to filter with native vegetation, consider with LJos 5
		Little Josephine 5	10-25k	Expand existing pond, consider combined project with LJos 4
		Little Josephine 6	20-50k	Excavate sediment forebay and wetland treatment ponding
		Little Josephine 9	2-10k	Retrofit (in)filtration raingarden into existing turf-grass swale
	Tier 2	Little Josephine 3, 7 & 12		
	Tier 3	Little Josephine 2, 8, 10 & 11		
Karth	Tier 1	Karth 1	35-50k	Ponding, (in)filtration or wetland treatment at existing depression
		Karth 5	25-150k	Island (in)filtration features or porous pavement / underground filtration
		Karth 6	<1k	Vegetative amendments
		Karth 7	1-2k	Outfall/channel stabilization
	Tier 2	Karth 2, 3 & 4		
	Tier 3	No Tier 3 Projects Identified		

Lake	Tier	Project ID	Range of Probable Cost (\$)	Description / Notes
Langton	Tier 1	Langton 1	15-30k	Relocate playground, incorporate filtration or water quality ponding
		Langton 3	15-40k	Remove tree, incorporate filtration or water quality ponding
		Langton 4	15-30k	Smaller alternate to Langton 3
		Langton 6	25-40k	Pavement reduction, linear filtration
	Tier 2	Langton 5		
	Tier 3	Langton 2		
Locke	Tier 1	Locke 2	20-75k	1 or 2 cell wetland treatment ponding
		Locke 14	15-50k	Reroute stormsewer outfall east, under trail, to floodplain terrace for filtration
		Locke 19	2-5k	Linear filtration along existing lot-line swale
		Locke 24	5-20k	Retrofit existing dry pond, provide (in)filtration storage, native vegetation
	Tier 2	Locke 1, 13, 16, 17, 18, 23, 25, & 27, Long 1, Pike 1		
	Tier 3	Locke 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 20, 21, 22 & 26		
Long	Tier 1	Long 1	100-500k	Reconstruct weir, consider additional upstream impoundments & excavation
		Long 14	5-25k	Excavate shallow storage areas adjacent to existing onsite catchbasins
		Long 17	10-30k	Expand and enhance existing rock storage/filter feature
		Pike 1	50-300k	Hanson Pond - Excavate sediment, expand, vegetation and carp mgmt.
		Pike 2	50-250k	Mirror Pond - sediment sealing and/or chemical treatment (add annual costs)
	Tier 2	Long 3, 4, 5 & 10, Little Johanna 2, Pike 9 & 27		
	Tier 3	Long 2, 6, 7, 8, 9, 11, 12, 13, 15 & 16		

Lake	Tier	Project ID	Range of Probable Cost (\$)	Description / Notes
Marsden	Tier 1	Marsden 2	5-15k	(In)filtration raingarden for local drainage
		Marsden 3	5-15k	Retrofit dry basin to incorporate (in)filtration
	Tier 2	Marsden 4, Martha 1, 2 & 3		
	Tier 3	Marsden 1		
Martha	Tier 1	Martha 1	5-20k	Vegetative filter and/or shallow (in)filtration raingarden
	Tier 2	Martha 2 & 3		
	Tier 3	No Tier 3 Projects Identified		
Moore	Tier 1	Moore 7	10-40k	Enhance/expand existing swale, sediment forebay with downstream filtration
		Moore 10	5-10k	Convert turf to filtration raingardens
		Moore 11	10-20k	Remove bituminous flume, create linear filtration swale
		Moore 12	1-3k	Expanded storage and native vegetation amendments
	Tier 2	Moore 1, 2, 4, 5, 8 & 9		
	Tier 3	Moore 3 & 6		
Pike	Tier 1	Pike 1	50-300k	Excavate accumulated sediment, expand, vegetation and carp management
		Pike 2	50-250k	Sediment sealing and/or chemical treatment (additional annual costs)
		Pike 9	5-15k	Divert west stormsewer & 7 th St runoff to filtration or water quality basin
		Pike 11	5-20k	Retrofit (in)filtration storage into dry basin
		Pike 13	20-50k	Expand or create upstream (in)filtration cell at existing basin/wetland
		Pike 27	10-25k	Ramsey County Ditch 3 outfall energy dissipation and bank stabilization
		Jones 12	25-100k	Retrofit existing dry pond to provide (in)filtration or water quality storage
	Tier 2	Pike 6, 10, 12, 14, 16, 19, 20, 21, 23, 25 & 26		
	Tier 3	Pike 3, 4, 5, 7, 8, 15, 17, 18, 22 & 24		

Lake	Tier	Project ID	Range of Probable Cost (\$)	Description / Notes
Poplar	Tier 1	Poplar 1	20-100k	Need to first determine if and when the pond discharges to Poplar Lake
		Poplar 4	5-20k	Depressional storage and vegetation amendments
	Tier 2	Poplar 2 & 3		
	Tier 3	No Tier 3 Projects Identified		
Round	Tier 1	No Tier 1 Projects Identified		
	Tier 2	Round 1, 2 & 3		
	Tier 3	No Tier 3 Projects Identified		
Rush	Tier 1	Rush 2	5-20k	Wetland treatment or filtration at stormsewer outfall, assess with 3 & 4
		Rush 3	5-20k	Wetland treatment or filtration at stormsewer outfall, assess with 2 & 4
		Rush 4	5-20k	Wetland treatment or filtration at stormsewer outfall, assess with 2 & 3
	Tier 2	Rush 1		
	Tier 3	No Tier 3 Projects Identified		
Spring	Tier 1	Spring 2	5-15k	Demonstration/Education raingarden at parking lot outfall
	Tier 2	Spring 1, 3, 4, 5 & 6		
	Tier 3	No Tier 3 Projects Identified		
Sunfish	No Projects Identified			

Lake	Tier	Project ID	Range of Probable Cost (\$)	Description / Notes
Turtle	Tier 1	Turtle 3	<1k	May need minor site modifications to ensure water is routed to existing BMP
		Turtle 4	5-20k	Increase treatment capacity & creatively tuck second cell to south
	Tier 2	Turtle 1 & 2		
	Tier 3	No Tier 3 Projects Identified		
Valentine	Tier 1	Valentine 2	10-20k	Small wetland treatment system or filtration basin
		Valentine 3	5-20k	(In)filtration storage & vegetation enhancement of swale upstream of culvert
		Valentine 4	20-60k	Expand & enhance swale to create shallow filtration basin, relocate parking
		Valentine 11	5-20k	Retrofit additional storage, native vegetation amendments to reduce geese
	Tier 2	Valentine 1, 6, 8, 9, 10, 13 & 14		
	Tier 3	Valentine 5, 7 & 12		
Walsh	Tier 1	Walsh 6	5-15k	Sediment excavation, pond expansion, native vegetation amendments and skimmer
		Walsh 7	3-6k	Native vegetation buffer
	Tier 2	Walsh 1, 2, 3, 4, 5 & 8		
	Tier 3	No Tier 3 Projects Identified		
Zimmerman	Tier 1	Zimmerman 5	5-10k	Retrofit dry basin, incorporate (in)filtration storage, native vegetation amendments
		Zimmerman 8	2-5k	Retrofit dry swale, incorporate (in)filtration storage, native vegetation amendments
	Tier 2	Zimmerman 1, 3, 4 & 6		
	Tier 3	Zimmerman 2 & 7		

6. References

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Appendix – Management Actions Plans

Hart Lake Management Action Plan

Hart Lake (02-0081) is located in the City of Columbia Heights, Hennepin County, Minnesota (Figure 1). The lake has a surface area of 8 acres, a maximum depth of 5 feet¹. Based on its low estimated maximum depth, it is considered a shallow lake according to MPCA's definition. The lake has a very small watershed of only 14 acres and is tributary to Silver Lake. A TMDL study for Silver Lake is currently being completed and will contain allowable phosphorus loading within the entire Silver Lake watershed, which includes Hart Lake. Because the drainage area to Hart Lake is predominantly residential backyards or commercial areas that have recently retrofitted water quality treatment BMPs, it is not anticipated that additional water quality improvements will be made within the Hart Lake watershed as a result of the TMDL.

The surrounding watershed area is a mix commercial and residential land use. The east shore of the lake is a very steep, slightly vegetated slope. Exposed fill rubble has been observed.

The primary use of the lake is for local lakeshore owner enjoyment. The DNR does not stock the lake with fish, and a fisheries survey is not available.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos. No bathymetric data were available for this lake. The maximum depth was estimated using depth data collected during sediment sampling.

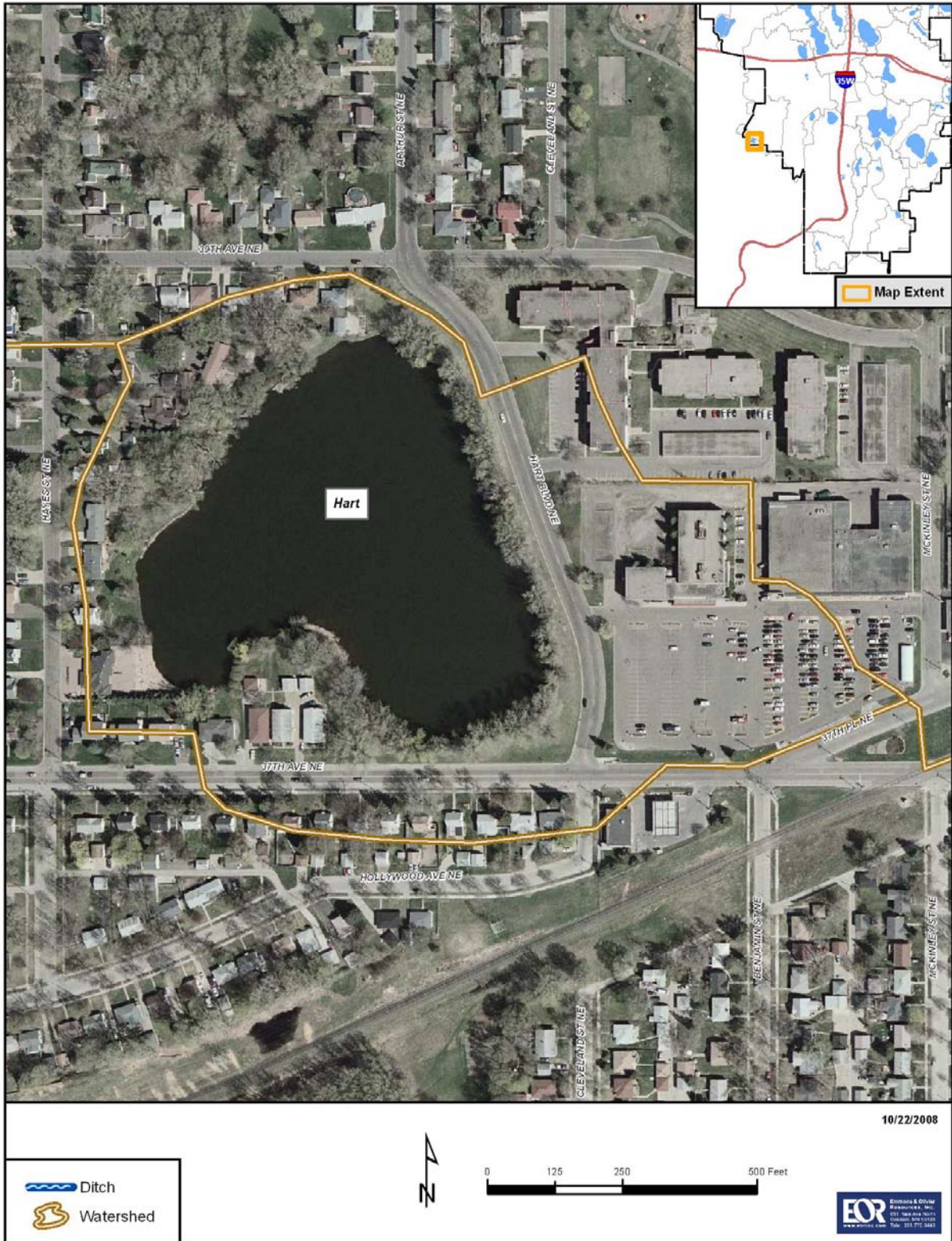


Figure 1. Hart Lake

Water Quality Summary

Water quality data for Hart Lake were collected through the Metropolitan Council's Citizen Assisted Monitoring Program (CAMP) from 2004-2006. A summary of the three years of monitoring data suggest that the lake is not currently meeting lake water quality standards (Table 1).

Table 1. Average Water Quality Data (2004-2006) and Standards

Parameter	Hart Lake	Shallow Lakes Standard
TP ($\mu\text{g/L}$)	168	60
Chl ($\mu\text{g/L}$)	75	20
Secchi Depth (m)	0.4	1.0

Figures 2 through 4 show the growing season total phosphorous (TP), chlorophyll-*a* and Secchi depth (clarity) data from Hart Lake. The average water quality did not vary much during the three years of data collection. The large error bars are due to small sample size in some years ($n\sim 3$).

During an August 2007 site visit, the lake was chocolate brown from construction runoff from the east side of the lake. Data were not collected during 2007 when the effects of construction were seen.

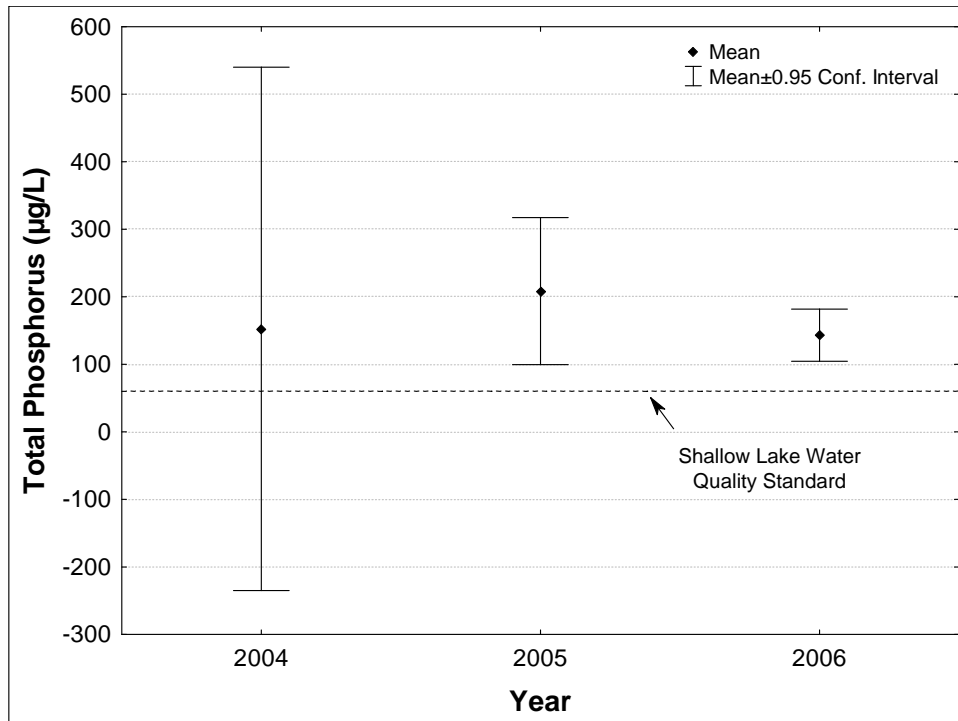


Figure 2. Hart Lake Total Phosphorus

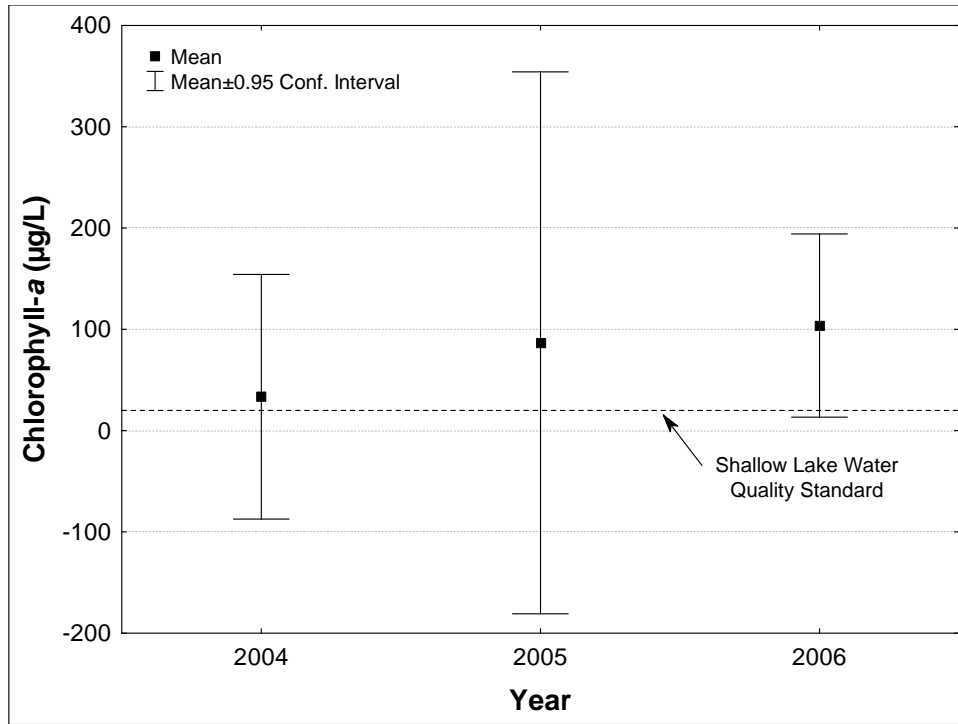


Figure 3. Hart Lake Chlorophyll-a

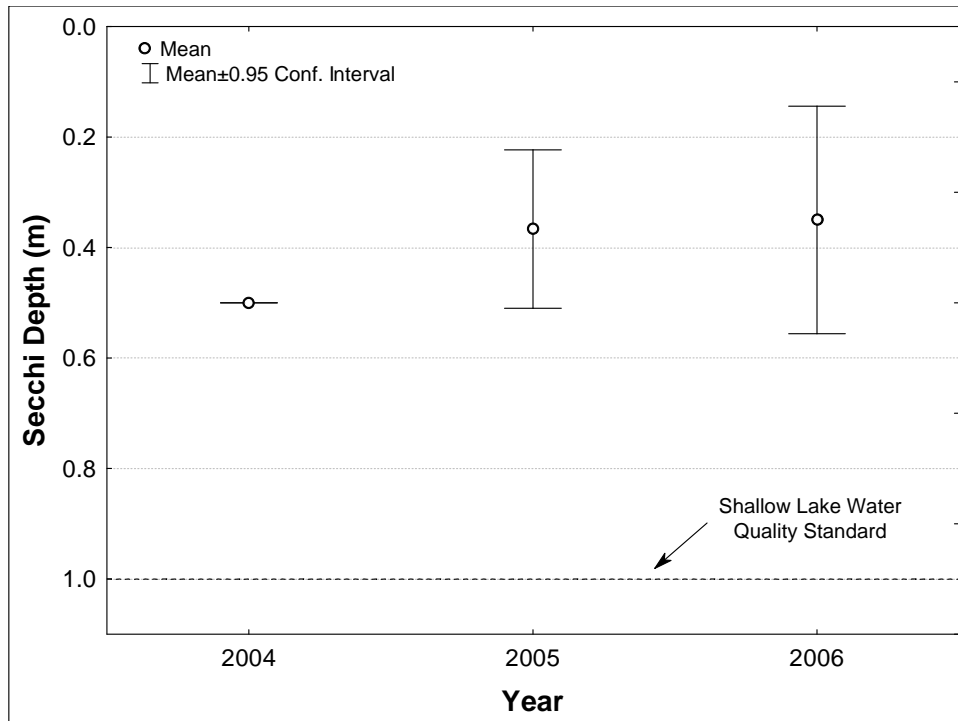


Figure 4. Hart Lake Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality modeling indicates that watershed inputs account for approximately 68% of the nutrient load, with internal loading accounting for the remaining 32% (Figure 5). To reach the in-lake goal of 60 µg/L TP, the phosphorous loading to the lake would need to be reduced by approximately 60%.

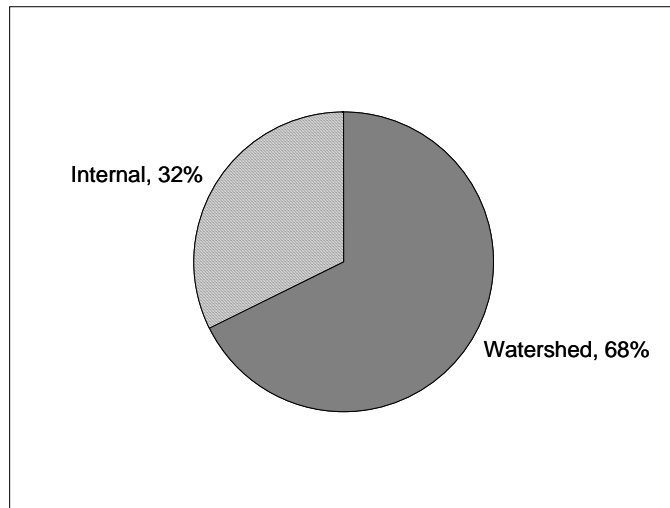


Figure 5. Hart Lake Phosphorus Load Distribution

Public Input

At the public input meeting held on June 2, 2008, no attendees spoke on issues related to Hart Lake.

Water Quality Issues

- Watershed runoff can negatively impact the water quality, as observed in 2007 by local construction east of the lake.
- Judging by the small watershed to lake ratio and the very high in-lake phosphorus concentrations, internal loading is likely a problem in Hart Lake.

Recommended Management Approach

Watershed Management Recommendations

It appears that most of the runoff entering the lake does so untreated, except for the recently redeveloped commercial area east of the lake. This area is now served by a water quality pond near the south east corner of the lake. While no BMP retrofit opportunities were identified during the preliminary field reconnaissance, there are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate and erosion control

- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control. The RCWD is currently working to remedy insufficient stormwater treatment from the construction site to the east.

Internal Lake Management Recommendations

With very little in-lake biological data for Hart Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Hart Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Hart Lake. There are only two years of in-lake data for Hart Lake; if the implementation of management practices for the lake were to move forward, in-lake data and bathymetric data would be needed and should be considered a high priority.

- Bathymetric data collection
- TP, chlorophyll, and Secchi depth data: Collect data for one to two additional years, with at least five sampling dates per year.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation.

Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.

- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Island Lake Management Action Plan

Island Lake (62-0075) is located in the City of Shoreview, Ramsey County, Minnesota (Figure 1). The lake is divided by I-694 into two basins, north and south. The south basin is 43.6 acres (Figure 2), with a maximum depth of 9 feet¹. The north basin is 18.6 acres in size, with a maximum depth of 9 feet. Both basins are 100% littoral and, based on the maximum depth, are both considered shallow lakes according to MPCA's definition. Island Lake is listed as an impaired lake on the EPA's 303(d) list of impaired water bodies. It is impaired for aquatic recreation due to high nutrients.

The watershed draining to the south basin of Island Lake is approximately 92 acres and the watershed draining to the north basin is approximately 183 acres. Both sub-watersheds are quite small compared to the size of the lake. The east side of the south basin is bordered by Island Lake County Park. This park provides swimming, boating, fishing, and passive recreational access to Island Lake. The west side of the south basin and most of the north basin are surrounded by residential area, with some open space and ponds. I-694 cuts between the two basins and spans a small bridge connection between them. The south basin is bordered on the northwest side by Island Lake Golf Center. On the northwest side of the lake, Island Lake discharges out of the north basin to the northwest. It discharges into the Valentine Lake watershed and eventually to Long Lake. Both Valentine and Long are on the EPA's list of impaired water bodies due to high nutrients.

Eurasian watermilfoil was detected in Island Lake beginning in 1991 and was treated with 2, 4-D herbicide in 1994. A Eurasian watermilfoil management plan was completed by Ramsey County in the late 1990s. An August 2004 DNR Lake Survey found that Eurasian watermilfoil and coontail are the most abundant aquatic plants present in Island Lake.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from the Rice Creek Watershed District website.

The lake is stocked by DNR with walleye, yellow perch, channel catfish, tiger muskellunge, and bluegill. A 2004 fisheries survey indicated a high density of bluegill and indicated the presence of carp in the lake. A 1995 DNR Lake Management Plan states that the long range goal for the lake is “to provide a gamefish population of legal size hybrid muskellunge that will support 225 man-hours/acre of fishing.” The report lists a 1974 rotenone fish eradication as a past management as well as the use of Antimycin partial chemical treatments to decrease young-of-the-year bluegills from 1975-1977. In 1989 an aeration system was installed by the county to prevent winter fish kills.



Figure 1. Island Lake and Potential BMP Locations

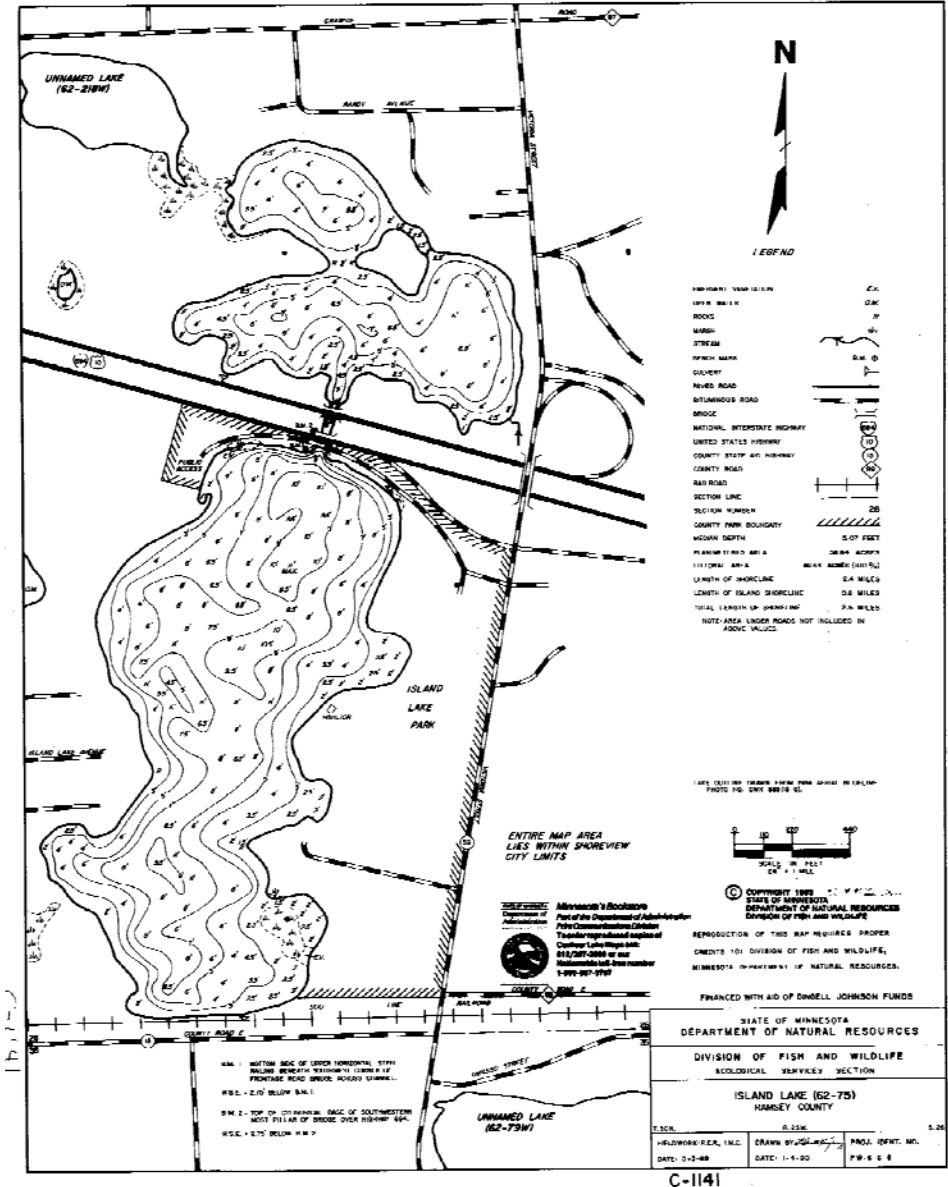


Figure 2. Island Lake Bathymetry

Water Quality Summary

Water quality data for Island Lake were collected from 1985-2007. Data were collected by Ramsey County Public Works and the Minnesota Pollution Control Agency. A summary of the most recent 10 years of monitoring data (Table 1) suggests that the total phosphorous (TP) and chlorophyll-*a* concentrations did not meet the MPCA water quality standards, while the Secchi depth (clarity) narrowly met standards.

Table 1. Average Water Quality Data (1998-2007) and Standards

Parameter	Island Lake North Basin	Island Lake South Basin	Shallow Lakes Standard
TP (µg/L)	102	86	60
Chl (µg/L)	25	34	20
Secchi Depth (m)	1.3	1.1	1.0

Figures 3 through 5 show the growing season total phosphorus (TP), chlorophyll-*a*, and Secchi depth (clarity) data over that period for the north basin of Island Lake. The same series of data is shown in Figures 6 through 8 for the south basin. Overall, the water quality of Island Lake has worsened since the 1990s.

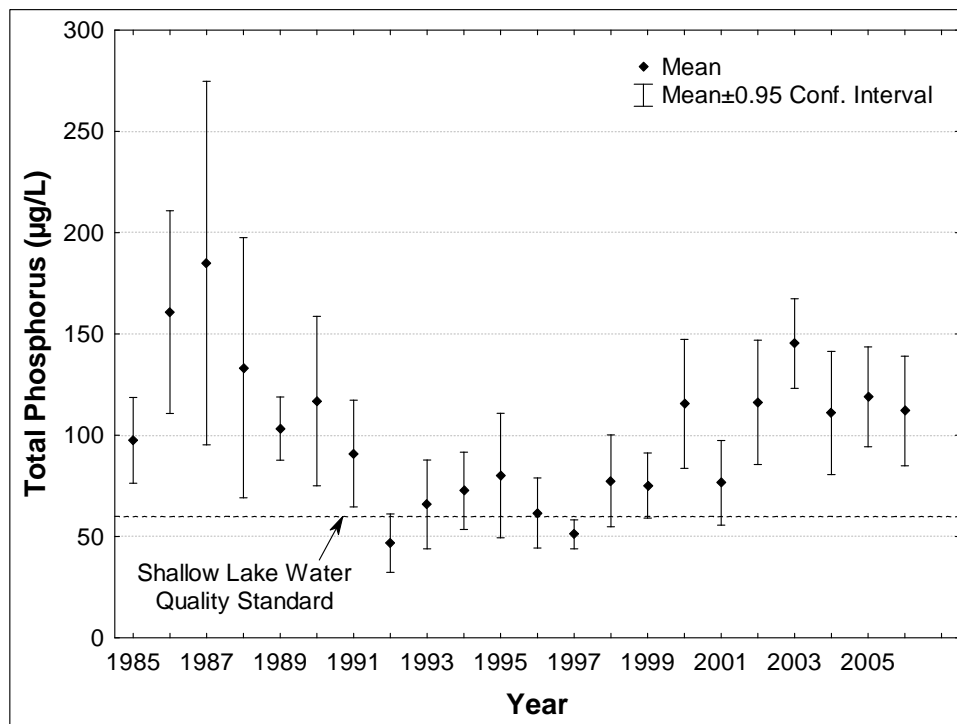


Figure 3. Island Lake North Basin Total Phosphorus

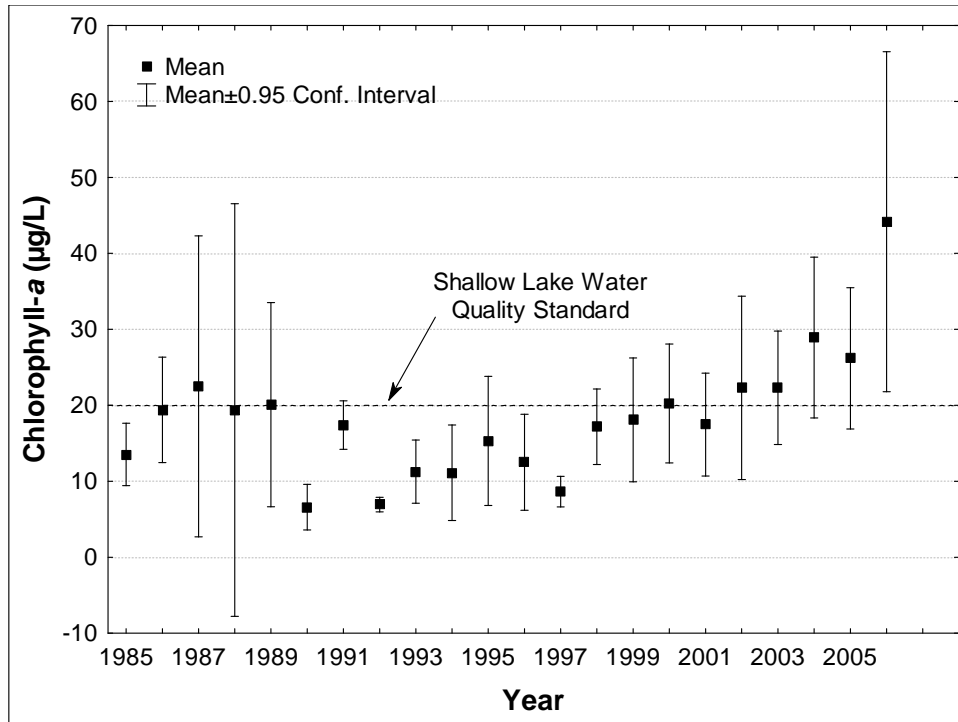


Figure 4. Island Lake North Basin Chlorophyll-a

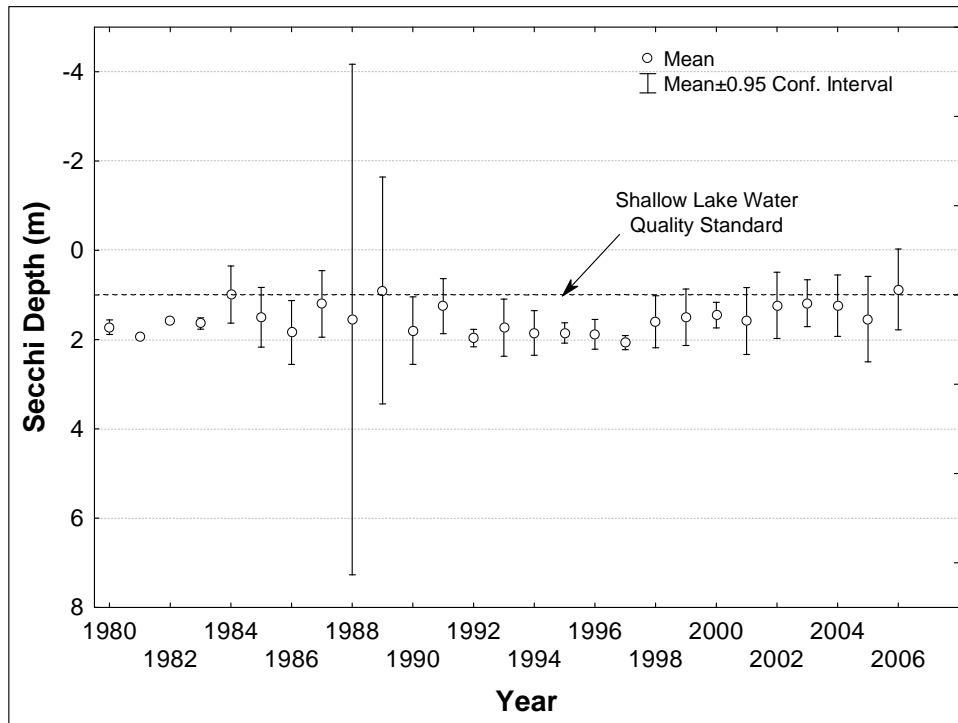


Figure 5. Island Lake North Basin Secchi Depth

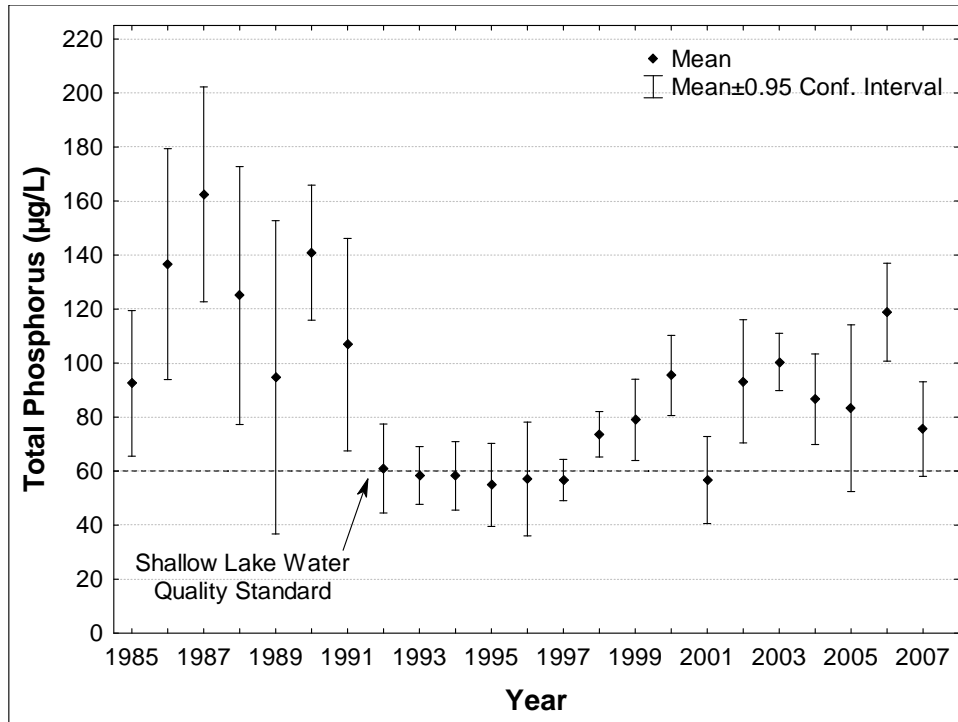


Figure 6. Island Lake South Basin Lake Total Phosphorus

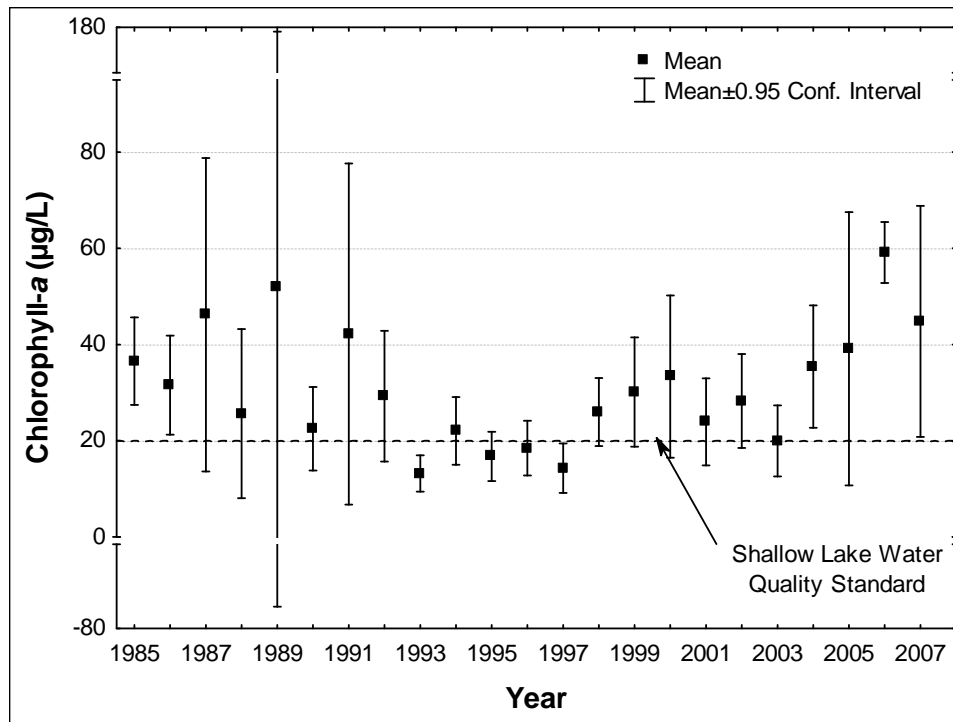


Figure 7. Island Lake South Basin Chlorophyll-a

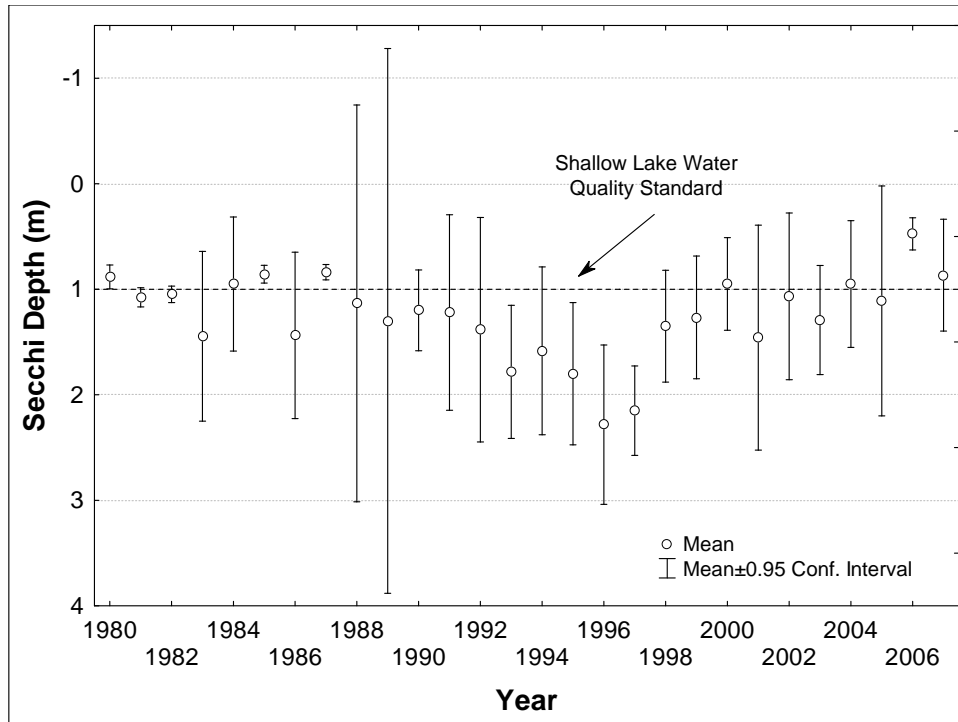


Figure 8. Island Lake South Basin Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality modeling indicates that watershed inputs account for approximately 36% of the nutrient load, with internal loading accounting for 64% (Figure 9). To reach the in-lake goal of 60 µg/L TP, phosphorus loading would need to be reduced by approximately 41%.

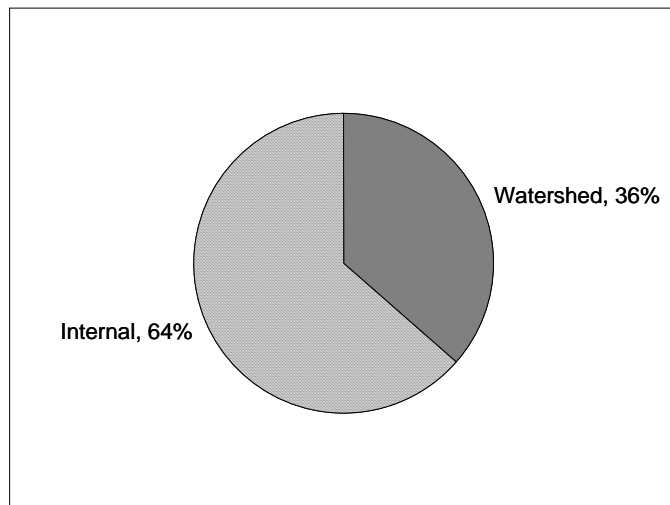


Figure 9. Island Lake Phosphorus Load Distribution

Public Input

At the public input meeting held on June 5, 2008, no attendees spoke on issues related to Island Lake.

Water Quality Issues

- Internal loading is high and likely has a big influence on the lake's water quality conditions.
- Although Island Lake has a relatively small watershed, it appears that the watershed load is still negatively impacting water quality.
- Both basins of the lake are directly adjacent to Interstate-694 and likely receive highway runoff.
- The presence of carp and high densities of bluegill likely contribute to the high rates of internal loading, through the disturbance of bottom sediments and through high grazing pressure on the zooplankton community.
- The prevalence of Eurasian watermilfoil displaces native plants and negatively impacts the habitat quality in the lake.

Recommended Management Approach

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing the nutrient impairment. Because the Island Lake watershed is nearly fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, seven BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of the four potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- Reduce runoff coming directly from the parking lots and impervious areas at the county park.
- Coordinate with Mn/DOT during the MS4 process when highway upgrades and reconstruction occurs to seek out opportunities to decrease runoff from the I-694 bridge.
- Develop BMPs between the road surface of CSAH 52 and the lake to decrease runoff.
- Coordinate with Ramsey County on opportunities to reduce runoff from Ramsey County property surrounding the lake.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

- Develop an aquatic vegetation management plan, focusing on Eurasian watermilfoil.
- The bluegill population size is well above the medial level for this type of lake. Planktivore size structure outlined in the DNR fisheries survey suggests that the population is dominated by small individuals; 97% of bluegills were less than 5 inches. This could indicate planktivore ‘stunting,’ where intraspecific competition limits growth. Dense populations of small planktivores are capable of limiting zooplankton populations, leaving no biological check on algae growth. Work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Island Lake. Since there is a long record of in-lake water quality data for Island Lake, additional data collection is not a high priority at this time.

- TP, chlorophyll, and Secchi depth data: Collect at least five sampling dates per year. The TMDL can be based on the existing monitoring data; additional data should be collected after management actions are implemented to track the response of the lake.
- Macrophyte surveys: Complete macrophyte surveys before and after aquatic vegetation management practices are implemented.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the existing fisheries information regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.
- Work with city to identify all stormwater input locations.

The watershed drainage to Island Lake is all direct drainage; there are no incoming tributaries that could be monitored to better define the watershed phosphorus loads to the lake. Occasional grab samples could be taken from the many stormwater outfalls to the lake to provide information on the TP concentration in the watershed’s runoff.

Island Lake Field Reconnaissance Supplement

Local Management BMPs



Island #1

Location: South end of Milton Street west of Island Lake

Description: Area at stormsewer outlet

Possible Improvements: Squeeze in feature to treat piped outlet at this location



Island #2

Location: South of County Road E and east of Vivian Avenue

Description: Ditch / swale areas at corner

Possible Improvements: Rain gardens for roof outlet (seen in pic) or larger feature at corner also picking up adjacent street and parking (larger feature would need to be quite deep and may not be practical).



Island #3

Location: South side of Randy Avenue north of Island Lake

Description: Small green space areas

Possible Improvements: Incorporate small treatment areas for street runoff going directly to the lake



Island #4

Location: South side of Randy Avenue north of Island Lake

Description: Small green space areas

Possible Improvements: Incorporate small treatment areas for street runoff going directly to the lake

Site Specific Management BMPs



Island #5

Location: In park on east side of Island Lake

Description: Existing water quality pond

Possible Improvements: Excavation of second cell of pond downstream of bituminous trail; fix existing skimmer that has been heaved by ice and has been rendered ineffective.



Island #6

Location: South of County Road E and west of Vivian Avenue

Description: Green space next to parking lot

Possible Improvements: Provide treatment for parking lot in open space



Island #7

Location: In park west side of Island Lake

Description: Parking lot at boat launch draining via curb cut

Possible Improvements: Lower grade downstream of curb cut to improve drainage and consider enhancement of existing treatment area

Lake Johanna Management Action Plan

Lake Johanna (62-0078) is located in the City of Arden Hills, Ramsey County, Minnesota (Figure 1). The lake has a surface area of 214 acres, a maximum depth of 41 feet, and a mean depth of approximately 17 feet (Figure 2)¹. Lake Johanna is listed on the EPA's 303(d) list of impaired waters due to the mercury content in fish. The MPCA completed a statewide TMDL study and implementation plan to address the state's mercury impairments.

The watershed draining to Lake Johanna is 3,413 acres. The surrounding watershed area is primarily residential with some commercial and transportation land uses. The campus of Northwestern College sits on the south shore of the lake.

An aquatic vegetation survey was performed by the DNR in late July of 2001. Coontail, bushy pondweed, and water celery were listed as common in abundance, while curly-leaf pondweed was listed as rare.

In past years the lake has been stocked with walleye, tiger muskellunge, and northern pike. According to a 2002 DNR fisheries assessment, the most abundant species of fish within Lake Johanna is bluegill. Other fish found in the lake include yellow perch, pumpkinseed sunfish, hybrid sunfish, green sunfish, northern pike and black crappie. The City of Arden Hills's 2030 Comprehensive Plan states that the fish within Lake Johanna had elevated levels of perfluorooctane sulfonate (PFOS) in 2007; however, the source is unknown.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from the Rice Creek Watershed District website.

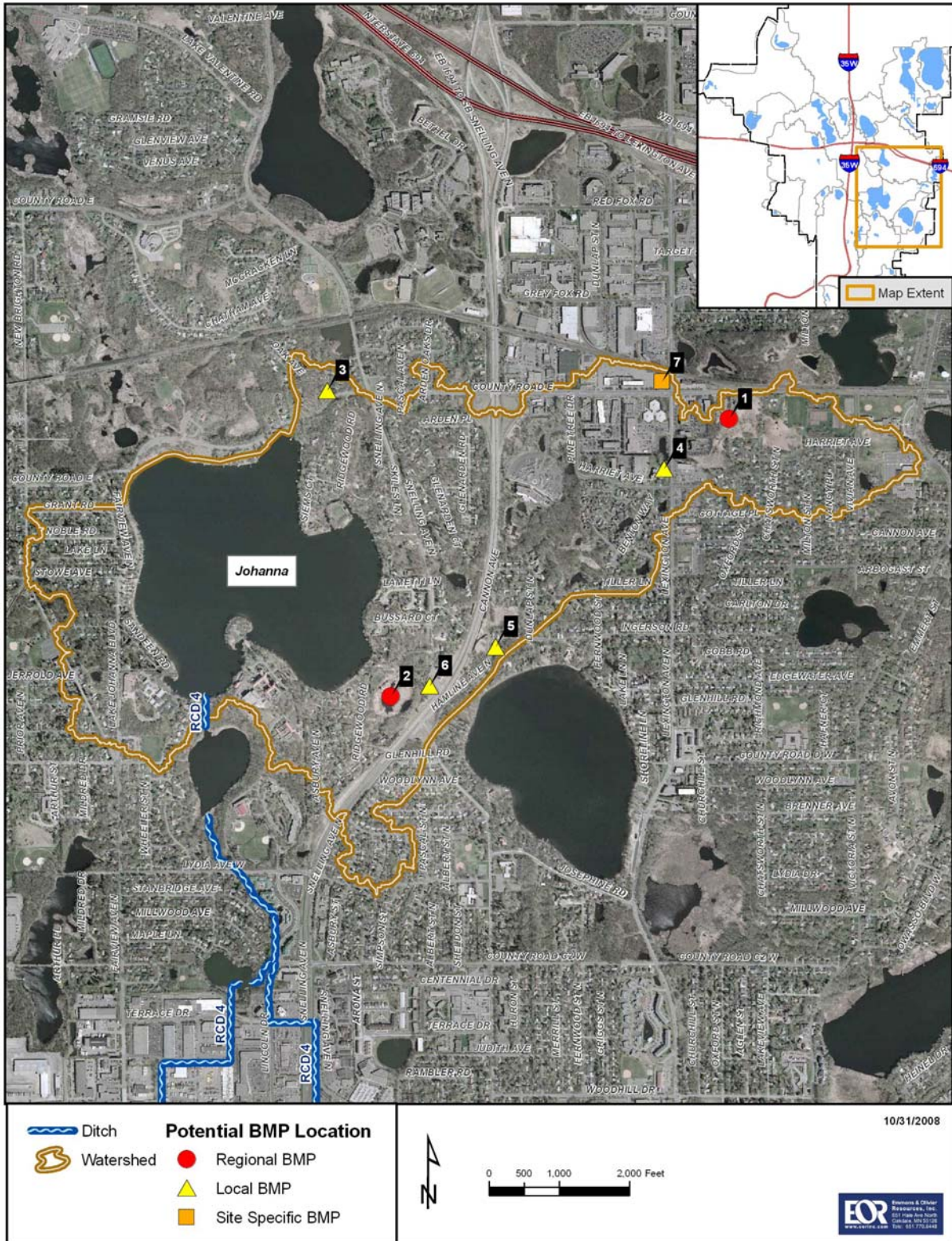


Figure 1. Lake Johanna and Potential BMP Locations

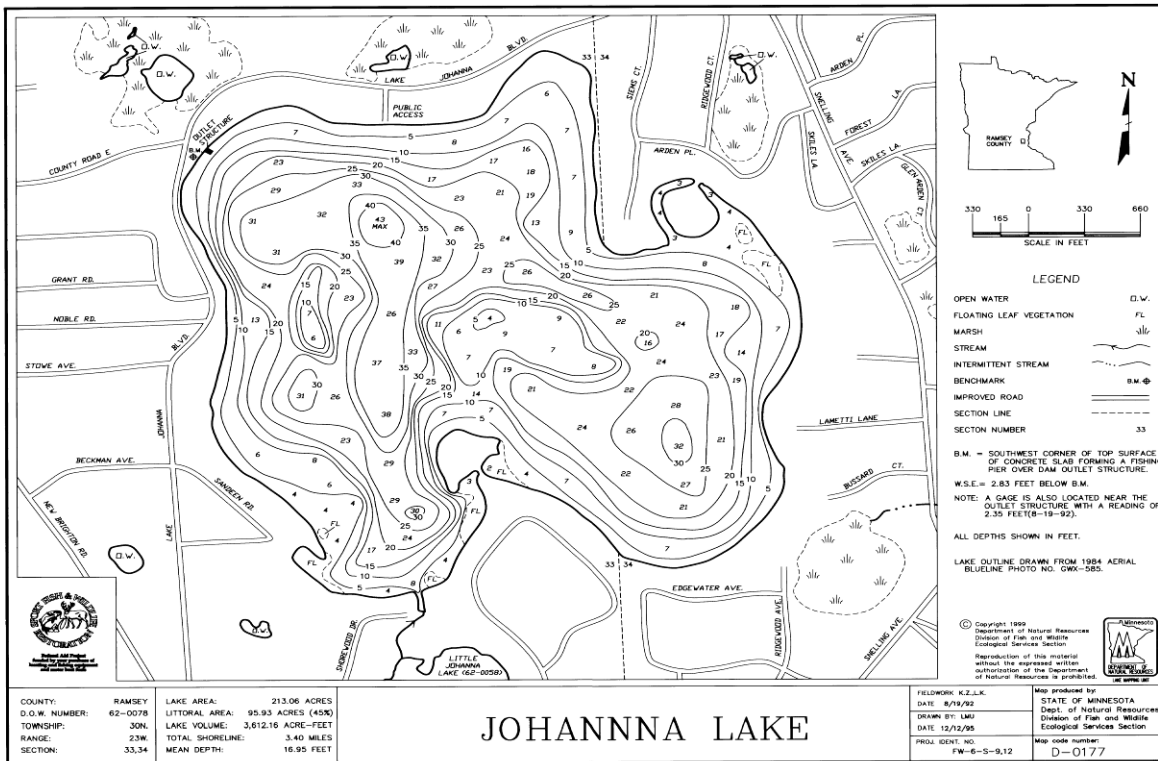


Figure 2. Lake Johanna Bathymetry

Water Quality Summary

Water quality data for Lake Johanna have been collected from 1971-2007. Data are collected by Ramsey County Public Works, Metropolitan Council Environmental Services, and the Minnesota Pollution Control Agency. A summary of the most recent 10 years of monitoring data suggest that the lake is currently meeting water quality standards (Table 1).

Table 1. Average Water Quality Data (1998-2007) and Standards

Parameter	Lake Johanna	Standard
TP (µg/L)	31	40
Chl (µg/L)	12	14
Secchi Depth (m)	2.0	1.4

Figures 3 through 5 show the growing season total phosphorus (TP), chlorophyll- *a*, and Secchi depth (clarity) for Lake Johanna.

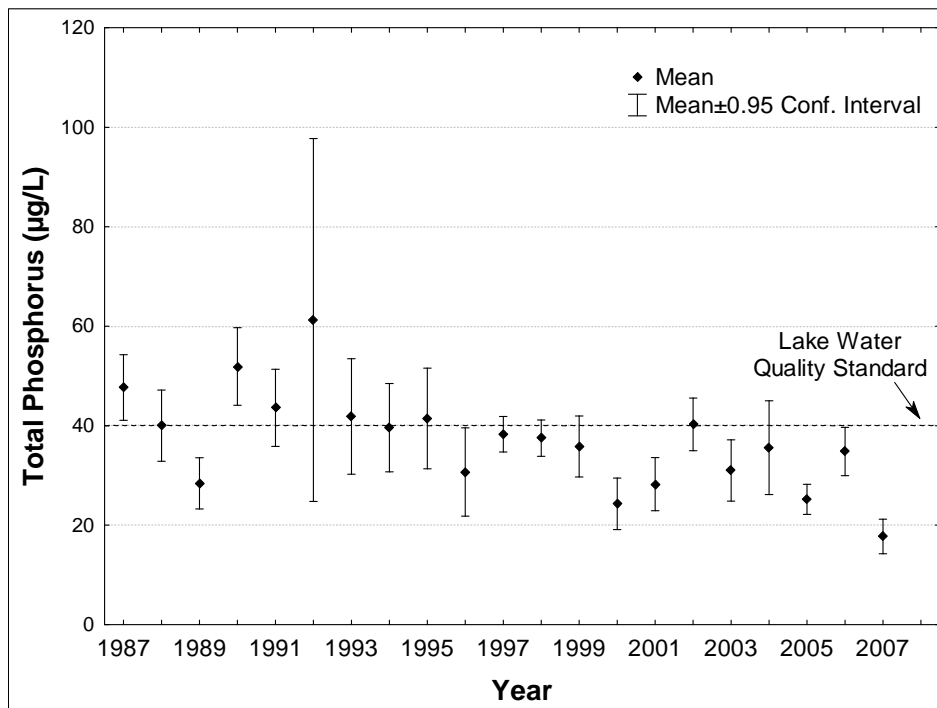


Figure 3. Lake Johanna Total Phosphorus

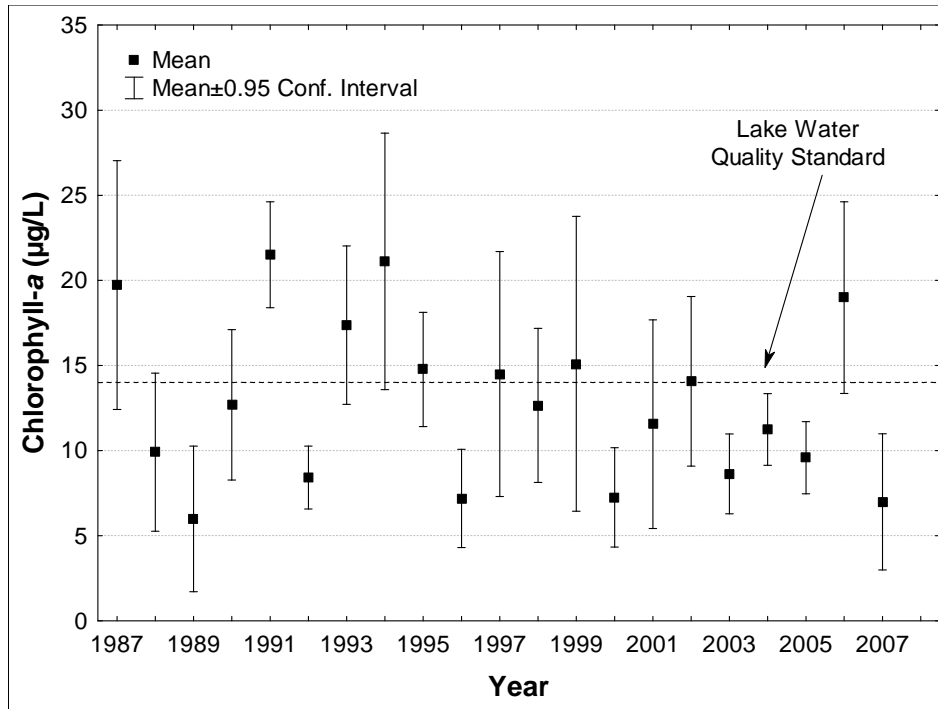


Figure 4. Lake Johanna Chlorophyll-a

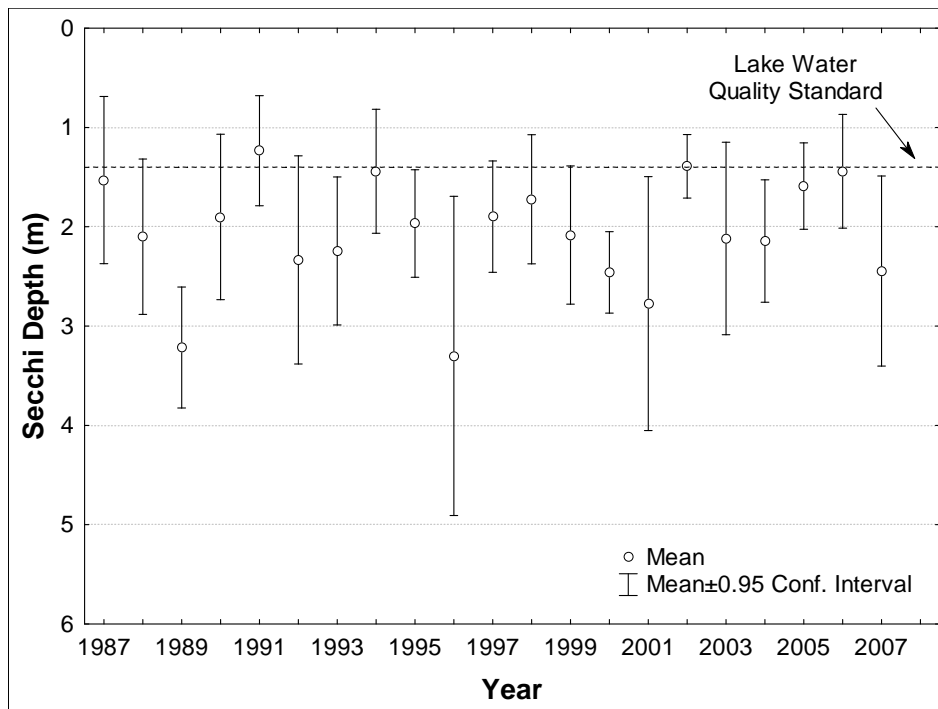


Figure 5. Lake Johanna Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality modeling indicates that

watershed inputs account for approximately 74% of the nutrient load, with internal loading accounting for the remaining 26% (Figure 6).

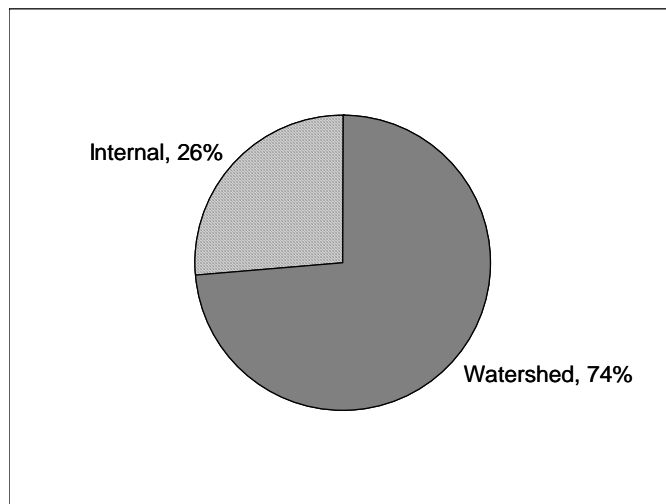


Figure 6. Lake Johanna Phosphorus Load Distribution

Public Input

At the public meeting held on June 5, 2008 issues facing Lake Johanna were addressed. Some of the comments refer to a previous Clean Water Partnership study for Long Lake that included recommendations for the Johanna and Little Johanna watershed. Many of the recommendations in that project were implemented and have proven successful to some degree, but problems continue to exist with the lake.

- Many of the comments for Lake Johanna pertained to the need to clean-up Little Lake Johanna so that it would stop discharging highly nutrient-laden water into Lake Johanna and degrading its quality. The lake has traditionally been very good quality, but this year has started off recognizably bad and all fingers pointed to Little Johanna inflows. The attendees indicated their top priority would be cleaning up the Little Johanna inflow into the south side of the lake.
- It was pointed out that runoff from essentially all of the land on the west side of the lake enters the lake untreated. This should be a focal point for retrofitting BMPs with a phosphorus reduction emphasis. Lametti's Addition, Northwestern College (east side of the lake), and Bussard Ct. were mentioned as examples of locations in need of treatment.
- There was mention that at times the outlet to the lake plugs and is in need of maintenance, but no one knew who to call. It has since been determined that the RCWD owns the structure. Field staff from the District inspected and cleaned the outlet in August 2008. District personnel will regularly inspect the structure in the future.
- Several residents are concerned that the DNR will eliminate the ability of lakeshore owners to chemically treat weeds. They believe that the agency has cut back their permitting of these applications and might eventually eliminate this as a macrophyte management tool. The residents currently spray three times a year with a chemical they could not off-hand identify. They do not currently harvest plants. The suggestion should

be made that the homeowners work with the RCWD and DNR on an overall macrophyte management plan to identify a long-term plan for nuisance weed control on the lake. This approach would allow the homeowners to engage in direct communication with DNR on which approaches will be allowed in the future and which might be curtailed.

- The smell of algae on the lake was raised by some attendees. Solving the nutrient influx into the lake would go a long way toward reducing algal blooms, but it was recognized that short-term improvements are not likely. However, due to the fact that Little Johanna is impaired for excess nutrients, the MPCA will be required to complete a TMDL study in the future.
- Street sweeping was a popular recommendation by meeting attendees. It was stated that the City of Roseville sweeps its streets only once per year and that the Rosedale shopping Center does not do a good job of keeping its parking lots clean. Attendees recommended that the city increase its sweeping frequency and that the shopping center(s), including others in the sub-watershed, also be asked to do a better job of sweeping. Spot sweeping of critical areas, such as those directly tributary to lakes, was encouraged.
- It was noted that detention ponds on the Northwestern College campus, one located west of Snelling and south of Co. Rd. C, and at EagleCrest Retirement Community, were in need of deepening to restore their ability to adequately handle runoff.
- Some attendees expressed their unhappiness with runoff leaving some of the construction underway at the Northwestern College campus. The attendees urged the RCWD to do a better job of site inspection for construction activities within the watershed.
- Residents would like some attention placed on fish management. Nuisance rough fish are currently a problem. The number of panfish (planktivores) is unusually high, although most are very small in size.

In addition to the public input provided at the meeting held on June 5, 2008, members of both the Lake Johanna Improvement Society and the Arden Hills Beach Club expressed concern about the condition of Lake Johanna's outlet structure. Visits by RCWD staff revealed that the structure had been damaged, and was allowing water to pass approximately 0.02 feet lower than designed (Figure 7). RCWD engineers produced a technical memo recommending repair of the structure. Repair is slated for 2009.



Figure 7. Photos of damaged outlet structure, Sept 9, 2008

Water Quality Issues

- Curly-leaf pondweed was found in the lake at a rare abundance in a late July 2001 aquatic plant survey. Since curly-leaf pondweed usually dies back after June, its presence in late July could indicate that it is abundant earlier in the growing season. Curly-leaf pondweed can contribute to internal loading.
- The poor water quality of Little Lake Johanna may negatively influence the water quality of Lake Johanna. Approximately half of the watershed load comes from the Little Lake Johanna outlet.
- High densities of bluegill and other panfish may contribute to periodic high algal concentrations through grazing pressure on the zooplankton community. Nuisance rough fish have also been observed, which can increase internal loading rates.

Recommended Management Approach

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing the nutrient impairment of Little Lake Johanna and the overall health of Johanna. Because the Lake Johanna watershed is nearly fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, seven BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Feasibility and Benefit Level Assessment of the potential regional BMP locations identified in the *field reconnaissance supplement*.
- Consideration of local partnerships for further assessment of the four potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- As stated in The City of Arden Hills 2030 Comprehensive Plan, stormwater treatment systems are being evaluated as part of the city's pavement management program to reduce pollutants entering Lake Johanna.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)

- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

- Develop an aquatic vegetation management plan to prevent curly-leaf pondweed abundance from increasing within the lake.
- The bluegill population size is well above the medial level for lakes of this type. Planktivore size structure outlined in the DNR fisheries survey suggests that the population is dominated by small individuals; 65% of bluegills were less than 5 inches, and no black crappie larger than 8 inches were sampled. This could indicate planktivore ‘stunting,’ where intraspecific competition limits growth. Dense populations of small planktivores are capable of limiting zooplankton populations, leaving no biological check on algae growth. Work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Lake Johanna. Since there is a long record of in-lake water quality data for Lake Johanna, additional data collection is not a high priority at this time.

- TP, chlorophyll, and Secchi depth data: Continue to collect at least five sampling dates per year.
- Macrophyte surveys: A late spring / early summer macrophyte survey should be completed to better assess plant communities, especially in regards to curlyleaf pondweed occurrence and abundance. Macrophyte surveys should also be conducted pre-planning and post-implementation of an aquatic vegetation management plan.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the existing fisheries information regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Johanna Lake Field Reconnaissance Supplement

Regional Management BMPs



Johanna #1

Location: North of the intersection of Richmond Avenue and Richmond Court

Description: Wetland areas receiving upstream stormwater discharges.

Potential Improvements: Enhancements to the existing wetlands to provide more saturation and reduce ditched conditions that may exist in the complex. An assessment of the water quality leaving the wetland complex and the quality of the existing wetland vegetation should be assessed to determine the need for alterations.



Johanna #2

Location: Northeast of the intersection of Edgewater Avenue and Ridgewood Road

Description: Large wetland area, currently receiving water from a sizable drainage area.

Potential Improvements: Potential excavation/cattail removal. Assess the current water quality treatment being provided by the basin and assess options for improvement if warranted.

Local Management BMPs



Johanna #3

Location: North of County Road E and west of Oak Avenue

Description: Low open area at the corner

Potential Improvements: Use for treatment of adjacent roadways.



Johanna #4

Location: North of Harriet Avenue and west of Lexington Avenue

Description: Mowed swale area

Potential Improvements: Use and enhance to provide treatment for adjacent business and/or roadway.



Johanna #5

Location: South of Ingerson Road and east of Hamline Avenue

Description: Open green space at the corner

Potential Improvements: Incorporate large raingarden to provide treatment for adjacent roadways.



Johanna #6

Location: West of Snelling Avenue and north of Hamline Avenue

Description: Open space at corner

Potential Improvements: Use for wetland treatment or ponding for Snelling Avenue.

Site Specific Management BMPs



Johanna #7

Location: North of County Road E and west of Lexington Avenue

Description: Green space at edge of parking lot

Potential Improvements: Incorporate raingarden areas for treatment of adjacent parking lot.

Jones Lake Management Action Plan

Jones Lake (62-0076) is located in the City of New Brighton, Ramsey County, Minnesota (Figure 1). The lake has a surface area of 37.5 acres (Figure 2) and a maximum depth of approximately 1 foot¹. The lake has a very large watershed of about 2,775 acres and is tributary to Pike and Long Lakes.

Jones Lake meets the MPCA definition of wetland and is classified as a Class 2D (wetland) water in accordance with Minn. Rules Ch. 7050. Furthermore its designation as a Public Water Wetland [“W” 62-76] by the DNR Protected Water Inventory and the lack of an aquatic recreational resource management history (MPCA (*Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment*, 2007) substantiates the designation as a Class 2D water. The Class 2D designation means that the wetland resource is protected for the “maintenance of a healthy wetland aquatic community and for wetland based aquatic recreation.” Numeric nutrient standards developed for shallow lakes (i.e. 60 µg/L TP) do not apply to Class 2D wetlands.

Jones Lake is listed as an impaired wetland on the EPA’s 303(d) list of impaired waters. It is impaired for aquatic life, based on aquatic macroinvertebrate and aquatic plant bioassessments. In the 2008 listing cycle, the MPCA began listing wetlands that are tributary to other impaired water bodies; in the case of Jones Lake, both Pike Lake and Long Lake are on the 303(d) list of impaired water bodies. The intent of listing wetlands is to highlight the potential of wetland restoration within the context of restoring the downstream impaired water body, while avoiding the use of the wetland as a treatment basin, which might improve the downstream resource but would further degrade the wetland. The MPCA will be developing guidance on how an impaired wetland will be addressed through the TMDL program. In its report on the reasoning behind the recommendation to list Jones Lake as an impaired wetland, the MPCA acknowledged that the potential to restore Jones Lake will be limited due to history of watershed disturbance and management practices in the Jones Lake watershed.

The primary use of the wetland is for temporary detention of stormwater. The biological impairment is likely the result of years of urban runoff passing into and through this stormwater feature, in addition to substantial water level fluctuations. In the 1960s, the water level in Jones Lake dropped by approximately 18 inches after projects were implemented in the Jones Lake watershed to alleviate flooding. In response to the lowered water level, a weir was installed in the late 1970s to restore the lake’s water level.

¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from the Rice Creek Watershed District website.



Jones Lake is a wetland with a dense population of cattails around the fringes and open water in the middle. It is currently used to treat stormwater runoff from an urbanized watershed and has suffered from water level fluctuations and high nutrient loading.

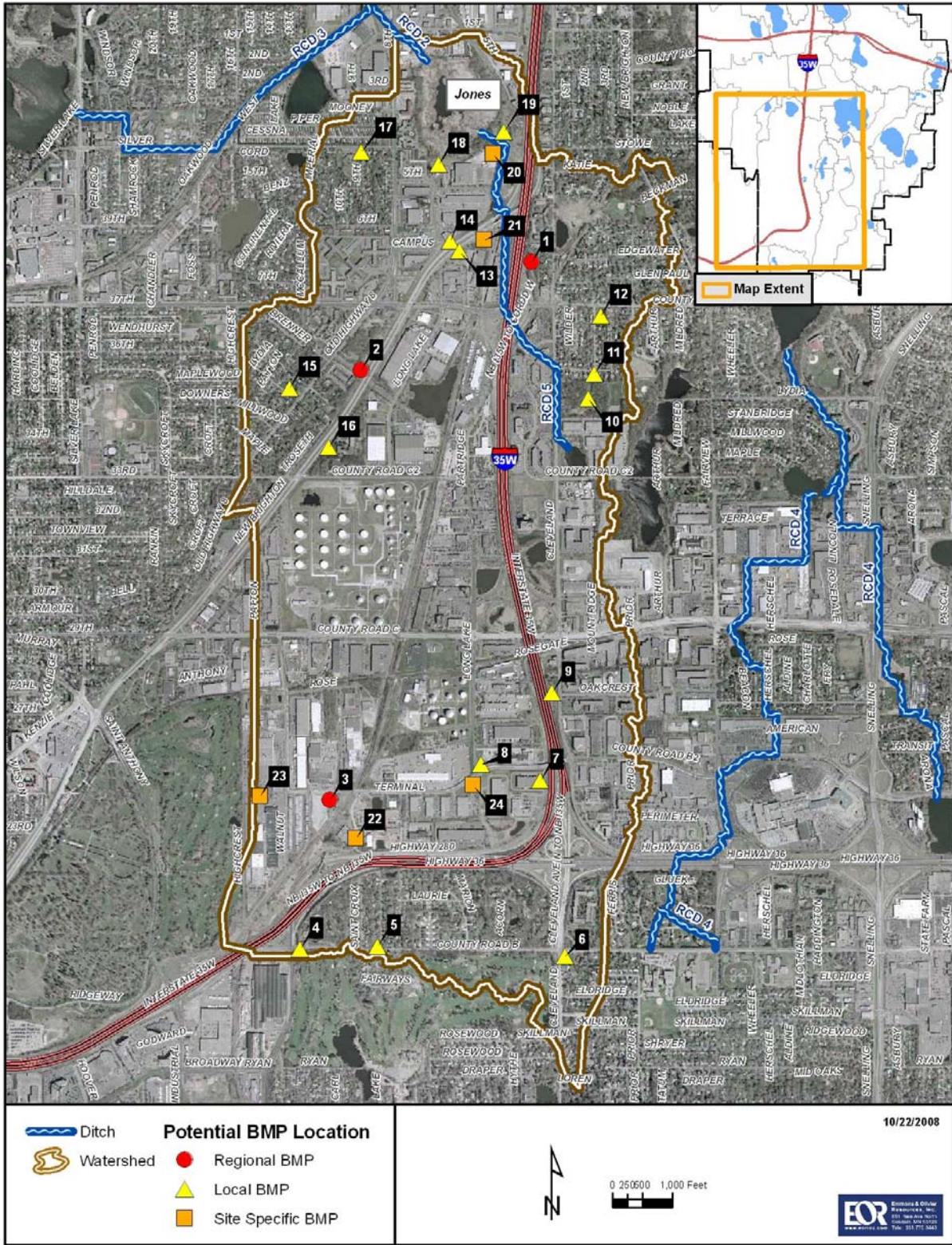


Figure 1. Jones Lake and Potential BMP Locations

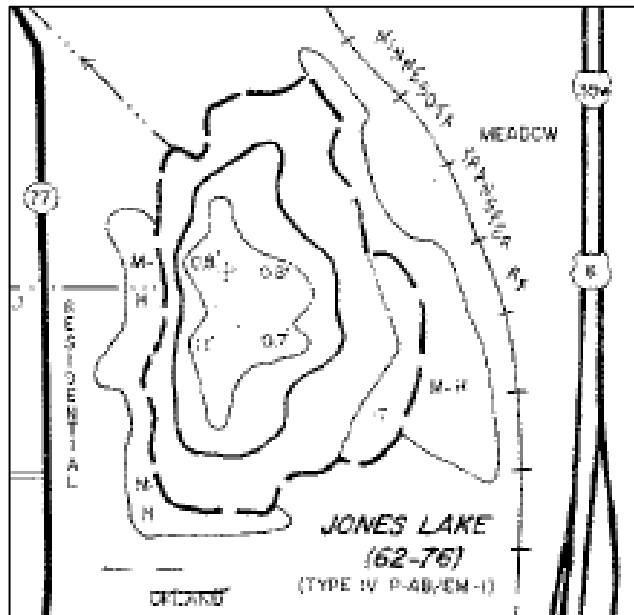


Figure 2. Jones Lake Bathymetry. Map from DNR files, unknown date.

Water Quality Summary

Water quality and biological data for Jones Lake are very limited. A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. There are no in-lake monitoring data to calibrate the lake model. Water quality modeling indicates that watershed inputs account for approximately 92% of the nutrient load, with internal loading accounting for the remaining 8% (Figure 3). Without any in-lake nutrient data for the lake for model calibration, the modeling results should be considered preliminary.

In 2001, RCWD undertook a phosphorus budget study of Jones Lake, which concluded that Jones Lake was capturing approximately 13% of the TP entering it. The study noted the dense plant growth in the lake, with even the open water areas having almost complete coverage from the dense amount of submerged macrophytes.

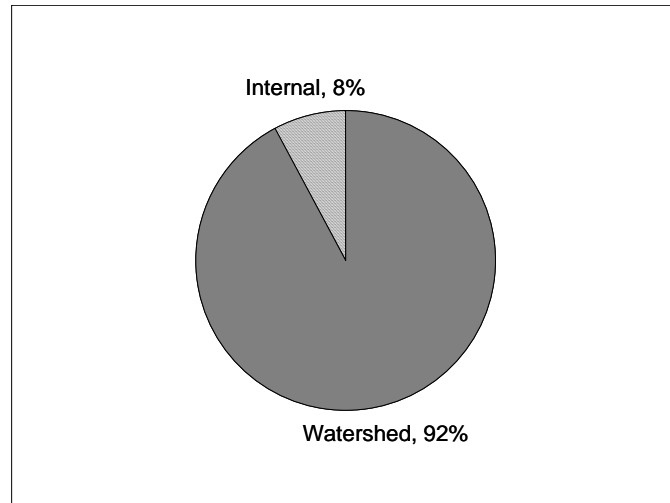


Figure 3. Jones Lake Phosphorus Load Distribution

Public Input

At the public input meeting held on June 2, 2008, no attendees spoke on issues related to Jones Lake.

Water Quality Issues

- Historically, Jones Lake has been used for stormwater management and not treated as its own water body. The resulting water level fluctuations and the stormwater runoff to the lake have degraded the ecological health of the wetland.
- In addition to decreasing phosphorus loading to the lake, the degraded plant community in Jones Lake will need to be restored. This will provide improved habitat for aquatic macroinvertebrates and will lead to an overall improved ecological health.

Recommended Management Approach

A watershed-level TMDL study should be completed for the Jones Lake, Pike Lake, and Long Lake impairments. Although the approach to developing a wetland TMDL has not yet been defined by the MPCA², this watershed could be used as a pilot study that would demonstrate how to incorporate a wetland biological impairment with other downstream impairments. The following recommendations would be further refined in a TMDL study.

Watershed Management Recommendations

Management of land in the watershed may not be as critical an element as in-lake management in addressing the biotic impairment of Jones Lake. However, improvements within the watershed will have effects not only for Jones Lake but also on nutrient impaired downstream receiving waters (i.e. Pike and Long Lakes). The Jones Lake watershed is fully developed, with the bulk of the watershed developed without any onsite water quality treatment. Therefore, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify

² US EPA has recently (Dec 2008) developed draft guidance for watershed TMDLs. The document is titled "Handbook for Developing Watershed TMDLs," and can be found at www.epa.gov/owow/tmdl.

likely regional, local, and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 24 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Feasibility and Benefit Level Assessment of the three potential regional BMP locations identified in the *field reconnaissance supplement*.
- Consideration of local partnerships for further assessment of potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- The sub-watershed draining to Jones Lake contains a long ditch paralleling railroad tracks on the west side of I-35W. There is a small detention pond on the ditch near the top of the watershed; this pond has a substantial sediment delta and is not likely operating at its design capacity. At a minimum, this pond should be restored to its original design. A retrofit opportunity should also be assessed to increase its storage capacity and stormwater treatment effectiveness.
- Runoff from the sub-watershed to the southeast of Jones Lake is delivered by Ramsey County Ditch 5 (RCD 5). This ditch drains the Langton Lake sub-watershed, as well as other areas adjacent to the I-35W corridor. This part of the Jones Lake watershed contains some small-scale drainage ponds that should be evaluated for performance.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization and runoff management.
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

The poor plant and macroinvertebrate communities in Jones Lake suggest that in-lake management practices will be needed to address the poor quality habitat. However, the water level fluctuations and the high nutrient loading create an environment that makes it difficult for the establishment of native plant communities, and supports cattail dominance. Any in-lake restoration project will have a greater likelihood of success after the rate and volume of stormwater runoff to Jones Lake is controlled.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Jones Lake:

- RCWD should use the recent draft EPA *Handbook for Developing Watershed TMDLs* and work with the MPCA to define data needs for a potential watershed TMDL.
- TMDLs for wetland impairments have not yet been completed by the MPCA and therefore the process is not well-defined. Work closely with MPCA on data collection efforts aimed at completing the TMDL for Jones Lake.
- Ramsey County Ditch 5 should be monitored close to the inlet to Jones Lake to provide flow and phosphorus loading estimates.

Jones Lake Field Reconnaissance Supplement

Regional Management BMPs



Jones Lake #1

Location: North of County Road D and west of Cleveland Avenue

Description: Large open area south of an apartment complex

Potential Improvements: Area could be used for a significantly sized feature depending on the drainage area that could be routed to this area.



Jones Lake #2

Location: South of County Road D and west of New Brighton Blvd

Description: Large open/wooded area with drainage running southeast under New Brighton Blvd.

Potential Improvements: Create regional treatment feature for drainage area west of this location. An assessment of grades and routing would be required.



Jones Lake #3

Location: South of Terminal Road and west of railroad tracks

Description: Large vacant lot

Potential Improvements: A large treatment area could be incorporated here to serve untreated industrial areas. Further assessment of the drainage area that could be routed to this location would be required.

Local Management BMPs



Jones Lake #4

Location: County Road B and TH 280

Description: Road closed off due to TH 280 expansion

Potential Improvements: If County Road B and TH 280 will no longer be connected, this area could be converted to a stormwater BMP



Jones Lake #5

Location: North of County Road B and west of Saint Stephen Street

Description: Open corner lot

Potential Improvements: Route road runoff to this area and provide treatment



Jones Lake #6

Location: South of County Road B and east of Cleveland Avenue

Description: Large open green space with no apparent current use

Potential Improvements: Use this area to treat adjacent roads. The site sits higher than roads so additional excavation would be required if this site were to be used.



Jones Lake #7

Location: West side of Rosegate and south of County Road B2

Description: Large grass swales along Rosegate with catch basins at the bottom

Potential Improvements: Convert into treatment areas to provide storage/infiltration



Jones Lake #8

Location: East of Long Lake Road and north of County Road B2

Description: Green space at the corner

Potential Improvements: Incorporate infiltration/water quality treatment BMP to treat roads or the adjacent business



Jones Lake #9

Location: West of the intersection of Oakcrest Avenue and Cleveland Avenue

Description: Triangular open space between 35W and Cleveland Avenue

Potential Improvements: Potentially incorporate large treatment area. Would need to assess what areas could be routed to this area.



Jones Lake #10

Location: East of Cleveland Avenue and South of Brenner Avenue

Description: Low wetland area

Potential Improvements: Enhance wetland to provide additional water quality treatment. Would need assessment to evaluate need, the quality of the wetland, and what could be routed to it.



Jones Lake #11

Location: South of the intersection of Brenner Avenue and Mount Ridge Road

Description: Green space that could be used to treat adjacent roads

Potential Improvements: Infiltration or ponding feature.



Jones Lake #12

Location: South of County Road D and east of Mount Ridge Road

Description: Large dry pond

Potential Improvements: Retrofit to provide infiltration or water quality storage.



Jones Lake #13

Location: North of County Road D and west of New Brighton Blvd

Description: Large open area

Potential Improvements: Use area to treat New Brighton road and/or adjacent businesses.



Jones Lake #14

Location: West side of New Brighton Blvd and north of County Road D

Description: Large grass swale areas

Potential Improvements: Could easily be enhanced to provide additional treatment and infiltration.



Jones Lake #15

Location: North of the intersection of Manson Street and Stanbridge Street

Description: Green space next to trail

Potential Improvements: Incorporate raingarden



Jones Lake #16

Location: North of County Road C2 and east of New Brighton Blvd

Description: Large grass swale area

Potential Improvements: Could be enhanced to provide additional treatment.



Jones Lake #17

Location: South of Foss Road and west of 9th Avenue

Description: Low green space

Potential Improvements: Retrofit to provide treatment for adjacent roads.



Jones Lake #18

Location: North of 5th Street and east of Old Highway 8

Description: Open space behind water tower

Potential Improvements: Use area to treat adjacent untreated industrial areas. Would need to assess adjacent drainage area to evaluate what could be routed here.



Jones Lake #19

Location: East side of Jones Lake

Description: Large open area, perhaps used as raspberry patch.

Potential Improvements: Use to treat industrial areas to the north. Would need further assessment of the drainage area and would have to get water under railroad tracks. A smaller feature north of this location and closer to the drainage connection under the railroad tracks might be more practical.

Site Specific Management BMPs



Jones Lake #20

Location: North of Lakeview Point Drive just south of Jones Lake

Description: Large amounts of impervious area routed directly to Jones Lake

Potential Improvements: Remove some impervious area and install treatment features or incorporate underground treatment devices.



Jones Lake #21

Location: North of County Road D and west of New Brighton Blvd

Description: Large amounts of impervious areas from warehouse site routed through wooded area directly into culvert with no treatment.

Potential Improvements: Plenty of room to incorporate wetland treatment or an infiltration feature depending on site soils.



Jones Lake #22

Location: West of St. Croix Street and North of Frontage (north of I-35W)

Description: Grass swale to pipe outlet

Potential Improvements: Easy retrofit into raingarden area for adjacent business.



Jones Lake #23

Location: West of Walnut Street and south of Terminal Road

Description: Large parking lot routed directly to piped outlet. Area in front of pipe has been collecting sediment with vegetation growing.

Potential Improvements: Remove this corner of flood-prone parking and incorporate a ponding or infiltration feature.



Jones Lake #24

Location: West of Long Lake Road and south of Terminal Road

Description: Parking area draining straight to a catch basin.

Potential Improvements: Retrofit to provide treatment in the available green space.

Lake Josephine Management Action Plan

Lake Josephine (62-0057) is located in the cities of Arden Hills and Roseville, Ramsey County, Minnesota (Figure 1). The lake has a surface area of 116 acres (Figure 2), a maximum depth of 44 feet, and a mean depth of approximately 20 feet¹. The watershed that drains to Lake Josephine is 774 acres. The surrounding watershed area is primarily residential with some commercial and transportation land uses. The lake is bordered on the southeast side by Lake Josephine Park. Little Lake Josephine and its watershed are contained within the Lake Josephine watershed.

Lake Josephine is on the EPA's 303(d) list of impaired waters due to the mercury content in fish. The MPCA completed a statewide TMDL study and implementation plan to address the state's mercury impairments.

An aquatic vegetation survey was performed by the DNR in late July of 2001. Coontail was found to be abundant and clasping-leaf pondweed was common. The lake has a history of aquatic vegetation control, including the treatment of approximately 10 acres of aquatic vegetation in 1996.

In the last 4 years, the DNR has stocked Lake Josephine with walleye and largemouth bass.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from the Rice Creek Watershed District website.

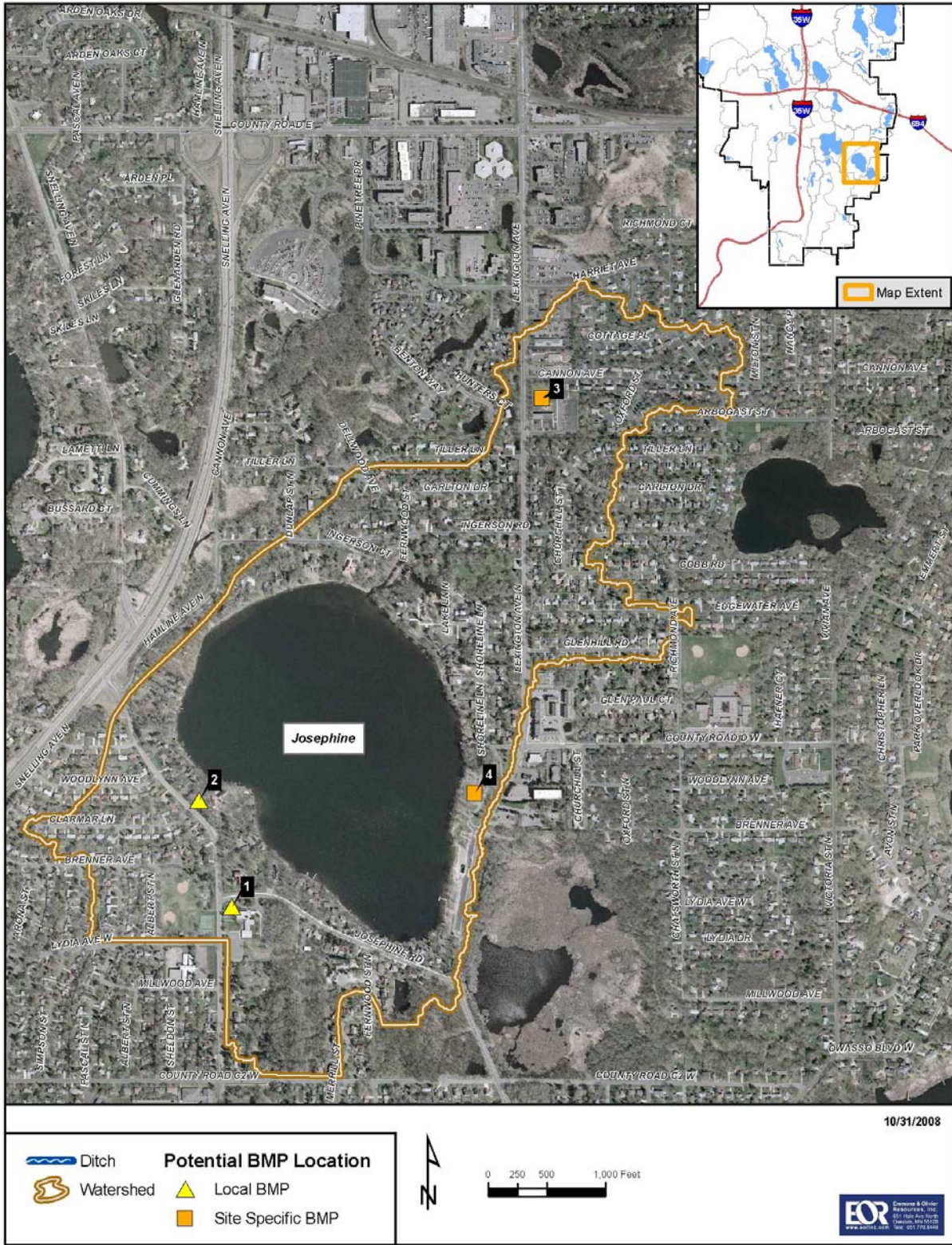


Figure 1. Lake Josephine and Potential BMP Locations

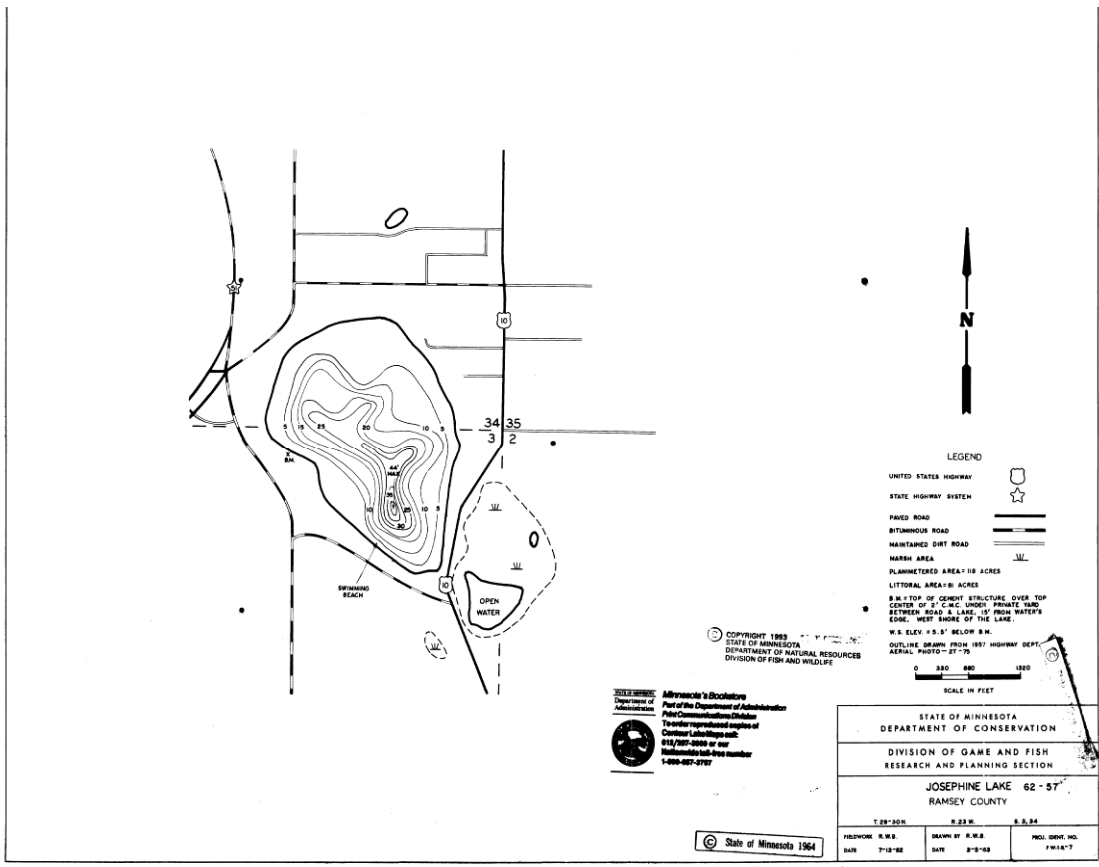


Figure 2. Josephine (and Little Josephine) Lake Bathymetry

Water Quality Summary

Lake Josephine has an abundance of water quality data that have been collected over recent years. Data are collected by Ramsey County Public Works, Metropolitan Council Environmental Services, and the Pollution Control Agency. A summary of the most recent 10 years of monitoring data suggests that the lake is currently meeting water quality standards (Table 1), although the average water quality conditions are close to the standards.

Table 1. Average Water Quality Data (1998-2007) and Standards

Parameter	Lake Josephine	Standard
TP ($\mu\text{g/L}$)	36	40
Chl ($\mu\text{g/L}$)	11	14
Secchi Depth (m)	2.0	1.4

Figures 3 through 5 show the total phosphorus (TP), chlorophyll-*a*, and Secchi depth (clarity) data for Lake Josephine. The figures show that in some years the standards are exceeded. Water quality improved through the 1980s and 1990s and appears to have stabilized. However, the last two years of chlorophyll-*a* and Secchi depth data show that water quality worsened during that time period.

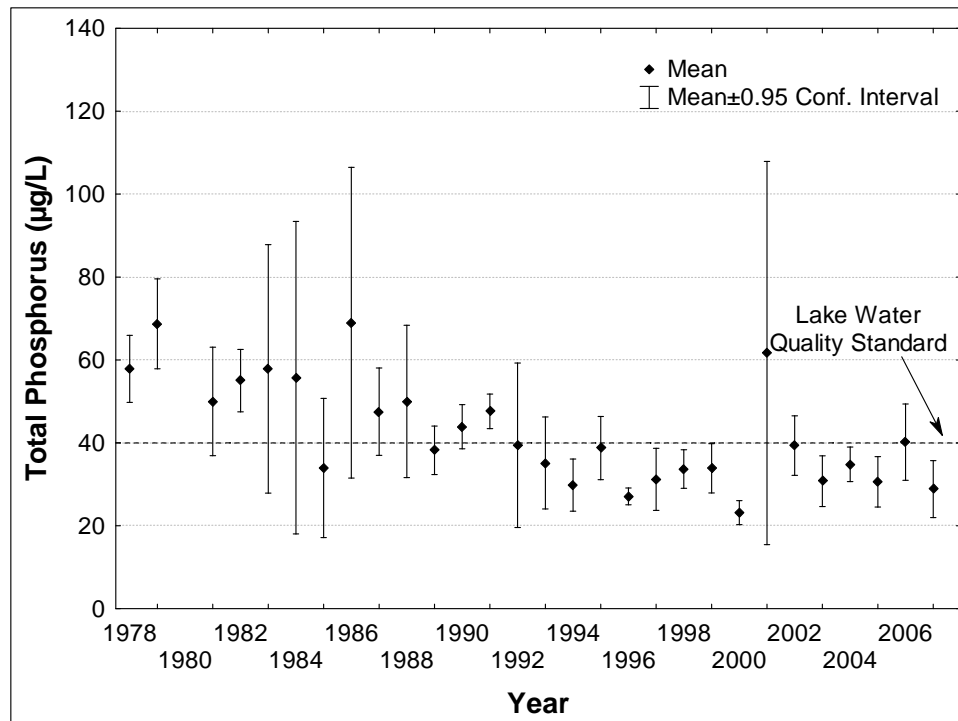


Figure 3. Lake Josephine Total Phosphorus

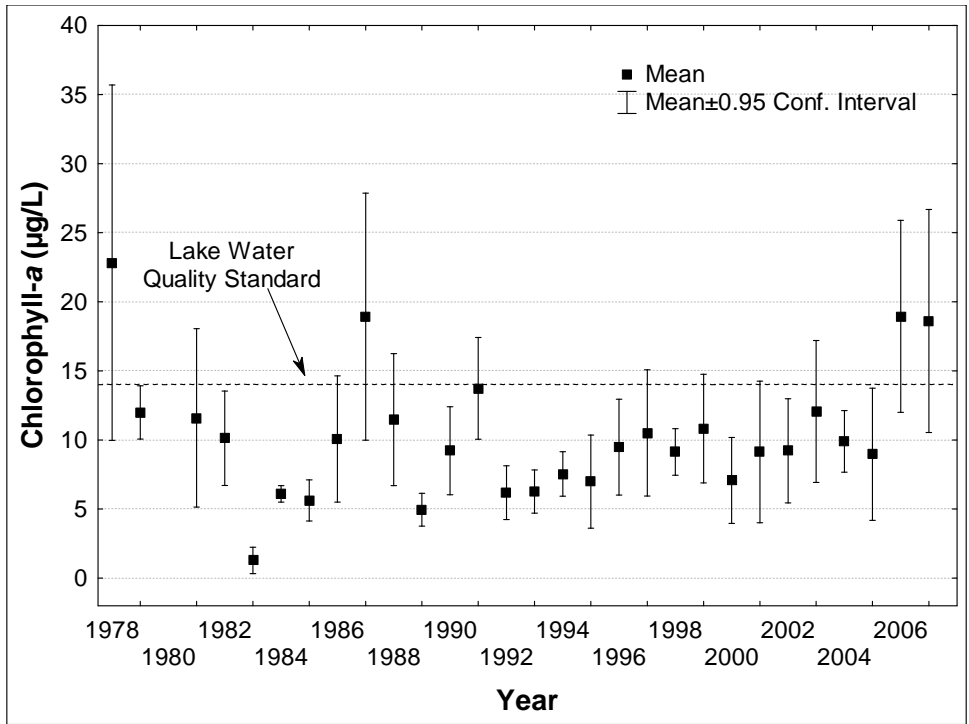


Figure 4. Lake Josephine Chlorophyll-a

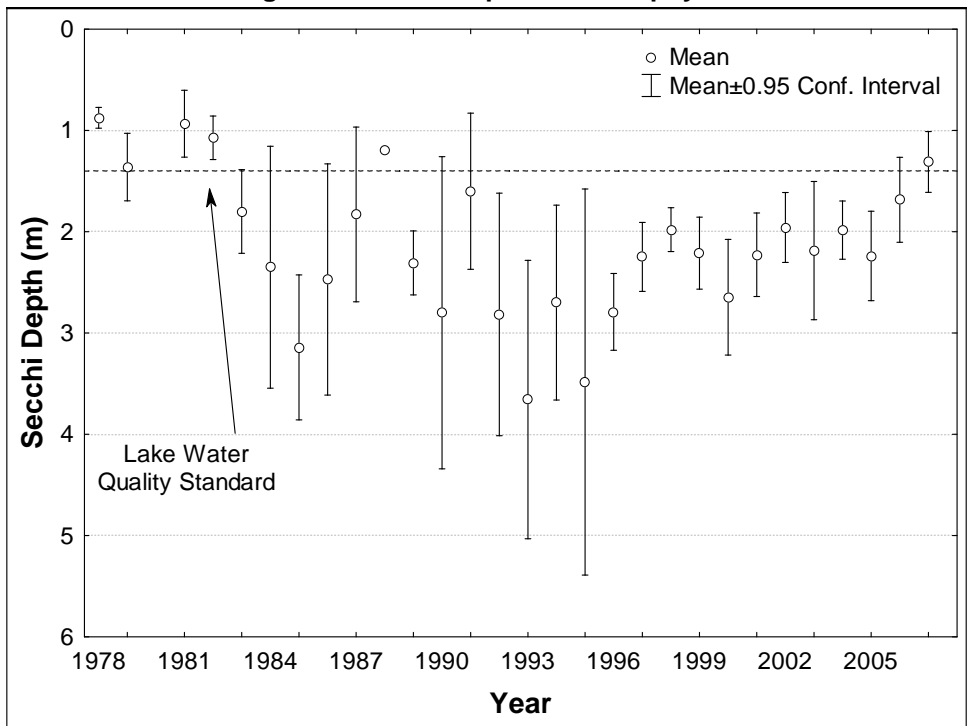


Figure 5. Lake Josephine Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality modeling indicates that

watershed inputs account for approximately 35% of the nutrient load, with internal loading accounting for 65% (Figure 6).

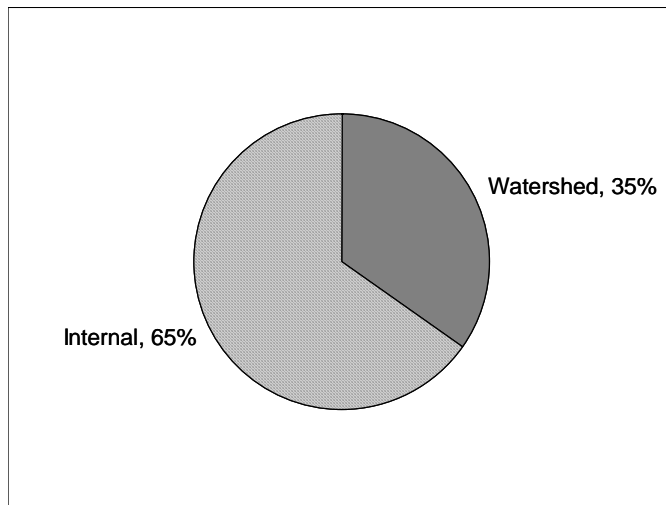


Figure 6. Lake Josephine Phosphorus Load Distribution

Public Input

At the public input meeting held on June 5, 2008, issues facing Lake Josephine were addressed. Preparation for this meeting and some comments offered refer to a previous Clean Water Partnership study for Long Lake that included recommendations for the Lake Josephine watershed. Many of the recommendations in that project were implemented and have proven successful to some degree, but problems continue to exist with the lake.

- Attendees at the public meeting recognized the good quality of Lake Josephine and acknowledged their desire to keep it clean. Lake residents did note the presence of nuisance algae this year. Also noted were problems with carp and dense curly-leaf pondweed. A DNR 2001 survey from late July did not identify the presence of curly-leaf pondweed. However, curly-leaf pondweed dies back after June and therefore could have been missed in the late July survey.
- Runoff management programs in the watershed focusing on nutrient control were indicated as a desirable approach to pursue.
- The attendees also indicated the need for more education on runoff control for residents of the watershed.

Water Quality Issues

- Algae reaches nuisance levels in mid-summer.
- Curly-leaf pondweed is present in the lake and likely contributes to internal loading.
- Bluegill are present in high densities in the lake, potentially leading to overgrazing of zooplankton.

Recommended Management Approach

Watershed Management Recommendations

Because the Lake Josephine watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 4 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of the two potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

Although the water quality of Lake Josephine is relatively good, it is close to water quality standards and should be managed to prevent any degradation in water quality.

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- The abundance of coontail and other macrophytes have in the past created conflicts with the recreational use of the lake, in that they inhibit boating. Efforts to remove vegetation could be potential stressors to the stability of the lake's water quality; aquatic macrophytes tend to hold back the growth of planktonic algae and stabilize lake sediments from re-suspension. If removal of aquatic vegetation besides curly-leaf

pondweed is desired by residents, care should be taken to only remove nuisance species, and to encourage the growth of non-invasive native species. All vegetation management actions should be coordinated and permitted with the DNR.

- Although there is a substantial population of northern pike and other piscivorous fish in the lake, there are also *very* high densities of planktivores, including bluegill and sunfish. In addition to the high numbers, planktivores are mostly small in size – 97% of bluegill were less than 5 inches. This could indicate planktivore ‘stunting,’ where intraspecific competition limits growth. High densities of small planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. Work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Lake Josephine. Since there is a long record of in-lake water quality data for Lake Josephine, additional data collection is not a high priority at this time.

- TP, chlorophyll, and Secchi depth data: Continue to collect at least five sampling dates per year.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the existing fisheries information regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Josephine Lake Field Reconnaissance Supplement

Local Management BMPs



Josephine #1

Location: South of Josephine Road and east of Hamline Avenue

Description: Large openspace at church

Potential Improvements: Use area for treatment of church or adjacent roads.



Josephine #2

Location: East of the intersection of Hamline Avenue and Clarmar Lane

Description: Stormsewer outfall through large estate lot(s). Roseville apparently installed a control structure at this location.

Potential Improvements: Assess effectiveness of structure and consider if additional opportunities exist to provide treatment prior to discharge to the lake.

Site Specific Management BMPs



Josephine #3

Location: South of Cannon Avenue and east of Lexington Avenue

Description: Large dry pond on church lot

Potential Improvements: Retrofit to provide infiltration / water quality treatment.



Josephine #4

Location: Lake Josephine Park

Description: Green space adjacent to parking lot and boat launch.

Potential Improvements: Incorporate raingarden area in green space. (Note: impervious areas are routed to a ponding area to the north.)

Karth Lake Management Action Plan

Karth Lake (62-0072) is located in the City of Arden Hills, Ramsey County, Minnesota (Figure 1). The surface area of the lake is approximately 20 acres (Figure 2) and the lake has a maximum depth of 14 ft.¹ Based on its low maximum depth, it is considered a shallow lake according to MPCA's definition.

The watershed draining to Karth is approximately 118 acres and includes mixed commercial and residential areas, while the immediate lakeshore is primarily residential with a city park (Karth Lake Park) on the south and southwest sides. The primary use of the lake is by the residents or the public visiting the park. No motors are allowed on the lake. Public access for non-motorized boating is available from the park. Flooding has occurred in the past at Karth Lake so an outlet pump was installed in 2004 on the south side of the lake. This is the only current outlet from the lake and it flows to Valentine Lake.

Limited environmental and fish monitoring data are available, with a single DNR Lake Survey Summary available from 1980. This survey notes a problem with winter fish-kills, but no information is available on the fish community in the lake. DNR does not currently stock the lake with fish.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from DNR files.

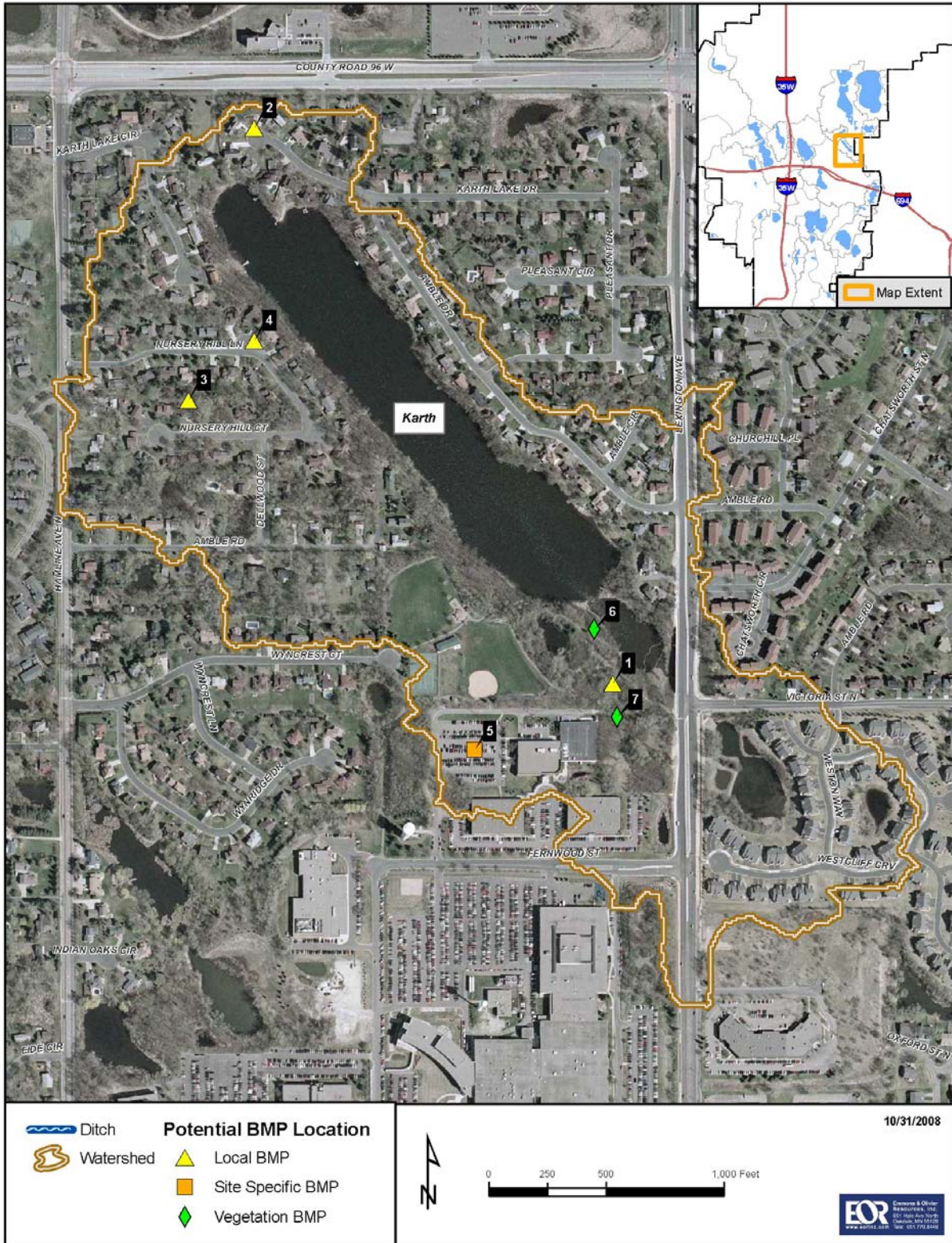


Figure 1. Karth Lake and Potential BMP Locations

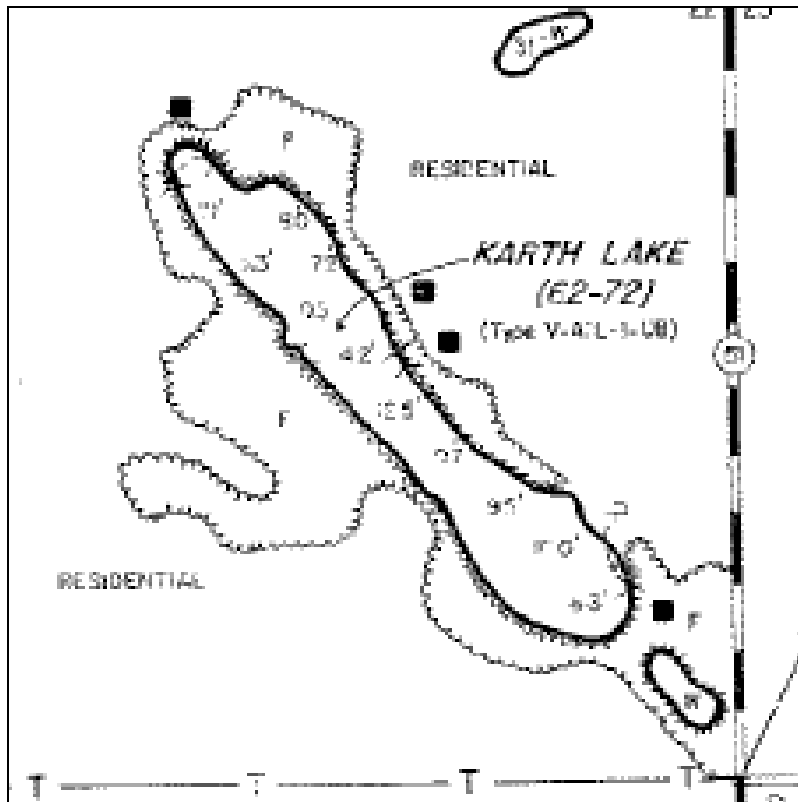


Figure 2. Karth Lake Bathymetry. Map from DNR files, unknown date.

Water Quality Summary

Limited historic data exist on the quality of Karth Lake. The Metropolitan Council's Citizen Assisted Monitoring Program (CAMP) has had the lake as part of its program since 2006. A summary of the CAMP data taken over the last two years (Table 1) shows that Karth Lake is meeting the water quality standards for shallow lakes.

Table 1. Average Water Quality Data (2006-2007) and Standards

Parameter	Karth Lake	Shallow Lakes Standard
TP ($\mu\text{g/L}$)	54	60
Chl ($\mu\text{g/L}$)	18	20
Secchi Depth (m)	1.0	1.0

Figures 3 through 5 show the total phosphorus (TP), chlorophyll-*a*, and Secchi depth (clarity) data from Karth Lake.

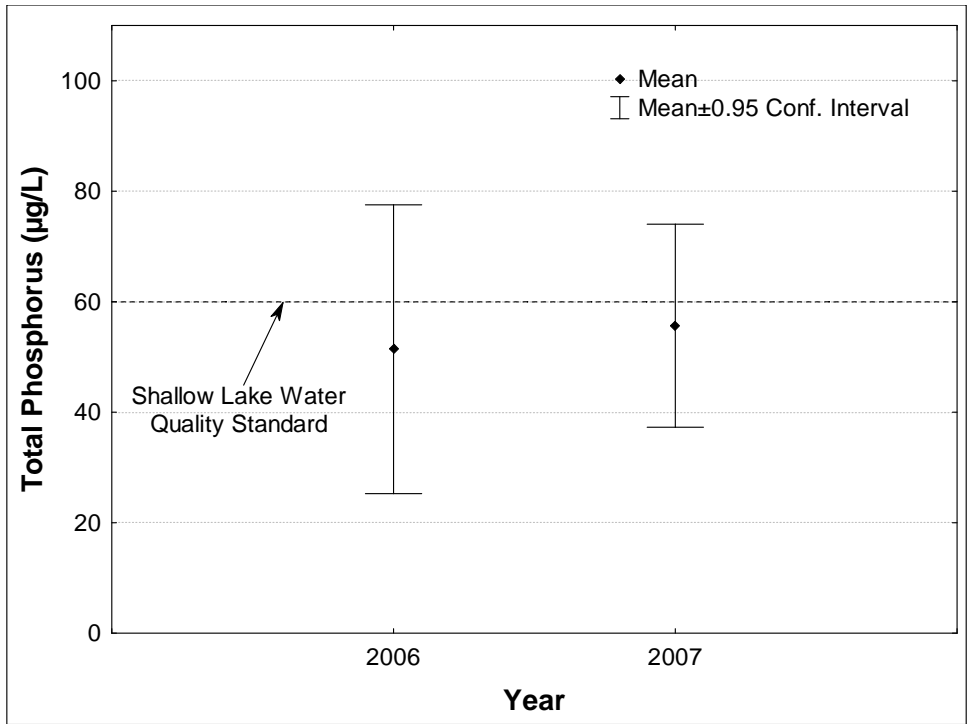


Figure 3. Karth Lake Total Phosphorus

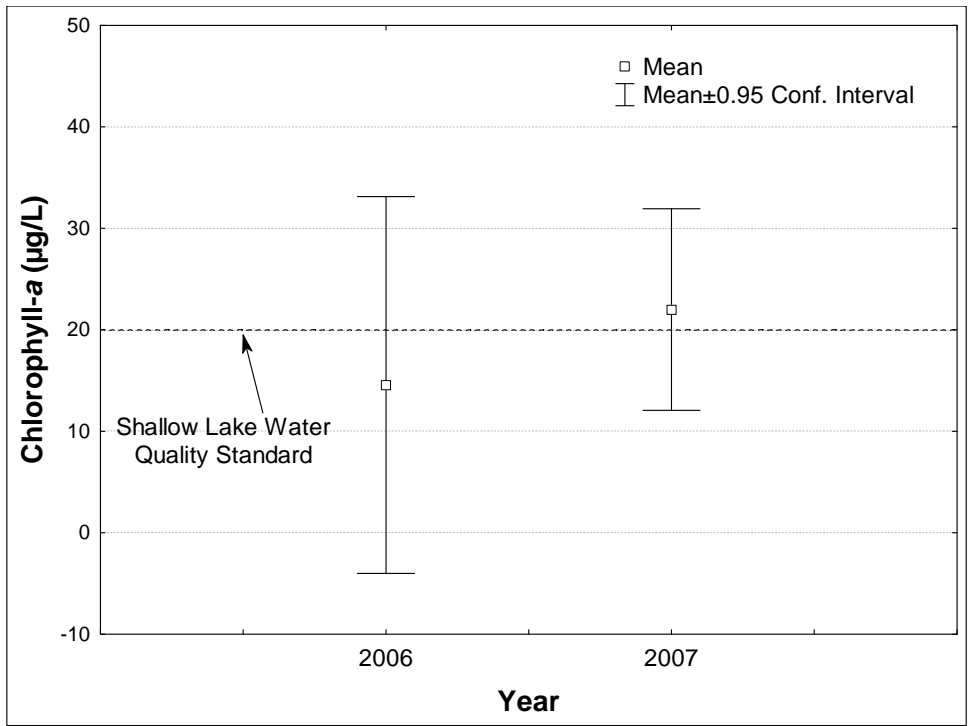


Figure 4. Karth Lake Chlorophyll-a

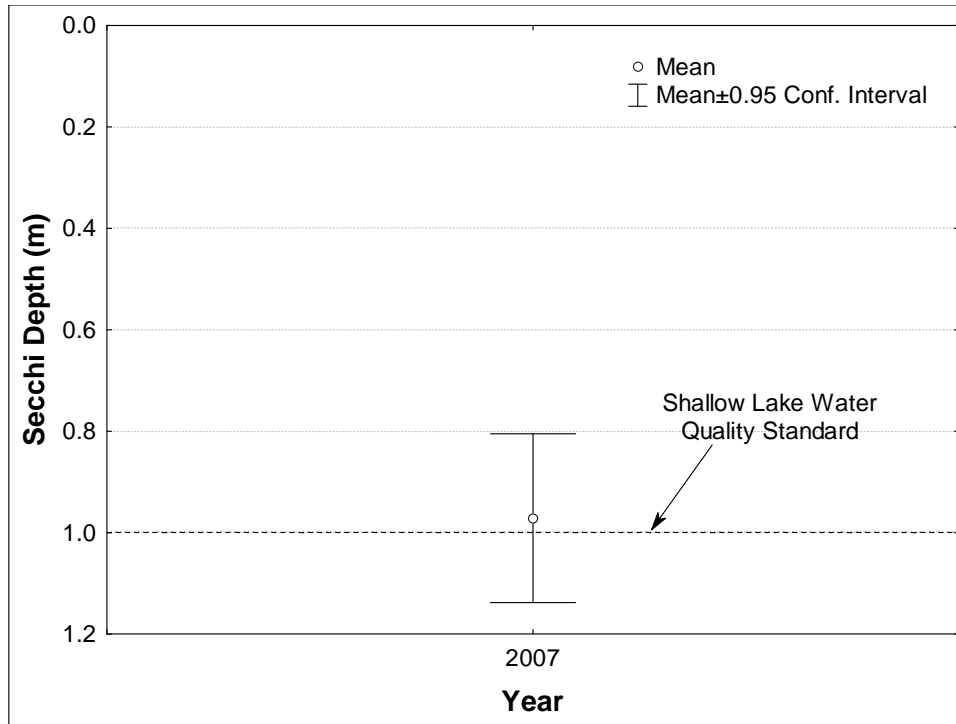


Figure 5. Karth Lake Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality modeling indicates that the watershed inputs account for approximately 85% of the nutrient load, with internal loading accounting for the remaining 15% (Figure 6).

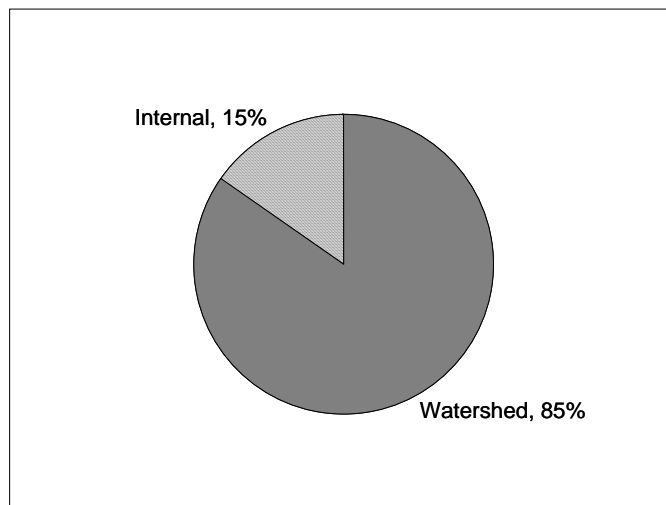


Figure 6. Karth Lake Phosphorus Load Distribution

Public Input

At the public input meeting held on May 29, 2008, lake residents offered local insight on Karth Lake. Residents are very interested in keeping the lake at its current quality or even in reducing the TP level further. A homeowners group, the Karth Lake Improvement District, has attempted to establish technical assistance from RCWD in framing issues and defining problems and solutions.

- Attendees noted that they have seen an orange discharge entering the lake occasionally from the Cummings stormsewer outlet on the southeast side of the lake. The nature of this discharge is unknown. The RCWD was urged to collect a sample if this colored discharge is seen again by residents. It was mentioned that it could be simply an iron coloring from groundwater seepage into the pipe.
- The residents felt that additional BMPs should be identified and retrofit opportunities sought. Several general approaches were recognized within the immediate watershed for retrofits whenever redevelopment or road projects are undertaken.
- The residents were also interested in undertaking a fish stocking program to attain a better ecological balance. They would like to either invite DNR to stock the lake or do some stocking themselves if an affordable supplier could be found and permission granted from DNR. The residents were interested in conducting a fish survey to see what fish are present and then determining a proper mix that would restore ecological balance among the planktivores (plankton eaters) and piscivores (fish eaters).
- The presence of curly-leaf pondweed (a nuisance macrophyte) was noted by attendees at the meeting. RCWD staff confirmed the presence of curly-leaf, but also noted that some native macrophytes (like coontail) were also present in the lake. A plant management program could target curly-leaf pondweed eradication and fostering of natives. Residents would like to pursue curly-leaf pondweed control either through chemical addition or control of sediment pH. The residents are interested in how such a program could be initiated, perhaps in cooperation with the RCWD. Various methods of chemical control were discussed at the meeting.
- Residents are currently controlling buckthorn along the shore of the lake to improve overall habitat and bank stability.

Water Quality Issues

- Curly-leaf pondweed, a nuisance macrophyte, is present in the lake. Curly-leaf may contribute to internal loading of phosphorus.
- Soil erosion has been observed at the site of the outlet pump on the south side of the lake.
- There is an access/parking street between the commercial/industrial area and the lake that slopes steeply to the east and discharges water at a high velocity into a channel draining to the lake.

Recommended Management Approach

Watershed Management Recommendations

Because the Karth Lake watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-

specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, four BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of the 4 potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to FairIssac (business area south of the lake) educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program. All of this area (BMP #5) discharges directly to the lake untreated. There would be opportunity for easy (surface) retrofits in this area during pavement maintenance activities.
- Erosion control measures could be put in place to address soil erosion at the site of the outlet pump (BMP #6) on the south side of the lake.
- Erosion at the bottom of the slope that discharges water at a high velocity into a channel (BMP #7) draining to the lake should be stabilized.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs

Internal Lake Management Recommendations

With very little in-lake biological data for Karth Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Karth Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus

into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Karth Lake. Since there are only two years of in-lake data on Karth Lake and the lake is close to the water quality standards, additional in-lake data collection on the lake should be considered high priority.

- Updated bathymetric data collection
- TP, chlorophyll, and Secchi depth data: Collect data for one to two additional years, with at least five sampling dates per year. Continued support of data collection through the CAMP program will provide sufficient information.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Karth Lake Field Reconnaissance Supplement

Local Management BMPs



Karth #1

Location: South end of Karth Lake

Description: Low wooded area that could be used to treat the large manufacturing business south of lake. There is room to incorporate a good sized feature, which would be needed for that large amount of impervious draining to this location.

Potential Improvements: Incorporate ponding, infiltration, or wetland treatment depending on soils and water table.



Karth #2

Location: Cul-de-sac at the end of Karth Lake Drive

Description: Catch basins drain directly to lake

Potential Improvements: Incorporate island with treatment in cul-de-sac to treat adjacent impervious.



Karth #3

Location: North of Nursery Hill Court and west of Dellwood Street

Description: Low wooded wetland area

Potential Improvements: Incorporate treatment for adjacent roads (would need to assess current quality and function of the wetland)



Karth #4

Location: Cul-de-sac on Nursery Hill Lane

Description: A lot of unnecessary impervious, typical of several neighborhood streets around Karth Lake.

Potential Improvements: Incorporate islands with treatment in cul-de-sacs and reduce street widths. Reclaimed green space could also be used for raingardens.

Site Specific Management BMPs



Karth #5

Location: Parking lot serving manufacturing business south of Karth Lake

Description: The flume for storm water runoff from the large parking area currently discharges offsite untreated.

Potential Improvements: Incorporate stormwater treatment retrofits onsite during pavement maintenance.

Vegetation Management BMPs



Karth #6

Location: South end of Karth Lake

Description: Outlet pump and associated erosion.

Potential Improvements: Incorporate erosion control measures to prevent sediments from entering the lake.

No Photo

Karth #7

Location: East end of private drive on FairIssac site

Description: Erosion at the bottom of the slope that discharges water at a high velocity into a channel.

Potential Improvements: Stabilize outfall to prevent further erosion.

Langton Lake Management Action Plan

Langton Lake (62-0049) is located in the City of Roseville, Ramsey County, Minnesota (Figure 1). The 30-acre lake has three connected basins defined by trail crossings. There is a wetland to the north of the lake that is dominated by wetland macrophytes; this wetland is connected to the other lake basins but is isolated under low flow conditions. The north and south basins of the lake are separated by the southern-most trail crossing. Langton Lake has a maximum depth of 5 feet, and is 100% littoral¹. The watershed area draining to Langton is approximately 208 acres with a mixed commercial-residential landuse, while the immediate lakeshore is primarily a city park.

Langton Lake meets the MPCA definition of a wetland and used to be classified as a Class 2D (wetland) water. In 2001, it was reclassified as a public water (not a wetland) as the request of a local legislator. Due to its shallow depth, it is considered a shallow lake according to MPCA's definition and, as a public water, is held to the state nutrient standards.

An aquatic plant survey was completed by the DNR in late June of 2000. The plant community consisted of both submerged vegetation (flatstem pondweed, Canada waterweed, sago pondweed, and narrowleaf pondweed) and emergent vegetation (cattail, arrowhead, bulrush, and spikerush). White waterlily is abundant in the northern wetland and common in the middle basin (referred to as Langton North in this report). The DNR field notes from the survey indicate that the City of Roseville has cooperated with local residents to control waterlily; this effort was initiated in 1996 to control white waterlily in the northern wetland, and the effort was expanded in 2000 to portions of the middle basin.

The DNR manages the fishery on Langton Lake as part of their Fishing in the Neighborhood (FIN) program. The FIN program provides fishing opportunities to local residents by stocking panfish and providing access; a fishing pier is located on the west shore of the south basin. Langton is a shallow lake subject to winterkill, so stocking efforts are active and continuous to replace fish that are caught or killed. The most recent DNR fisheries survey was conducted in 2000. In addition to high numbers of bluegill and sunfish, black bullheads were also sampled.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from the Rice Creek Watershed District website.

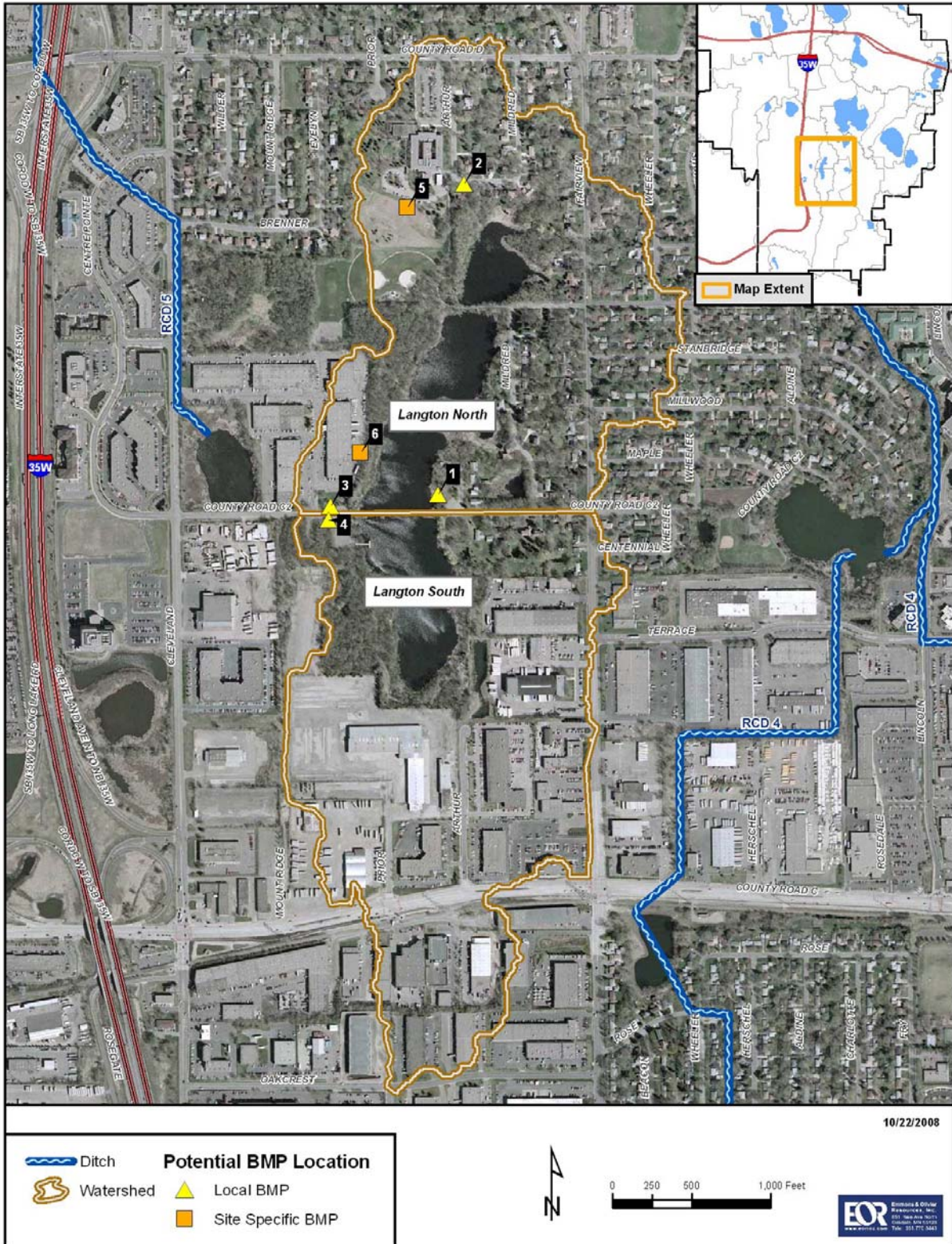


Figure 1. Langton Lake and Potential BMP Locations

Water Quality Summary

Water quality data for Langton Lake has been collected by the Metropolitan Council’s Citizen Assisted Monitoring Program (CAMP) since 2005. A summary of the monitoring data suggests that the lake is currently meeting lake water quality standards (Table 1). The phosphorus concentration is just meeting the standard, while the chlorophyll and Secchi depth are slightly better than the standards.

Table 1. Average Water Quality Data (2005-2007) and Standards

Parameter	Langton Lake North Basin	Langton Lake South Basin	Shallow Lakes Standard
TP (µg/L)	60	60	60
Chl (µg/L)	17	14	20
Secchi Depth (m)	1.1	1.2	1.0

Figures 2-7 show the TP, chlorophyll-*a*, and clarity (Secchi depth) data from both basins of Langton Lake.

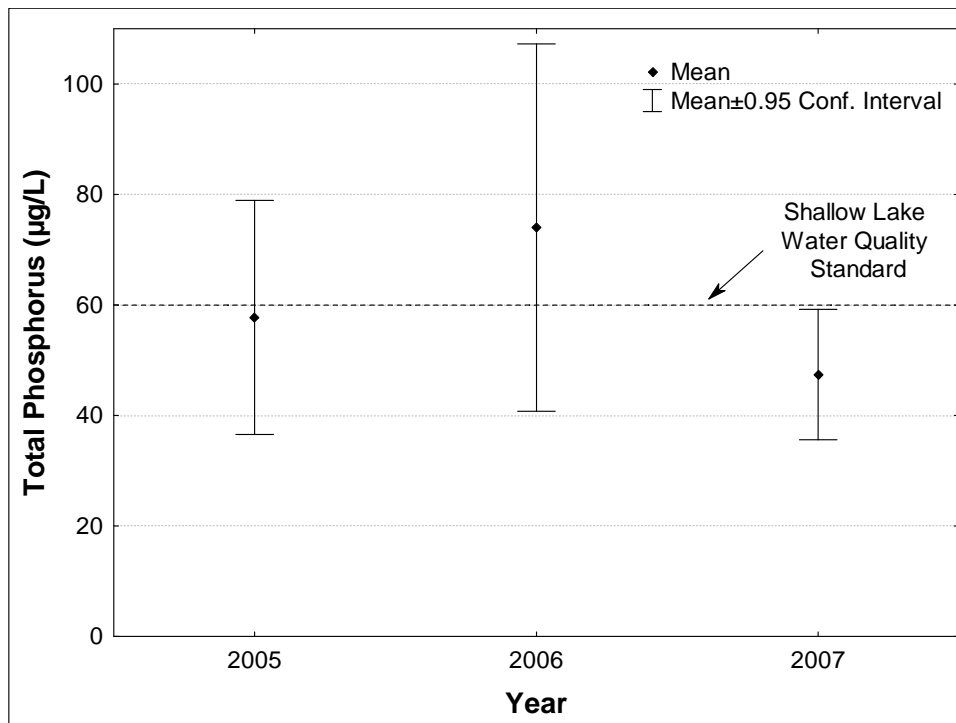


Figure 2. Langton Lake North Basin TP

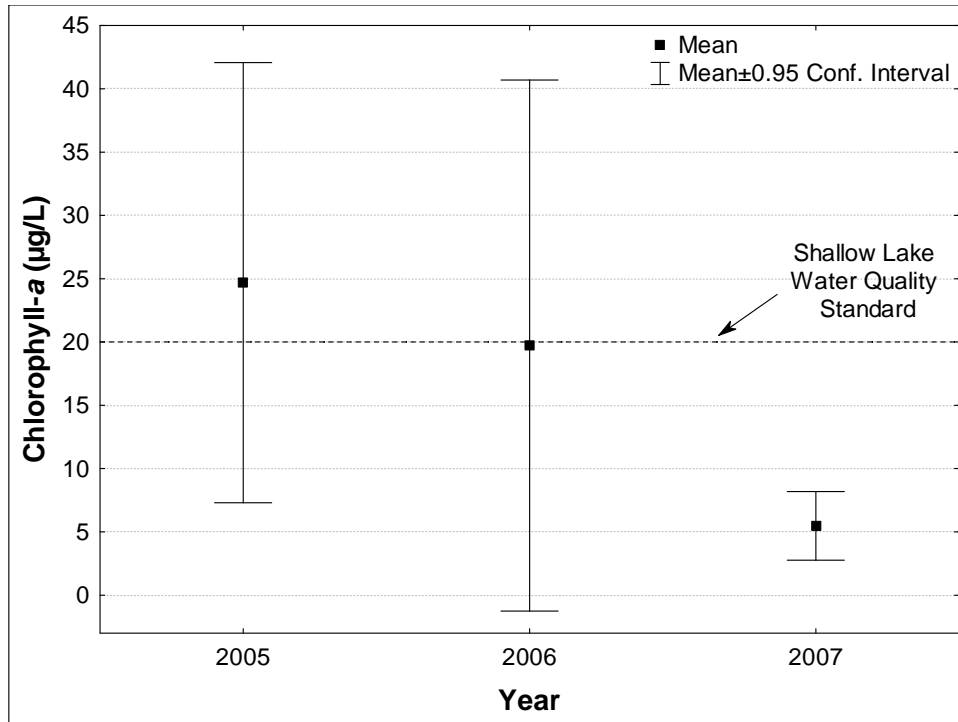


Figure 3. Langton Lake North Basin Chlorophyll-a.

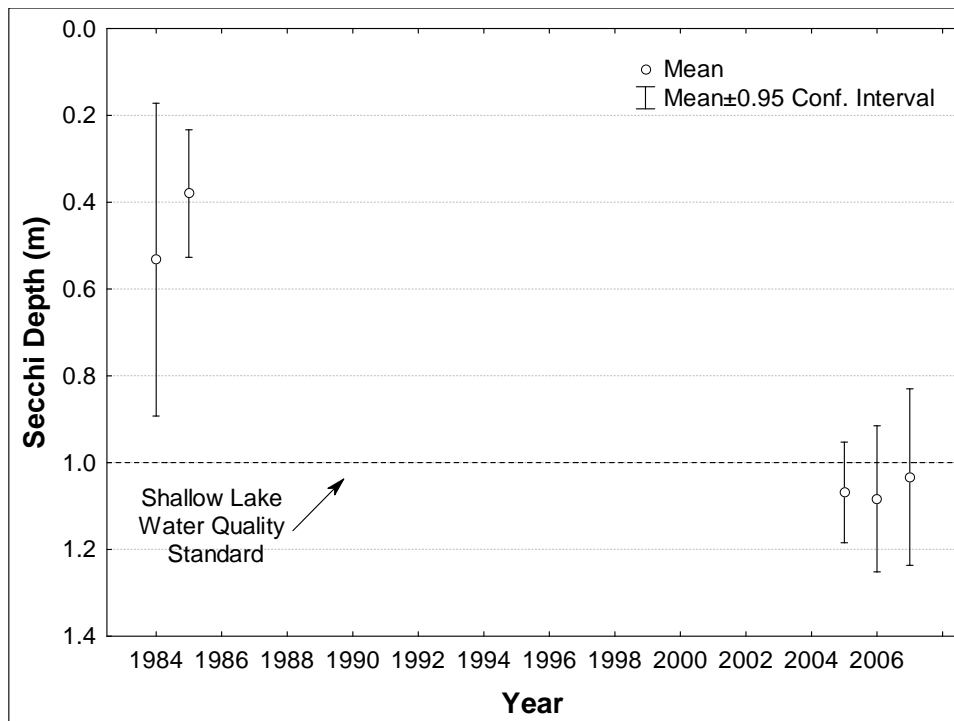


Figure 4. Langton Lake North Basin Secchi Depth

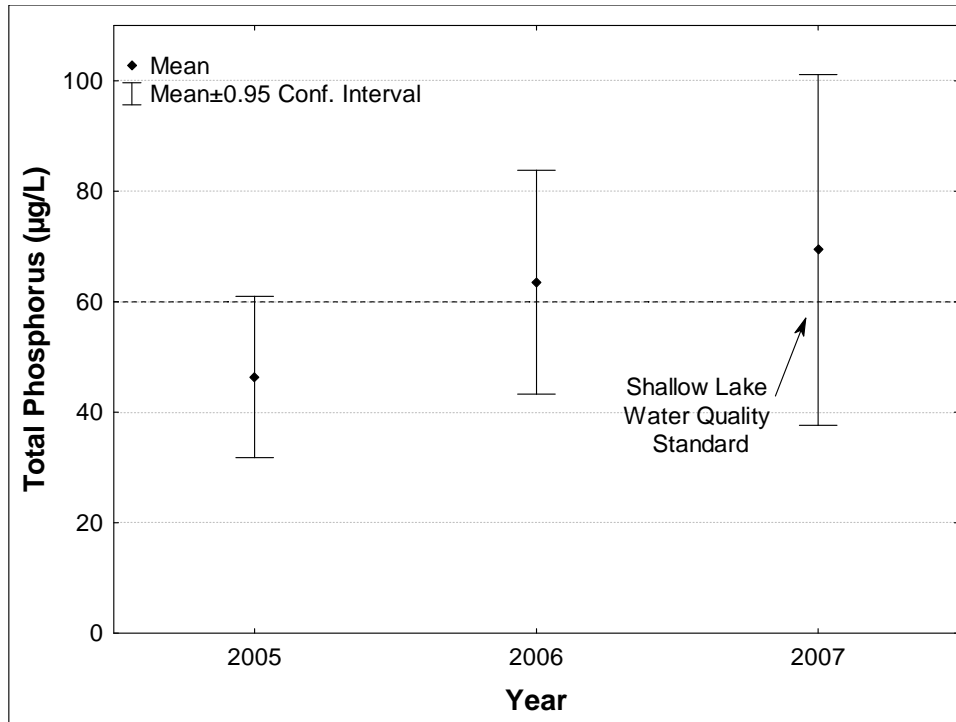


Figure 5. Langton Lake South Basin TP.

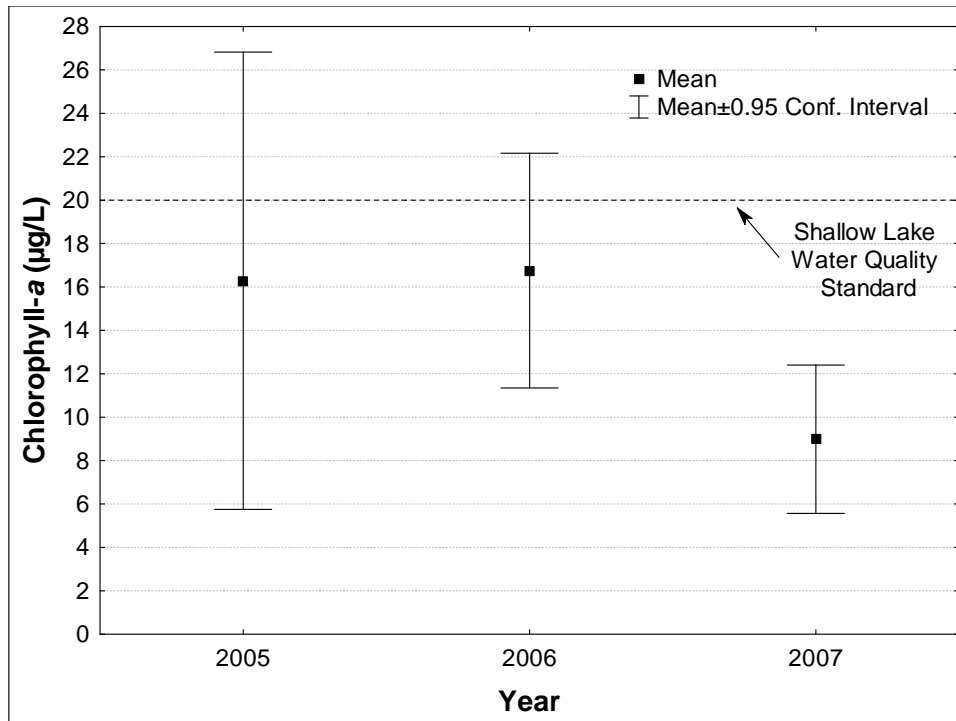


Figure 6. Langton Lake South Basin Chlorophyll-a.

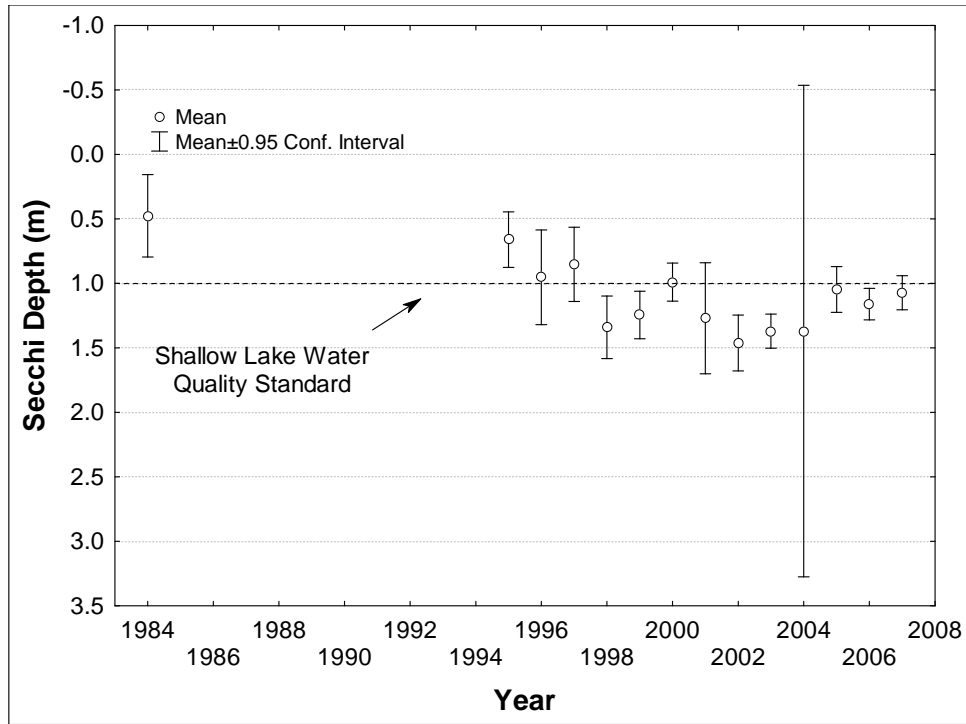


Figure 7. Langton Lake South Basin Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality modeling indicates that the watershed inputs account for approximately 94% of the nutrient load, with internal loading accounting for the remaining 6% (Figure 8). (The northern wetland was not included in lake modeling.)

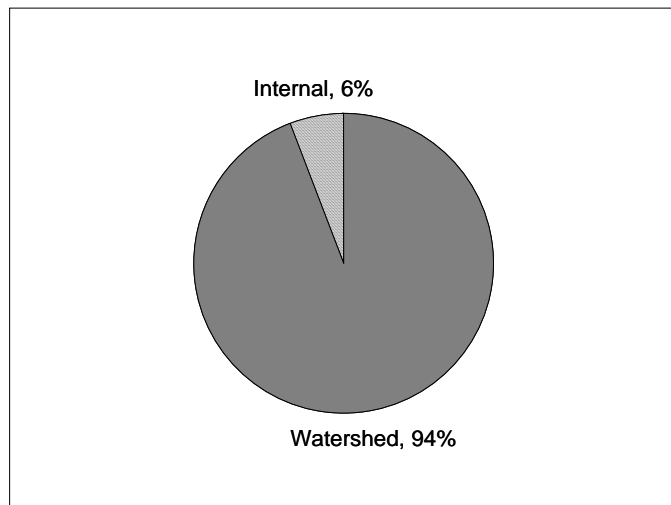


Figure 8. Langton Lake Phosphorus Load Distribution

Public Input

At the public input meeting held on June 2, 2008, a lake resident offered her insight on Langton Lake.

- This resident discussed the lake's water quality problems and suggested that untreated runoff from the surrounding area directly discharging into the lake was the obvious source of the problem. She suggested identifying major stormsewer inlets and getting some treatment upstream of those points. Specifically, she identified as one possible retrofit BMP site the parking lot on the west side of the lake that runs directly off into the lake. Installation of a treatment swale or rain garden would be an easy and inexpensive retrofit for this situation. The citizen urged that any new BMPs be adequately maintained because she has noticed that they often are ignored after installation.
- The resident also noted that there is an area in the south basin where there is no evident plant life. She also noted there is at least one barrel and some assorted debris (fence, old dock) visible in the south basin. Because she did not know the nature of the barrel or whether it was structurally intact, it is recommended that the MPCA or the county be contacted to assess it prior to removal. The barrel was reported to an MPCA Duty Officer on January 6, 2009 – reference #100698.
- The attendee also noted that her feeling is that concerned citizens want to do as much as they can to protect their lakes of interest, but often do not know what they can or should do. Some guidance from the RCWD, the city, and MPCA on lake protection activities for citizens would be appreciated. She also noted a past problem with agency responsiveness, wherein the buck was often passed to some other agency when action is requested. She specifically mentioned this in terms of the city, RCWD, the county, and MPCA. Although specific details were not offered, frustration resulted when she tried to find out which agency should be addressing the problems with Langton Lake.
- The resident also noted that she has observed the degradation of the wildlife corridor extending from Langton Lake to the east to Little Johanna Lake. She attributes the decline to development and the lack of concern for maintenance of the corridor.
- Shoreline erosion, especially near the access point on the south basin, is an issue.
- Rapid expansion of white waterlily, particularly in the north basin, has been noted as a problem by both the DNR and local residents.
- Residents suggested that the clarity (Secchi) data could be misleading. Dense aquatic vegetation often blocks viewing of the disk, suggesting that the average Secchi depth may be better than what the data indicate.

Water Quality Issues

- There appears to be a high phosphorus load originating in the watershed and several areas that are untreated that drain directly to the lake.
- The lake is meeting water quality standards, but a slight degradation in water quality could cause the lake to not meet standards. Additionally, a slight degradation in water quality could cause the lake to shift from the clear-water, macrophyte dominated phase to the turbid, algal-dominated phase common in shallow lakes.
- The waterlily removal effort is a potential stressor to the stability of the lake's water quality, in that aquatic macrophytes tend to stabilize the lake in the clear-water phase. White waterlily also provides excellent fish habitat.

- High densities of planktivores (bluegill and sunfish) can also stress the stability of the lake's water quality through overgrazing zooplankton, which normally keep the algal density under control. Although the lake is subject to winterkill, the continual stocking of the lake with panfish and the lack of piscivores in the lake ensure that the panfish densities remain high throughout the growing season.
- Although they don't appear to be a nuisance in Langton Lake, black bullhead are present in the lake. Black bullhead are benthivorous fish that can disturb bottom sediments, releasing sediment phosphorus into the water column.

Recommended Management Approach

Lake improvements could be achieved if additional watershed and internal lake management practices are pursued.

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing the water quality of Langton Lake. Because the Langton Lake watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 6 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- Continue to coordinate closely with the City of Roseville and developers of the Twin Lakes Area to ensure that District Rules are achieved or exceeded as this area develops.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management.
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs.
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control.

Internal Lake Management Recommendations

Although the lake is currently in the clear-water, macrophyte dominated phase, several stressors currently exist in the lake that could tip the balance and lead to a shift to the turbid, algal-dominated phase. Internal lake management should address these stressors and prevent the accumulation of additional stressors.

- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. Floating macrophytes can help keep a shallow lake in the clear-water phase by shading out algae and keeping the nutrients within aquatic macrophyte biomass instead of algal biomass. Although dense populations of white waterlily (a floating macrophyte) can inhibit boating, lake management should balance the recreational uses of the lake against the lake's water quality. Removal of aquatic macrophytes can destabilize the lake and make it more likely to shift to the turbid algal-dominated state commonly observed in shallow lakes.
- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. The fisheries stocking plan should take into account the potential impact of high densities of panfish. The black bullhead population should be tracked to determine if it reaches nuisance levels. Work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Langton Lake.

- Bathymetric data collection
- TP, chlorophyll, and Secchi depth data: Collect data for one to two additional years, with at least five sampling dates per year. Continued support of the CAMP program should ensure sufficient water quality data are collected.
- Macrophyte surveys: To update the survey from 2000, complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the existing fish data regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Langton Lake Field Reconnaissance Supplement

Local Management BMPs



Langton #1

Location: West of Arthur Place and north of County Road C2

Description: Playground area on the east side of Langton Lake Park.

Potential Improvements: Coordinate with Roseville Parks & Rec to incorporate water quality BMP at the location of the playground equipment. Capture adjacent parking and street runoff. Move playground equipment to the east on higher ground.



Langton #2

Location: Brenner Avenue just north of Langton Lake

Description: Open area currently being used as small basketball court.

Potential Improvements: Coordinate with Roseville Parks & Rec., consider this area for treatment of street runoff prior to discharge to lake. An assessment would need to be made with respect to how much drainage area could be routed to this location.



Langton #3

Location: Industrial area west of Langton Lake and north of County Road C2

Description: Open space with trees just north of County Road C2.

Potential Improvements: Coordinate with Roseville Parks & Rec and private landowner. Consider tree remove tree and excavation of large filtration or ponding. This location could potentially pick up a large amount of impervious area from the adjacent roads and industrial sites.



Langton #4

Location: South of County Road C2 and west of Langton Lake

Description: Open space with trees just south of County Road C2. (Note: area to the left of fire hydrant is lower and more suitable than the area in the center of the photo.)

Potential Improvements: Coordinate with Roseville Parks & Rec Dept. Consider tree remove tree and excavation of large filtration or ponding. This location could potentially pick up a large amount of impervious area from the adjacent roads and industrial sites.

Site Specific Management BMPs



Langton #5

Location: Eagle Crest at the corner of Brenner Avenue and Arthur Street

Description: Open area with swale currently receiving parking runoff

Potential Improvements: Swale could be enhanced to provide more treatment / depressional storage prior to discharge to the lake.



Langton #6

Location: Industrial area west of Langton Lake north of County Road C2

Description: Large amounts of impervious (parking and roof top) ponding in parking area before discharging to Langton Lake.

Potential Improvements: Create a ponding/treatment area for this runoff at discharge location. This would require removal of trees and/or pavement area.

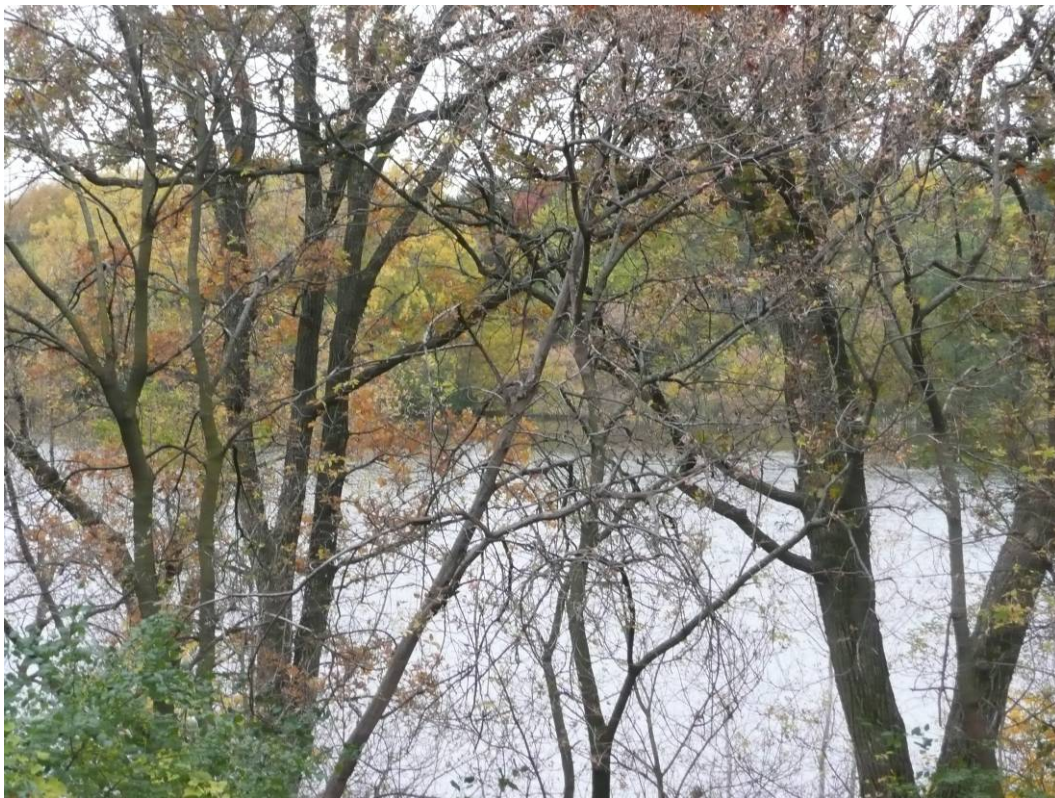
Little Lake Johanna Management Action Plan

Little Lake Johanna (62-0058) is located in the cities of Arden Hills and Roseville, Ramsey County, Minnesota (Figure 1). The lake has a surface area of 17 acres, a maximum depth of 28 feet (Figure 2)¹.

The watershed area draining to Little Lake Johanna is 1,751 acres; the majority of the watershed runoff reaches the lake through Ramsey County Ditch 4. The watershed's land use is primarily residential with some commercial and transportation uses.

Little Lake Johanna is listed as impaired on the EPA's 303(d) list for aquatic recreation due to high nutrient concentrations.

According to a 1984 DNR fisheries assessment, the carp, black bullhead, and black crappie are abundant. The lake also supports populations of northern pike and brown bullhead. A more current fisheries assessment is not available. Currently the lake is not stocked by the DNR.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from the DNR Lake Finder website.

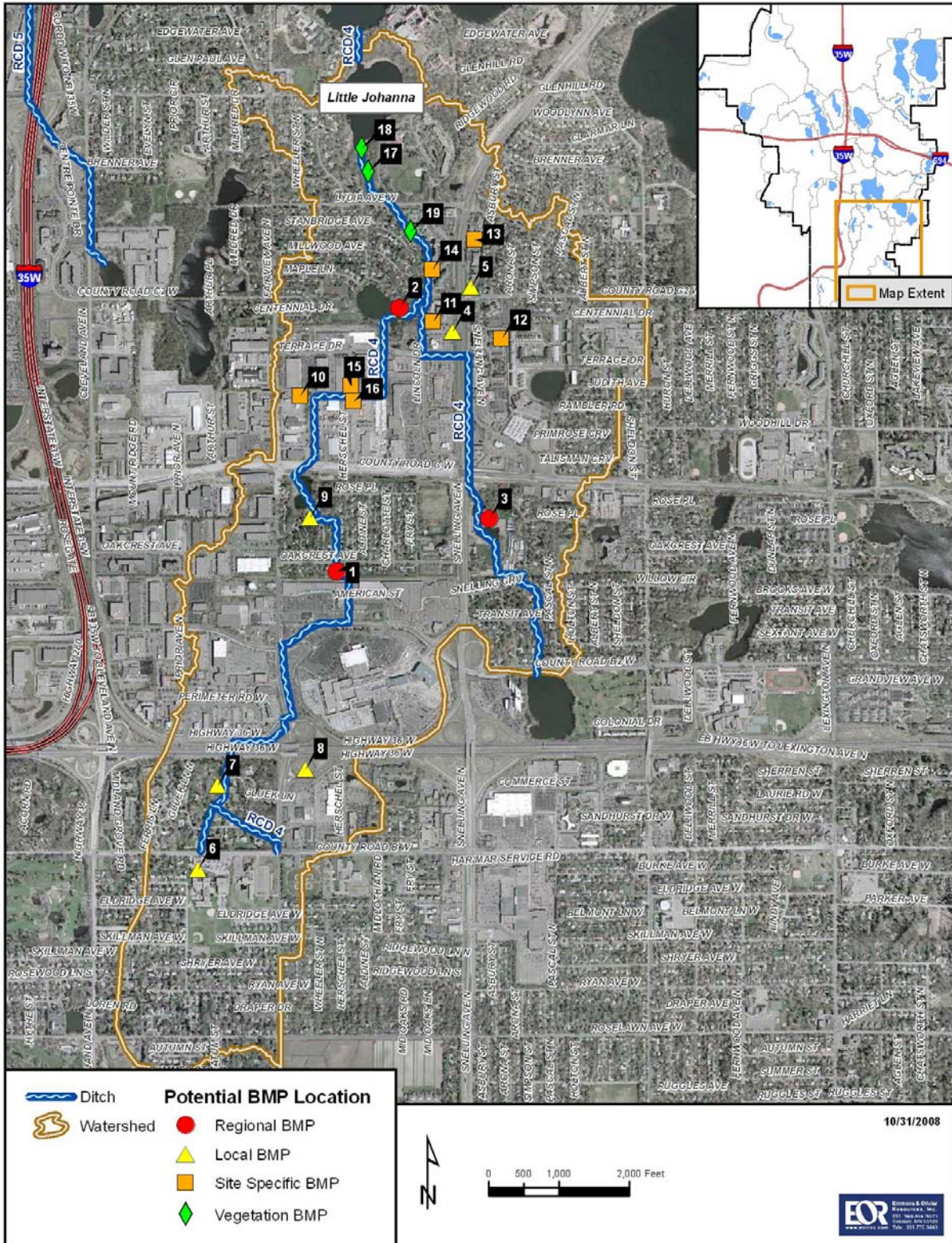


Figure 1. Little Lake Johanna and Potential BMP Locations

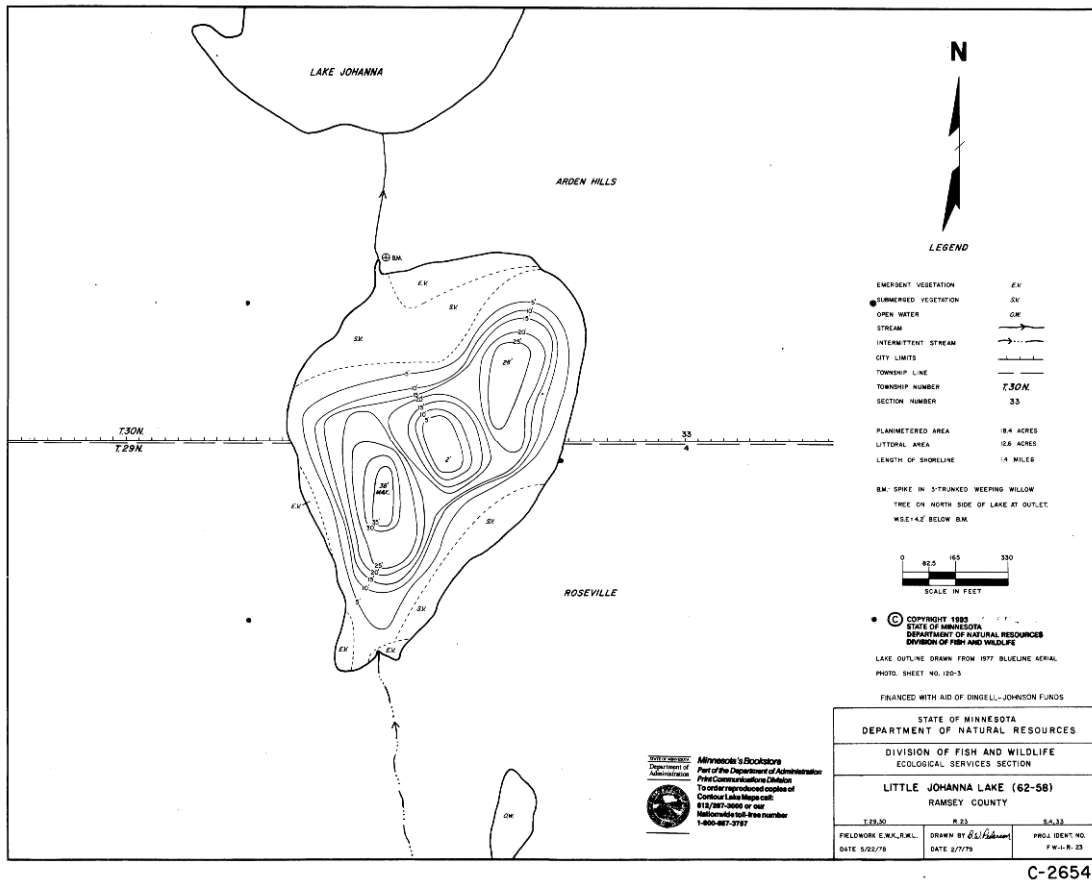


Figure 2. Little Lake Johanna Bathymetry

Water Quality Summary

Water quality data were collected for Lake Johanna from 2001 through 2006. Data were collected by volunteers through the Citizen Assisted Monitoring Program (CAMP). A summary of the six years of monitoring data (Table 1) suggests that the lake is not meeting the state water quality standards for total phosphorus (TP) or chlorophyll-*a*, but is meeting the standard for Secchi depth (clarity).

Table 1. Average Water Quality Data (2001-2006) and Standards

Parameter	Little Lake Johanna	Standard
TP ($\mu\text{g/L}$)	80	40
Chl ($\mu\text{g/L}$)	25	14
Secchi Depth (m)	1.5	1.4

Figures 3 through 5 show the growing season total phosphorus (TP), chlorophyll-*a*, and Secchi depth (clarity) for Little Lake Johanna.

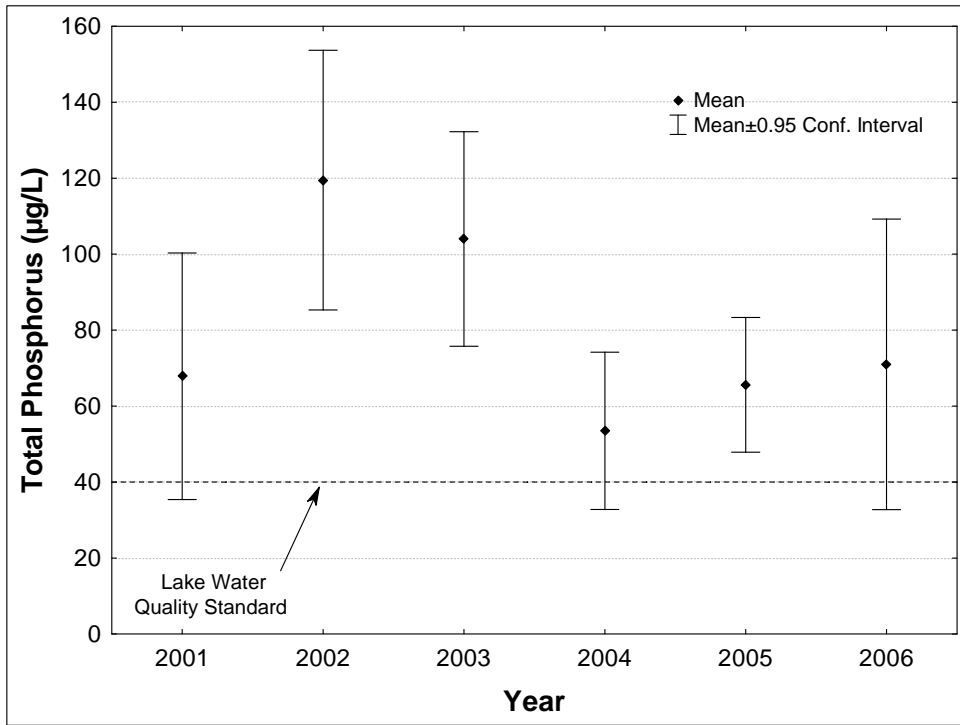


Figure 3. Little Lake Johanna Total Phosphorus

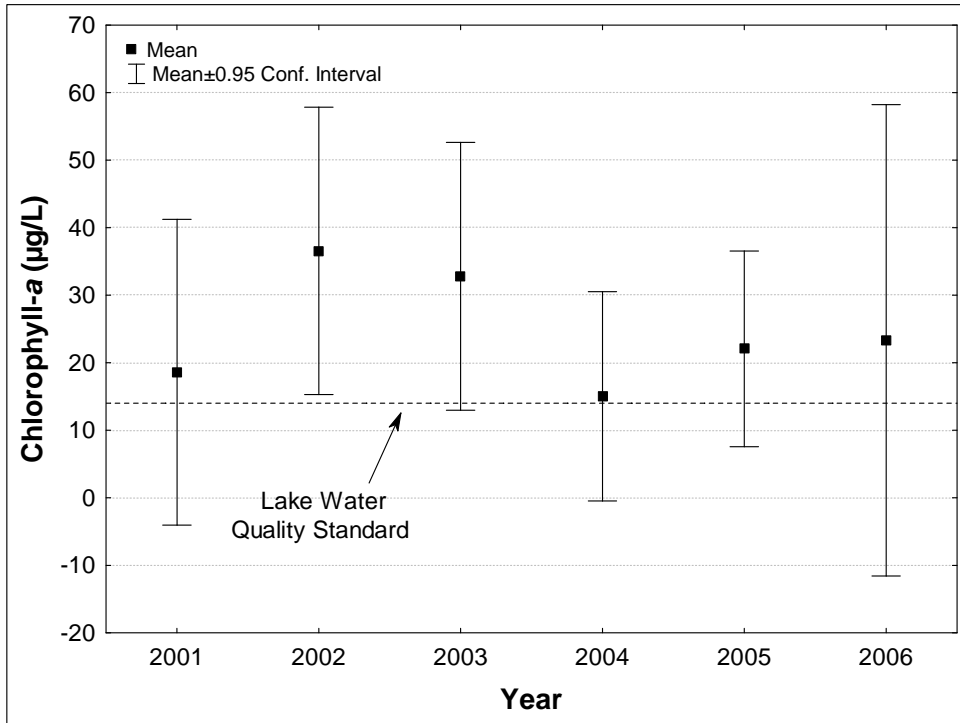


Figure 4. Little Lake Johanna Chlorophyll-a

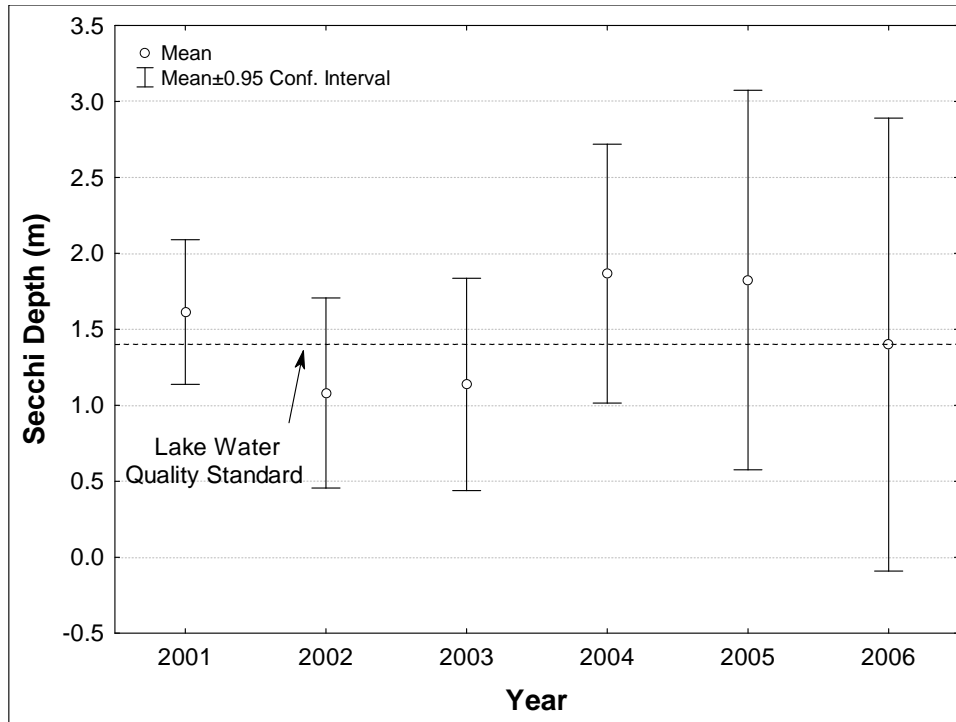


Figure 5. Little Lake Johanna Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality modeling indicates that watershed inputs account for approximately 79% of the nutrient load, with internal loading accounting for the remaining 21% (Figure 6). To reach the in-lake goal of 40 $\mu\text{g/L}$ TP, the phosphorous load needs to be reduced by 62%. Water quality and flow were measured in Ramsey County Ditch 4 during the summer of 2008. The RCWD plans to use this data to better estimate watershed loading.

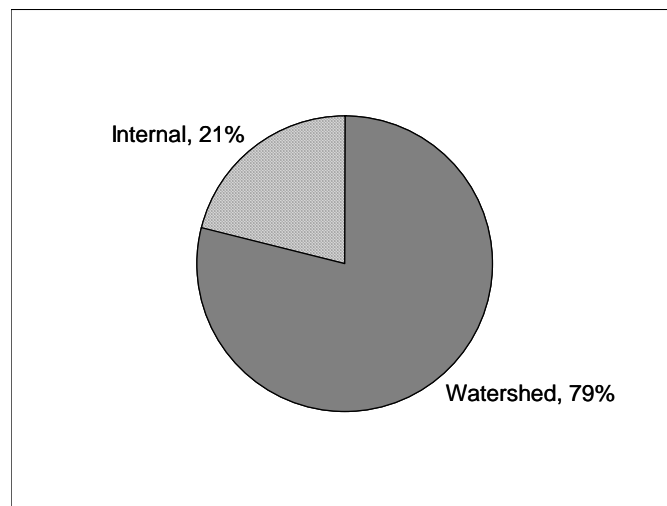


Figure 6. Little Lake Johanna Phosphorus Load Distribution

Public Input

At the public input meeting on June 5, 2008 issues facing Little Lake Johanna were addressed. Some comments offered refer to a previous Clean Water Partnership study for Long Lake that included recommendations for the Johanna and Little Johanna watershed. Many of the recommendations in that project were implemented and have proven successful to some degree, but problems continue to exist with the lake.

- Residents around the lake referenced the successful repair of the lake outlet by Ramsey County in early 2008. This repair appears to have addressed a low water problem that affected the lake for the last three years. Some residents supported the idea of dredging within the lake to remove material accumulated from the many years of watershed discharge. They also spoke of the fact that a 30+ foot hole still exists in the lake even though several areas of sediment accumulation also exist. The inflow from Ramsey County Ditch 4 (RCD 4) is the major input for problems encountered on the lake. Complaints about the erosive nature of this ditch and the lack of runoff treatment for the area draining to it are the basis for many of the recommendations for improvement.
- Curly-leaf pondweed is present in the lake at relatively high densities, and the lake was chemically treated for it in 2008.
- The smell of algae on the lake was raised by some attendees. Solving the nutrient influx into the lake would go a long way toward reducing algal blooms, but it was recognized that short-term improvements are not likely. However, the attention that Little Johanna is receiving now and will receive as an impaired water makes the future look a lot better.
- Street sweeping was a popular recommendation by meeting attendees. It was stated that the City of Roseville sweeps its streets only once per year and that the Rosedale shopping center does not do a good job of keeping its parking lots clean. Attendees recommended that the city increase its sweeping frequency and that the shopping center(s), including others in the sub-watershed, also be asked to do a better job of sweeping. Spot sweeping of critical areas, such as those directly draining to lakes, was encouraged.
- It was noted that detention ponds on the Northwestern College campus, one located west of Snelling Avenue and south of County Road C, and one at EagleCrest Retirement Homes, were in need of deepening to restore their ability to adequately handle runoff.
- Some attendees expressed their unhappiness with runoff leaving some of the construction underway at the Northwestern College campus. The attendees urged the RCWD to do a better job of site inspection for construction activities within the watershed.
- Residents suggested that the clarity (Secchi) data could be misleading. Although water clarity appears to meet state standards, dense algae colonies are often observed during the middle of summer. Colonies tend to be pushed to one shore or another (depending on wind), and clarity readings are usually taken in the middle of the lake, thus underestimating algal productivity (Figure 7).
- Finally, residents would like some attention placed on fish management. Nuisance rough fish are currently a problem.



Figure 7. Dense algae mats in the Little Lake Johanna outlet on June 29, 2008.

Water Quality Issues

- Ramsey County Ditch 4 likely carries a high phosphorus and sediment load to Little Lake Johanna. Portions of the ditch are eroding, and portions of the watershed draining to it remain untreated. Shopping centers and construction sites in the watershed may also be substantial sources of phosphorus and sediment.
- Detention ponds within the watershed are in need of maintenance.
- Carp densities were high in the 1984 fisheries survey. They are likely still a problem in the lake, contributing to internal loading rates.
- Curly-leaf pondweed is present in the lake and likely contributes to internal loading.

Recommended Management Approach

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing the nutrient impairment. Because the Little Lake Johanna watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 19 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Feasibility and Benefit Level Assessment of the three potential regional BMP locations identified in the *field reconnaissance supplement*.

- Consideration of local partnerships for further assessment of the six potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- The entire reach of Ramsey County Ditch 4 (RCD 4) from Co. Rd. C to Terrace Drive should be cleaned of debris scattered throughout. Within this reach, numerous adjacent commercial/transportation sites discharge runoff without any controls. Several areas of channel erosion also exist because of this unmanaged runoff. The use of rate reduction BMPs and BMPs to treat oil and grease and other toxic runoff components from these hot-spot locations is recommended. Oil and grease separators, and BMPs with sorbent pads, are needed to address the polluted runoff noted at these sites. Although these recommendations specifically address the more toxic content of urban stormwater runoff, they are also fairly effective at phosphorus removal and should benefit both Little Johanna and Johanna Lakes.
- The amount of untreated impervious runoff from the quadrant generally encompassed by Terrace Drive, Snelling Avenue, County Road C and Fairview is significant. While this area is routed to the Oasis Pond, additional field reconnaissance and cost-share opportunities should be identified as it is unlikely that Oasis Pond can adequately remove all of the pollutants being generated by this area. In addition, it is not anticipated that the Oasis Pond outlet could be retrofitted to provide substantially more water quality storage than exists today considering the lack of freeboard from streets, stormsewer and low floors north of the pond.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

The lake survey from 1984 showed an abundance of carp and high densities of panfish such as bluegill and black crappie. If this is still the case, the fisheries composition likely leads to high rates of internal loading, which should be addressed.

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be continued. Curly-leaf

pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.

- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Little Lake Johanna. Six years of in-lake water quality data exist for the lake and therefore additional in-lake data collection is not a priority at this time. Data collection at the lake's inlet (Ramsey County Ditch 4) is a high priority so that watershed loads can be estimated and loading goals developed for the future TMDL study.

- TP, chlorophyll, and Secchi depth data: Collect at least five sampling dates per year. The TMDL can be based on the existing monitoring data; additional data should be collected after management actions are implemented to track the response of the lake.
- Macrophyte surveys: Complete one macrophyte survey during early June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.
- Ramsey County Ditch 4 should continue to be monitored close to the inlet to Little Lake Johanna to provide flow and phosphorus loading estimates. These data will be needed in order to estimate the watershed phosphorus load to the lake for the TMDL study. In addition, the data could serve to evaluate watershed BMP effectiveness.

Little Johanna Lake Field Reconnaissance Supplement

Regional Management BMPs



Little Johanna #1

Location: South of Oakcrest Avenue and west of Herschel Street

Description: Ramsey County Ditch 4 concrete flume, appears to be designed as a surge basin. Located on City drainage parcel

Potential Improvements: Retrofit to provide additional infiltration/filtration for small storm events. Convert to native vegetation and get low flows out of the concrete flume.



Little Johanna #2

Location: North of Terrace Drive and west of Lincoln Drive

Description: Oasis Pond (Outlet maintained by Roseville)

Potential Improvements: Reroute inlet to reduce short circuiting; maintenance of sheetpile weir outlet. The sheet piling has some holes in it that were plugged but have rusted out, allowing water to pass at a lower-than-intended elevation.



Little Johanna #3

Location: East of Snelling Avenue and south of County Road C

Description: Treatment pond inline with Ramsey County Ditch 4

Potential Improvements: It appears that there may be potential area available for expansion. It would make sense to first monitor the outlet of this pond to determine the need for additional treatment.

Local Management BMPs



Little Johanna #4

Location: West of Snelling Avenue and south of County Road C2

Description: Green space

Potential Improvements: Use for infiltration/biofiltration features to treat adjacent drives/parking.



Little Johanna #5

Location: East of Snelling Avenue and north of County Road C2

Description: Green space

Potential Improvements: Use for treatment of Snelling Avenue. Note: There are several green space areas that appear to have the potential to be better used for treatment.



Little Johanna #6

Location: North of the intersection of Sharondale Avenue and Prior Avenue

Description: Swale area

Potential Improvements: Convert to raingarden.



Little Johanna #7

Location: South of Gluek Lane N

Description: Low areas adjacent and behind homes in this neighborhood. Stormwater from Gluek Lane appears to be routed directly to stormsewer and does not use these low areas.

Potential Improvements: Consider retrofits to provide treatment for Gluek Lane.



Little Johanna #8

Location: Intersection of Highway 36 and Fairview Avenue

Description: Green space in ramp loops

Potential Improvements: All three loops at this location could potentially be better used for treatment of adjacent roadways.



Little Johanna #9

Location: North of Rose Place and west of Wheeler Street

Description: City owner lot – open green space. Ramsey County Ditch 4 flows through a pipe below the green space.

Potential Improvements: Depending on depth and location of the pipe, a surface feature could be incorporated to treat local street runoff from Rose Place and Beacon Street.

Site Specific Management BMPs



Little Johanna #10

Location: East of Fairview Avenue and south of Terrace Drive

Description: Open space adjacent to parking areas

Potential Improvements: Use for area infiltration or biofiltration feature to treat adjacent parking.



Little Johanna #11

Location: East of Lincoln Drive and south of County Road C2

Description: Green space

Potential Improvements: Use for infiltration/ biofiltration features to treat adjacent drives/parking.



Little Johanna #12

Location: East of Snelling Avenue and south of County Road C2

Description: Green space adjacent to church parking lot

Potential Improvements: Incorporate infiltration or biofiltration feature for treatment of church parking lot.



Little Johanna #13

Location: East of Snelling Drive and south of Lydia Avenue

Description: Green space adjacent to parking.

Potential Improvements: Incorporate raingarden areas to treat adjacent parking.



Little Johanna #14

Location: South of Lydia Avenue and west of Lincoln Drive on the Presbyterian Homes property.

Description: A small detention pond on the SW side of the Presbyterian Homes looks as though it drains a portion of the parking lot for the home and possibly the street.

Potential Improvements: Retrofit existing pond, but only a small amount of local storage would likely result.



Little Johanna #15

Location: SALA truck/loading facility just south of Terrace Drive

Description: Runoff from the entire lot drains to some lot inlets and a surface pipe at the RCD 4 ditch bank.

Potential Improvements: Incorporation of a proprietary treatment device that both settles solids and adsorbs hydrocarbons.



Little Johanna #16

Location: Monarch Bus Company parking lot south of RCD 4.

Description: Parking lot runoff flows to northwest corner of site. Outfall in picture has been reconstructed to prevent bank erosion; however, parking lot is still not afforded any treatment before discharge to RCD 4.

Potential Improvements: Incorporation of a proprietary treatment device that both settles solids and adsorbs hydrocarbons.

Vegetation Management / Stabilization BMPs



Little Johanna #17

Location: Stormsewer outfall to RCD 4.

Description: Hanging stormsewer pipe on the west side of the channel midway between Lydia and the lake.

Potential Improvements: Outfall stabilization with reinforcement (ex. rip-rap, concrete, blocks) between the outlet and the channel; also the pipe itself should be supported so that it does not collapse. Roseville noted it will address this stability issue.



Little Johanna #18

Location: RCD 4 Outfall to Little Lake Johanna

Description: As the channel transitions from ditch to lake inflow, there is a break in the concrete and a drop of approximately one foot.

Potential Improvements: Stabilize with additional rock and/or concrete repair to stop undercutting and movement upstream.



Little Johanna #19

Location: Upstream of the Lydia Avenue crossing of RCD 4

Description: Homeowners west of the channel have removed a lot of the trees and planted grass down to the level of the rock emplacement; there is some erosion where the grass (sod) stops and the channel starts.

Potential Improvements: Education and buffer establishment in this stretch would address this erosion potential before a big event causes some wash-out.

Little Lake Josephine Management Action Plan

Little Lake Josephine (62-0201) is located in Roseville, Ramsey County, Minnesota (Figure 1). The lake has a surface area of 44 acres (Figure 2), a maximum depth of 25 feet, and is 90% littoral¹.

Little Lake Josephine meets the MPCA definition of wetland and is classified as a Class 2D (wetland) water in accordance with Minn. Rules Ch. 7050. Furthermore its designation as a Public Water Wetland [“W” 62-201] by the DNR Protected Water Inventory and the lack of an aquatic recreational resource management history (MPCA (*Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment*, 2007) substantiates the designation as a Class 2D water. The Class 2D designation means that the wetland resource is protected for the “maintenance of a healthy wetland aquatic community and for wetland based aquatic recreation.” Numeric nutrient standards developed for shallow lakes (i.e. 60 µg/L TP) do not apply to Class 2D wetlands.

The watershed area draining to Little Lake Josephine is 450 acres. The watershed is primarily residential with some commercial and transportation uses. The lake is surrounded by much of Lake Josephine Park. Little Lake Josephine and its watershed are contained within the Lake Josephine watershed.

According to a 1984 DNR fisheries survey, the lake has an abundance of bluegill, bullhead, carp, and green sunfish. A more recent fisheries survey is not available. The DNR does not stock this lake.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth and percent littoral were taken from the DNR Lake Finder website.

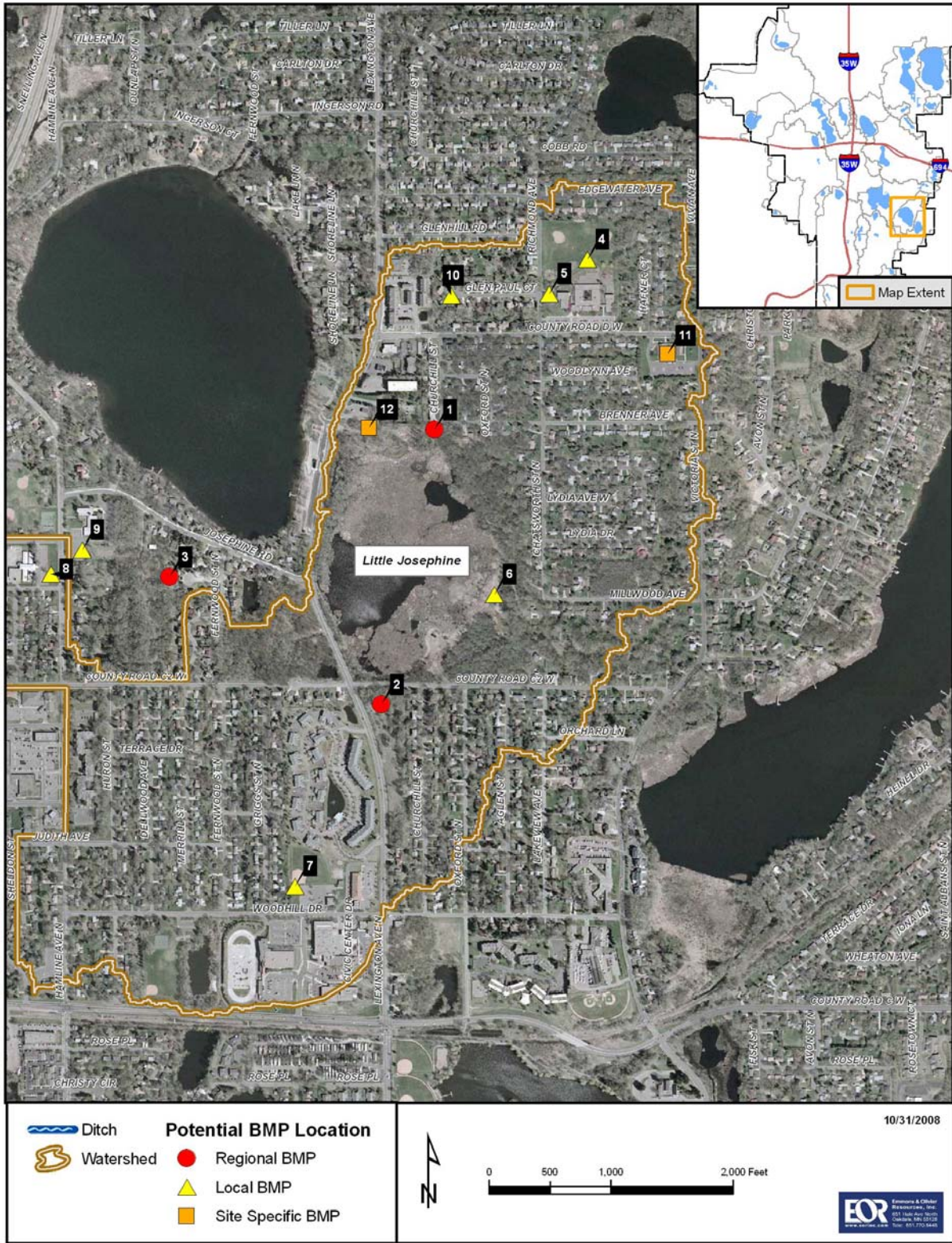


Figure 1. Little Lake Josephine and Potential BMP Locations

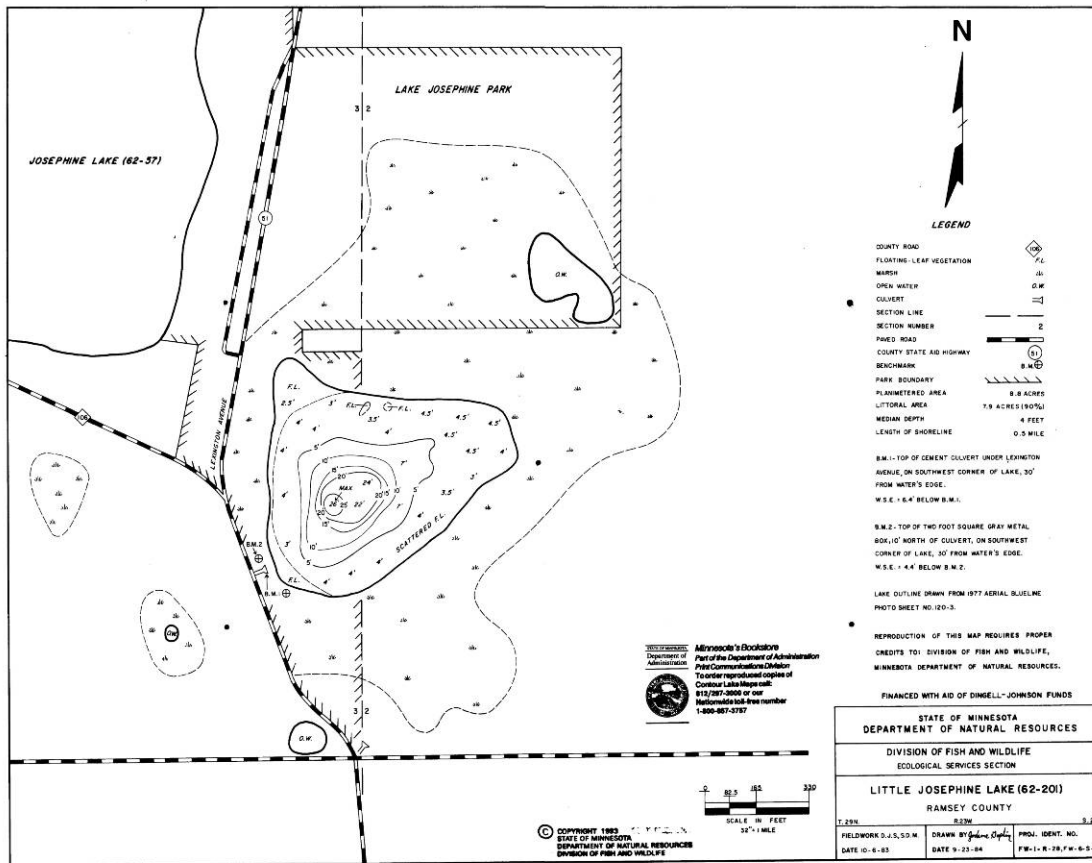


Figure 2. Little Lake Josephine Bathymetry

Water Quality Summary

There are no water quality data for Little Lake Josephine, and biological data are very limited. A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. There are no in-lake monitoring data to calibrate the lake model. Water quality modeling indicates that watershed inputs account for approximately 34% of the nutrient load, with internal loading accounting for the remaining 66% (Figure 3). Without any in-lake nutrient data for the lake for model calibration, the modeling results should be considered preliminary.

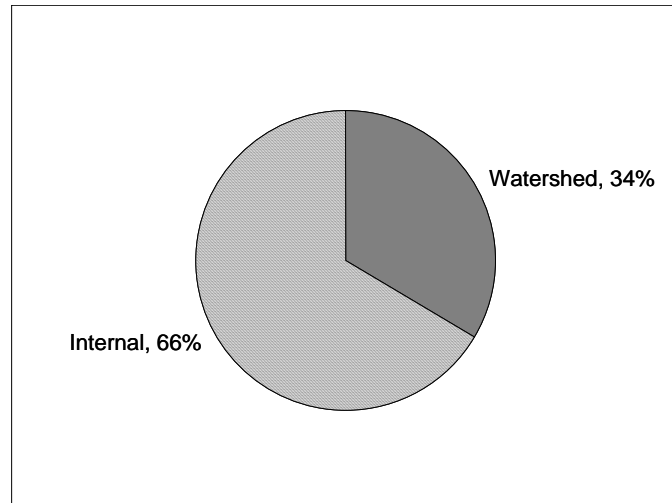


Figure 3. Little Lake Josephine Phosphorus Load Distribution

Public Input

At the public input meeting on June 5, 2008 issues facing Little Lake Josephine were addressed. Preparation for this meeting and some comments offered refer to a previous Clean Water Partnership study for Long Lake that included recommendations for the Little Lake Josephine watershed. Many of the recommendations in that project were implemented and have proven successful to some degree, but problems continue to exist with the lake.

- The attendees also indicated the need for more education on runoff control for residents of the watershed.

Water Quality Issues

- The fish community in 1984 was composed mainly of bluegill, bullhead, carp, and green sunfish. If the fish community composition is similar today, this prevalence of rough fish and planktivorous fish could lead to high rates of internal loading due to disturbance of the lake bottom sediments.
- Without further data or public input, additional water quality issues were not able to be defined.

Recommended Management Approach

Watershed Management Recommendations

Because the Little Josephine Lake watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 11 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Feasibility and Benefit Level Assessment of the two potential regional BMP locations identified in the *field reconnaissance supplement*.
- Consideration of local partnerships for further assessment of the seven potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- A trunk stormsewer from the west discharges to Little Josephine north of County Road C2. This trunk stormsewer could be further investigated for possible daylighting to a regional treatment pond within Cottontail Park and/or the open space east of the park.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

With very little in-lake biological data for Little Lake Josephine, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is

possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Little Lake Josephine. There are no in-lake water quality data for the lake; if the implementation of management practices for the lake were to move forward, in-lake data would be needed and should be considered a high priority.

- TP and chlorophyll data: Grab water quality samples should be collected if there is cause to believe that the water body is enriched with nutrients (as evidenced by mid-summer algae blooms) AND the waterbody is contributing flow to adjacent lakes.
- Macrophyte and/or aquatic invertebrate data should be collected in cooperation with the MPCA to determine if the water body is meeting the “healthy aquatic community standards.”

Little Josephine Lake Field Reconnaissance Supplement

Regional Management BMPs



Little Josephine #1

Location: South of the intersection of Brenner Avenue and Churchill Street

Description: Large piped outlet that flows through woods and then into Little Josephine Lake.

Potential Improvements: Install wetland treatment ponding between outfall and Little Josephine Lake.



Little Josephine #2

Location: South of County Road C2 and east of Lexington Avenue

Description: Low wooded area

Potential Improvements: Use for treatment of the neighborhood to the west and County Road C2.



Little Josephine #3

Location: Cottontail Park

Description: The trunk stormsewer line that runs through the park and across subwatershed divides per City of Roseville storm sewer mapping.

Potential Improvements: Daylight and provide treatment within Cottontail park or open space east of the park. The depth of this trunk line has not been investigated and will have significant effects on the feasibility and cost of this potential project.

Local Management BMPs



Little Josephine #4

Location: North of County Road D and east of Richmond Avenue

Description: Swale running through school property. Swale receives runoff from adjacent neighborhood.

Potential Improvements: Convert swale into a series of raingardens.



Little Josephine #5

Location: North of County Road D and east of Richmond Avenue

Description: Pond at the end of the swale (#4) appears to be undersized.

Potential Improvements: Expand pond (however it would seem to make sense to explore Little Josephine #4 first).



Little Josephine #6

Location: West of the intersection of Chatsworth Street North and Millwood Avenue

Description: Stormsewer outflow swaled to lake

Potential Improvements: Incorporate wetland treatment feature at outlet



Little Josephine #7

Location: North of Woodhill Drive and east of Griggs Street

Description: Open green space adjacent to Veterans Park parking lot and VFW

Potential Improvements: Use area for volume control/infiltration BMP. (This area is routed to a treatment pond.)



Little Josephine #8

Location: North of Millwood Avenue and west of Hamline Avenue

Description: Vacant Lot (redeveloping)

Potential Improvements: Use part of lot to provide treatment for adjacent roads / neighbor hood areas.



Little Josephine #9

Location: East of Hamline Avenue and south of Lydia Avenue

Description: Catch basin at the bottom of green space area

Potential Improvements: Retrofit to provide infiltration and better treatment.



Little Josephine #10

Location: Intersection of Glen Paul Court and Churchill Street

Description: Large cul-de-sec

Potential Improvements: Incorporate center island and provide infiltration/treatment for adjacent impervious.

Site Specific Management BMPs



Little Josephine #11

Location: North of Woodlynn Avenue and east of Milton Street

Description: Open green space adjacent to parking lot

Potential Improvements: Use area for treatment of parking lot.



Little Josephine #12

Location: East of Lexington Avenue and just north of Jones Lake

Description: Parking areas sheet flowing to Little Josephine

Potential Improvements: Incorporate water quality treatment prior to discharge to Little Josephine.

Locke Lake Management Action Plan

Locke Lake (02-0077) is located in the City of Fridley, Hennepin County, Minnesota (Figure 1). Locke Lake is a flow-through lake located on Rice Creek and is at the end of the creek just before its confluence with the Mississippi River. The lake has a surface area of approximately 26.5 acres and a maximum depth of 6 feet¹. Based on its low estimated maximum depth, it is considered a shallow lake according to MPCA's definition.

The watershed draining to Locke Lake is 115,583 acres and includes the entire Rice Creek drainage area and all of the various rural to urban land uses within it. The watershed to lake area ratio is approximately 4361:1. There are many improvements and studies underway in the watershed, all of which should lead in the long-term to improvement of Locke Lake. The east basin of Locke Lake essentially acts as a sediment basin for the lake.

Locke Lake is predominantly an aesthetic and habitat lake that residents use for recreational boating.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos. No bathymetric data were available for this lake. The maximum depth was estimated using depth data collected during sediment sampling.

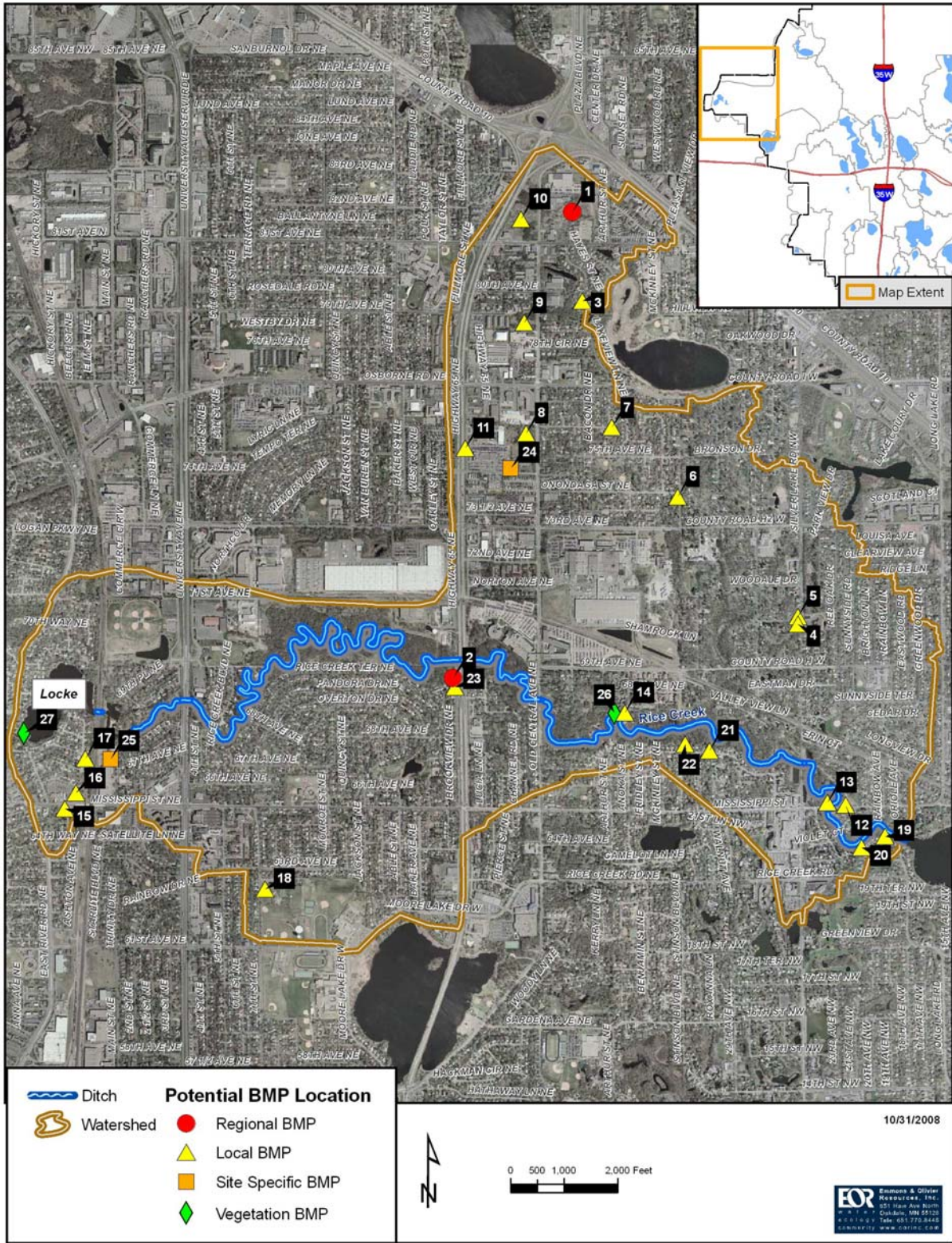


Figure 1. Locke Lake and Potential BMP Locations

Water Quality Summary

Water quality data were collected by RCWD in 2008. Preliminary phosphorus data were available at the time of the report, and are shown in Table 1. In 2008, Locke Lake was not meeting the MPCA phosphorus standard for shallow lakes.

Table 1. Average Water Quality Data (2008) and Standards

Parameter	Locke Lake	Shallow Lakes Standard
TP ($\mu\text{g/L}$)	84	60

Figure 2 shows the total phosphorus (TP) data for Locke Lake.

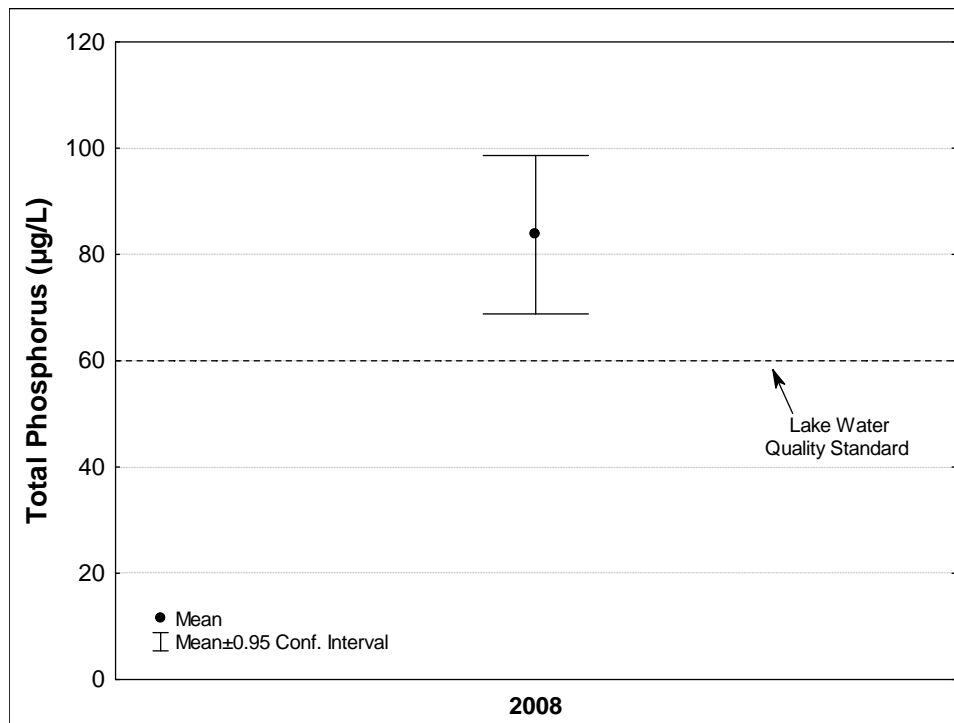


Figure 2. Locke Lake Total Phosphorus

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. Modeling indicates that watershed inputs account for nearly the entire nutrient load, with internal loading accounting for a negligible amount (Figure 3). Phosphorus data collected in 2008 were not used in the P8 model, and modeling results should be considered preliminary.

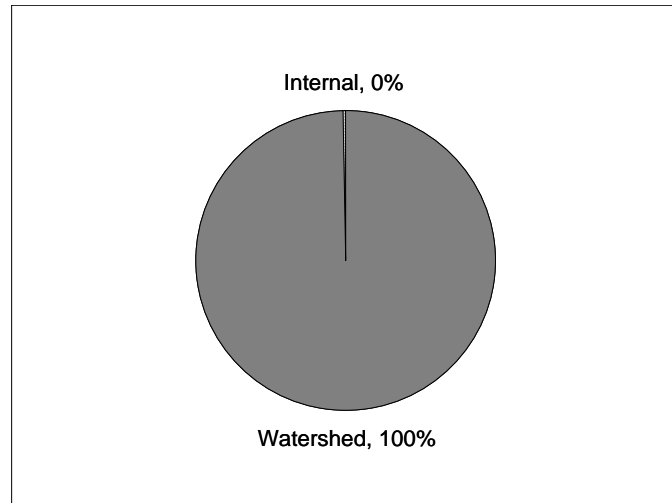


Figure 3. Locke Lake Phosphorus Load Distribution

Public Input

A public input meeting was held on June 3, 2008, no attendee spoke on issues concerning Locke Lake. A second public input meeting was held on January 19, 2008, during which a resident described difficulty reestablishing macrophytes and continuing shoreline erosion due to water elevation bounce on the lake.

Water Quality Issues

- The phosphorus concentration in Locke Lake is high due to its location as a flow-through lake along Rice Creek.
- Although secondary to watershed loading, the lack of aquatic shoreline vegetation coupled with water level fluctuations contributes to shoreline erosion and additional phosphorus inputs to the lake.

Recommended Management Approach

Watershed Management Recommendations

Because the Locke Lake watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. Note that most retrofit opportunities identified in the supplement would not only address Locke Lake, but lower Rice Creek as well. In summary, 27 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Feasibility and Benefit Level Assessment of the two potential regional BMP locations identified in the *field reconnaissance supplement*.
- Consideration of local partnerships for further assessment of the 21 potential local BMP locations identified in the *field reconnaissance supplement*.

- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- Routine monitoring of sediment accumulation and maintenance excavation of the in-lake sedimentation basin in eastern portion of the lake.
- Lower Rice Creek bank stability assessment and installation of bank stabilization amendments for areas with severe bank erosion.
- Continued project related improvements and the studies currently underway in the watershed. Various structural projects, such as critical weir replacements, maintenance projects, such as routine clean-out of the Long Lake sediment basin, and studies with implementation plans, such as the numerous TMDL studies, should all result in incremental improvements within the watershed.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Continued shoreline restoration / buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Continued public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

With very little in-lake biological data for Locke Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Locke Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an

overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Locke Lake. If the implementation of management practices for the lake were to move forward, bathymetric data would be needed and should be considered a high priority.

- Bathymetric data collection
- TP, chlorophyll, and Secchi depth data: Collect data for several years, with at least five sampling dates per year.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Locke Lake Field Reconnaissance Supplement

Regional Management BMPs

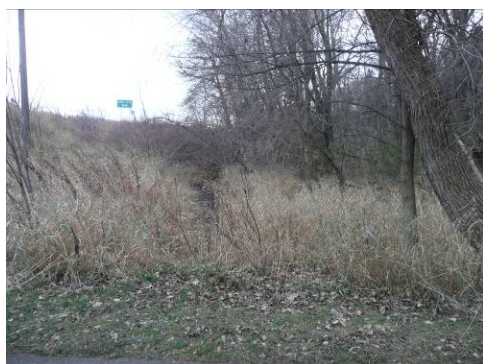


Locke 1

Location: East of Old Central Avenue and north of 81st Avenue

Description: Large existing wetland receiving drainage from adjacent industrial area.

Potential Improvements: Assess current treatment capacity and assess options for enhancements to improve water quality treatment.



Locke 2

Location: North of the intersection of Brookview Drive Rice Creek Terrace

Description: Stormsewer outfall from adjacent roadways from the south, runs through woods/swale into Rice Creek

Potential Improvements: Create wetland treatment/ponding area to provide treatment for stormsewer flows.

Local Management BMPs



Locke 3

Location: West of Hayes Street and north of 80th Avenue

Description: Green space on corner

Potential Improvements: Incorporation of a large raingarden for treatment of adjacent roadways.



Locke 4

Location: West of Silver Lake Road and south of Woodcrest Drive

Description: Open space/small trees on corner

Potential Improvements: Incorporation of a large raingarden to treat street runoff.



Locke 5

Location: West of Silver Lake Road and north of Woodcrest Drive

Description: Open space/small trees on corner

Potential Improvements: Incorporation of a large raingarden to treat street runoff.



Locke 6

Location: West of Stinson Boulevard and south of Onondaga Street

Description: Open low area at the corner.

Potential Improvements: Incorporation of infiltration basin or ponding area for treatment of adjacent roadways.



Locke 7

Location: East of the intersection of Arthur Street and 76th Avenue

Description: Large vacant lot.

Potential Improvements: Utilize area for treatment of adjacent roadways.



Locke 8

Location: West of Old Central Avenue and south of 76th Avenue

Description: Large vacant lot adjacent to industrial areas.

Potential Improvements: Utilize for a large treatment basin for Old Central Avenue and or adjacent industrial sites.



Locke 9

Location: West of Old Central Avenue and north of Lakeview Lane

Description: Large vacant lot adjacent to industrial and residential areas.

Potential Improvements: Utilize for a large treatment basin for Old Central Avenue and or adjacent impervious areas.



Locke 10

Location: East of Old Central Avenue and north of 81st Avenue

Description: Large open and wooded areas (current use unknown)

Potential Improvements: Utilize for treatment of adjacent highway and/or adjacent industrial park.



Locke 11

Location: North of Fireside Drive and east of Highway 65

Description: Example of large swales along Highway 65 providing treatment.

Potential Improvements: Maintain and or enhance rural section drainage.



Locke 12

Location: North of the intersection of Mississippi Street and Mississippi Circle

Description: Green space between Mississippi Street and existing trail.

Potential Improvements: Incorporate raingarden area for treatment of a portion of Mississippi Street.



Locke 13

Location: North of Mississippi Street and east of Violet Lane

Description: Wooded area west of the creek.

Potential Improvements: Route stormsewer to this area and construct a wetland treatment area.



Locke 14

Location: South of the intersection of Anoka Street and Timber Ridge South

Description: Stormsewer discharge from Timber Ridge Condos and Rice Creek Condos routed directly into Rice Creek.

Potential Improvements: Reroute outlet into existing wetland area and eliminate direct connection to creek. The quality of the existing wetland and potential impacts from stormsewer discharges would need to be assessed before rerouting/reconfiguring the system.



Locke 15

Location: South of Mississippi Street and west of Ashton Avenue

Description: Open green space at the corner.

Potential Improvements: Utilize for treatment of adjacent roadways with a large raingarden.



Locke 16

Location: South of 66 ½ Way and west of Ashton Avenue

Description: Open space adjacent to an existing church.

Potential Improvements: Utilize area for treatment of the church parking lot or the adjacent roadways.



Locke 17

Location: East of Ashton Avenue and north of 66th Way

Description: Open space within Edgewater Gardens Park

Potential Improvements: Incorporate raingardens along right-of-way to treat Ashton Avenue.



Locke 18

Location: East of 7th Street and south of 63rd Avenue

Description: Large open space located within Commons Park

Potential Improvements: Incorporate treatment features for adjacent parking lot and/or 7th Avenue.



Locke 19

Location: North of the cul-de-sac at the end of Thorndale Avenue

Description: Stormsewer outlet discharging through swale along lot line into Rice Creek

Potential Improvements: Create a linear treatment feature along the lot line prior to discharge to Rice Creek.



Locke 20

Location: North of Mound Avenue and west of Thorndale Avenue

Description: Stormsewer pipe running along lot line and discharging into Rice Creek

Potential Improvements: Daylight stormsewer discharge and create a raingarden providing treatment prior to discharge to Rice Creek.



Locke 21

Location: North of Rice Creek Terrace and east of Pleasant View Drive

Description: Unnecessary impervious area

Potential Improvements: Extend driveways to road and use remaining area for creation of raingardens to treat adjacent roadway.



Locke 22

Location: North of the intersection of Stinson Boulevard and 66 1/2 Avenue

Description: Stormsewer outfall discharging in woods flowing into Rice Creek

Potential Improvements: Create wetland treatment/ponding areas at stormsewer outfall.



Locke 23

Location: North of the intersection of Brookview Drive Rice Creek Terrace

Description: Local street discharge into PVC pipe connecting into stormsewer.

Potential Improvements: Convert area into a raingarden.

Site Specific Management BMPs



Locke 24

Location: North of Fireside Drive and west of Old Central Avenue

Description: Existing treatment facility adjacent to Fridley Chevrolet parking lot. Appears that the feature may provide rate control but limited water quality benefit.

Potential Improvements: Feature could be enhanced to provide additional infiltration and water quality treatment.



Locke 25

Location: West of Main Street and south of Rice Creek Terrace

Description: Low open space adjacent to industrial building

Potential Improvements: Enhance/retrofit low area and utilize for treatment of adjacent building.

Stabilization / Other BMPs



Locke 26

Location: Locke Lake Outlet

Description: Dam controlling water levels in Locke Lake. The dam is an obstruction to natural fish migration upstream.

Potential Improvements: Consider reestablishment of fish passage from the Mississippi into Locke Lake and Rice Creek. Establish a smallmouth fishery in the lower stretch of Rice Creek. The pros and cons of allowing Mississippi River fish (game and rough) to migrate upstream would need to be considered before proceeding with any studies/assessments.



Locke 27

Location: Rice Creek South of Timber Ridge South

Description: Ground water seepage beneath an undercut bank. Just one example of a failing bank along Rice Creek.

Potential Improvements: Incorporate bank stabilization for areas along Rice Creek with severe bank erosion. Continue to reduce rates and flows from upstream sources that are the cause accelerated bank erosion.

Long Lake Management Action Plan

Long Lake (62-0067) is located in the City of New Brighton, Ramsey County, Minnesota (Figure 1). The lake consists of a north and a south basin. The north basin has a surface area of approximately 73 acres, a maximum depth of 24 feet. (Figure 2)¹. The south basin has a surface area of 119 acres, a maximum depth of 24 feet.

The watershed area draining to Long Lake is 105,082 acres (164 square miles) and includes the entire Rice Creek watershed draining into the lake from the northeast, plus the contributing area from the south, including the Lake Johanna, Valentine Lake, and Jones Lake sub-watersheds. The watershed to lake area ratio is approximately 547:1.

Long Lake is surrounded on the west, north, and south sides by residential, transportation, and some open space. I-694 is in close proximity to the southern side of the lake. The east side of the lake is contained within the Long Lake Regional Park and a municipal park managed by the City of New Brighton. Recreational facilities on the east side include a swimming beach, boat launch, and fishing pier. The use of the east side as a major recreational resource in the region is a primary reason for seeking to improve Long Lake.



Long Lake is listed as an impaired lake on the EPA's 303(d) list of impaired waters. It is impaired for aquatic recreation due to high nutrients. There are other impaired waters tributary to the south basin of Long Lake, including Pike Lake (nutrients), Valentine Lake (nutrients), Jones Lake (wetland impaired for aquatic life), Little Lake Johanna (nutrients), Silver Lake

¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from DNR files.

(nutrients), and Island Lake (nutrients). The remaining impaired waters in RCWD are tributary to the north basin of Long Lake.

Long Lake was the subject of a major Clean Lakes Partnership study in the 1980-90s that resulted in the implementation of numerous projects. The completion and follow-up report indicated some progress being made toward clean-up, but also acknowledged that many of the watershed improvements did not result in measureable success.

Curly-leaf pondweed reaches a moderate growth level in Long Lake. A macrophyte survey completed in early August of 2008 by the Ramsey Conservation District and Ramsey County Public Works showed light densities of curly-leaf pondweed in many of the littoral areas of the lake. Since curly-leaf pondweed usually dies back after June, it was assumed that peak densities are higher in June than what was observed in the August survey. A lack of vegetation was observed in some of the shallow areas of both basins.

Extensive fisheries data exist for Long Lake in surveys dating back to 1953. The most recent information from 2003 indicates that a mix of fish exist in the lake as a result of migration up from the Mississippi River when the Locke Lake dam was being repaired. The lake supports populations of rough fish (carp, bullhead, sucker, and buffalo) and bluegill. Survey data indicate that the carp population size is above the normal range (i.e. higher than the third quartile) expected for lakes of this type. The bluegill population, although higher than the medial level for lakes of this type, exhibits good growth rates and a well balanced size structure. The DNR stocks the lake with walleye and northern pike.

Low concentrations of trichloroethylene (TCE) and cis-1,2-dichloroethylene (DCE), a breakdown product of TCE, have been found in Long Lake and local ground water. The occurrence of these chemicals is likely due to industries in the watershed that in the past handled solvents, degreasers, and petroleum products. The in-lake concentrations are lower than the TCE water quality standards and the DCE water quality guidance value, both based on protecting aquatic organisms and human health for fish consumption and incidental intake of water during swimming. The Minnesota Department of Health completed the Long Lake Health Consultation and concluded that levels of TCE, DCE, and vinyl chloride were well below levels of health concern. The concentrations have been decreasing over time, but it appears that there is a continuing source of the contaminants. The source is currently unknown. Recent MPCA monitoring of shallow aquifers did not show any elevated concentrations of TCE or DCE in shallow groundwater that would explain the detections found in Long Lake.

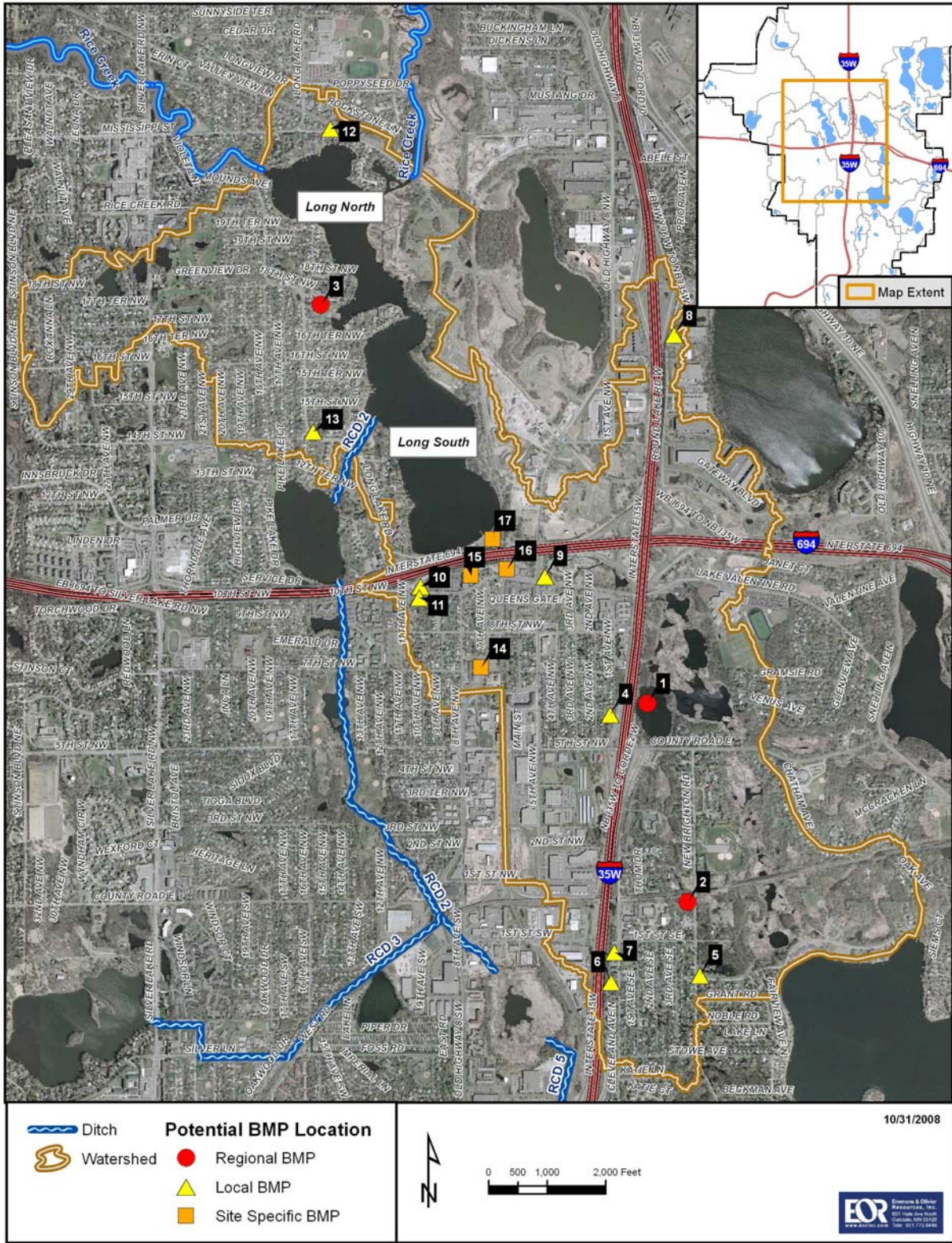


Figure 1. Long Lake and Potential BMP Locations

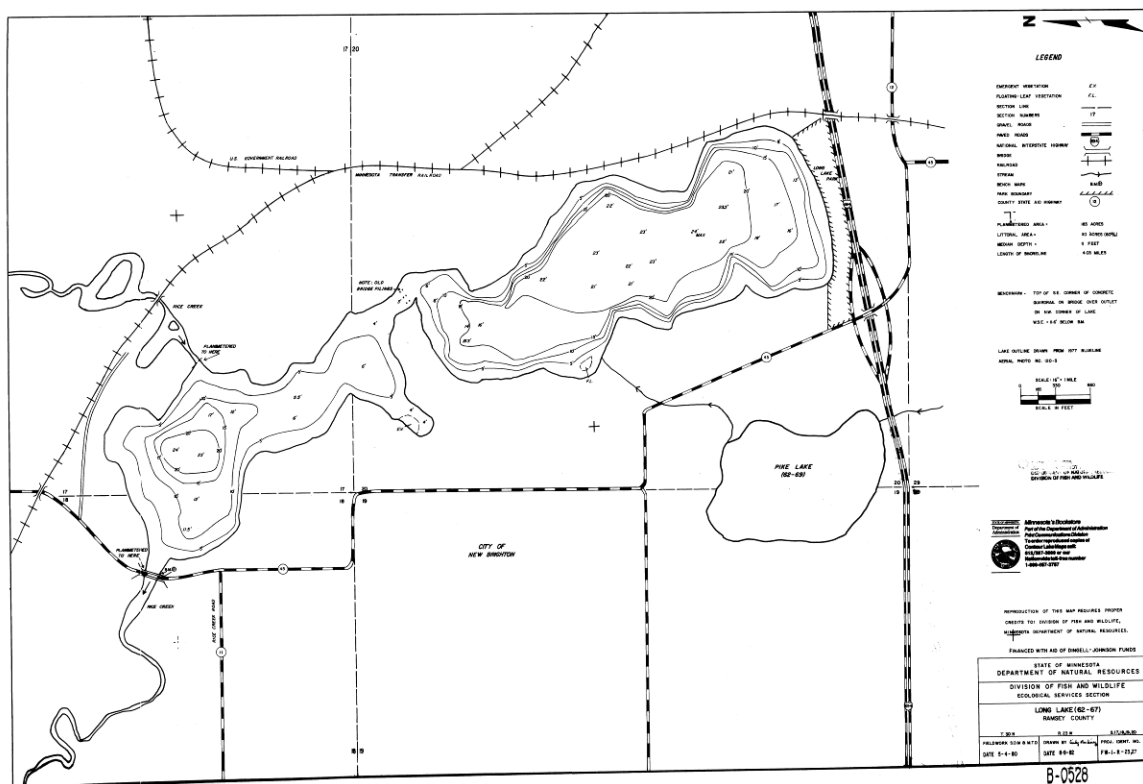


Figure 2. Long Lake Bathymetry

Water Quality Summary

Water quality data for Long Lake in recent history has been collected since the 1980s. Data were collected by Ramsey County Public Works. A summary of the most recent ten years of water quality information for the north and south basins of the lake suggest that the state water quality standards are not being met except for the Secchi depth (clarity) of the south basin. The north basin drains the entire upper Rice Creek watershed and reflects a high phosphorus load coming into the basin from the northeast. The south basin drains a large sub-watershed, but is buffered by flow through from many lakes in the sub-watershed and by Pike Lake immediately upstream of the inflow into the south basin.

Table 1. Average Water Quality Data (1998-2007) and Standards

Parameter	Long Lake, North Basin	Long Lake, South Basin	Standard
TP (µg/L)	145	54	40
Chl (µg/L)	57	25	14
Secchi Depth (m)	0.6	1.4	1.4

Figures 3 through 5 show the growing season total phosphorus (TP), chlorophyll-*a*, and Secchi depth (clarity) data for the north basin of Long Lake. The same series of data is shown in Figures 6 through 8 for the south basin.

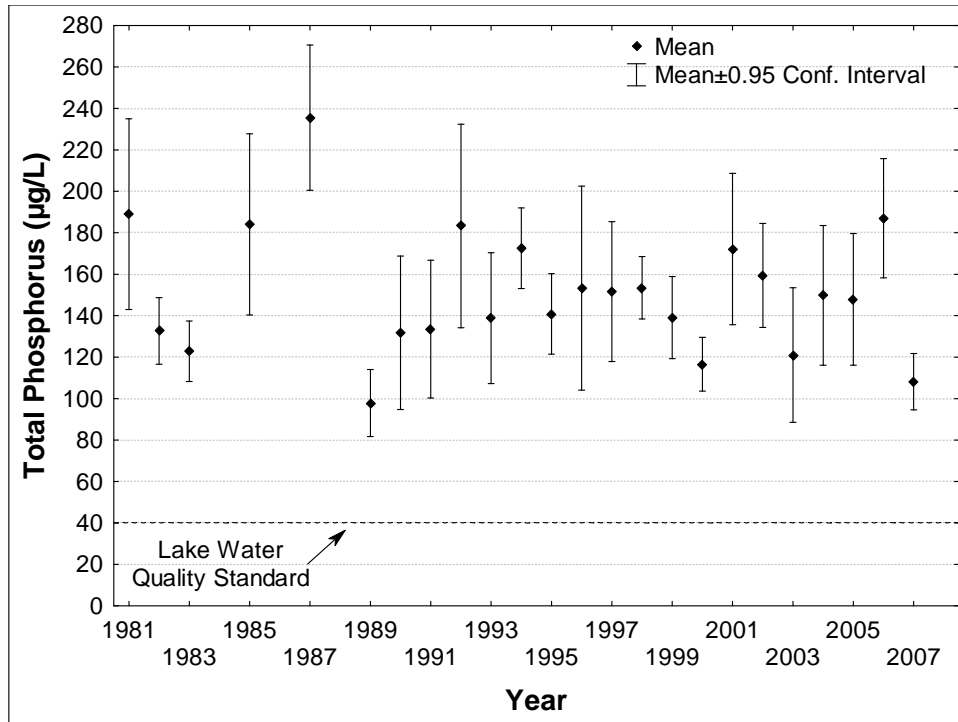


Figure 3. Long Lake North Basin Total Phosphorus

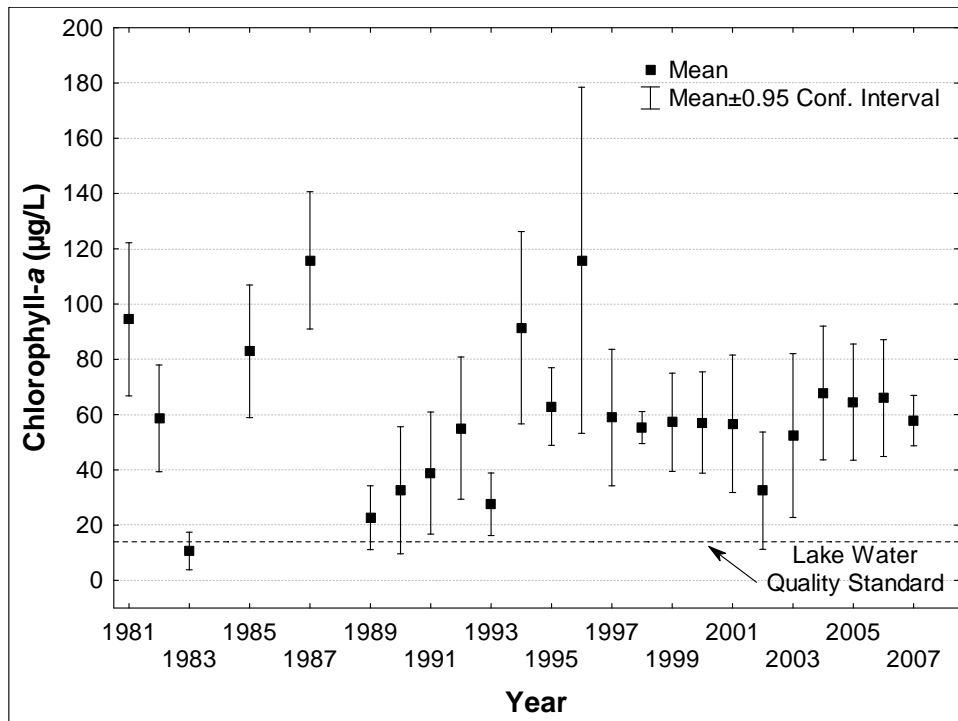


Figure 4. Long Lake North Basin Chlorophyll-a

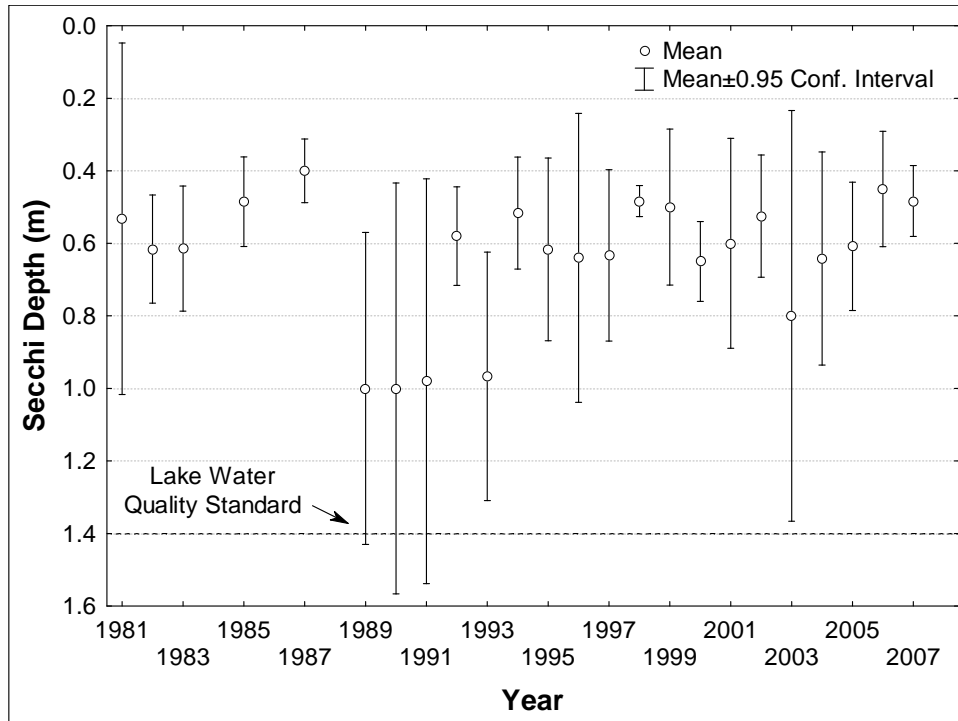


Figure 5. Long Lake North Basin Secchi Depth

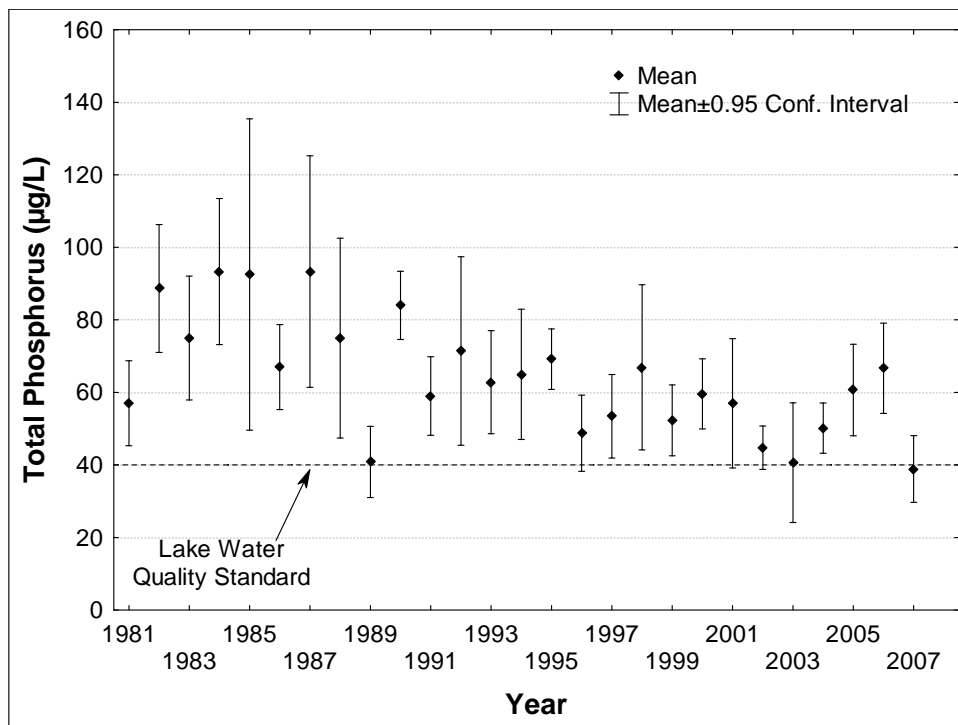


Figure 6. Long Lake South Basin Total Phosphorus

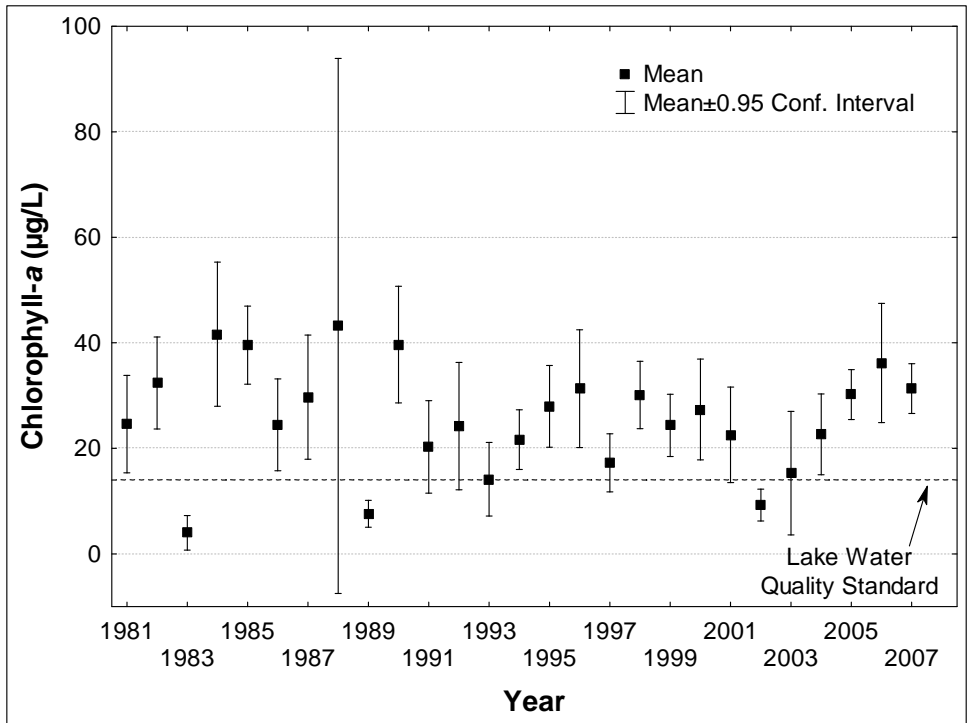


Figure 7. Long Lake South Basin Chlorophyll-a

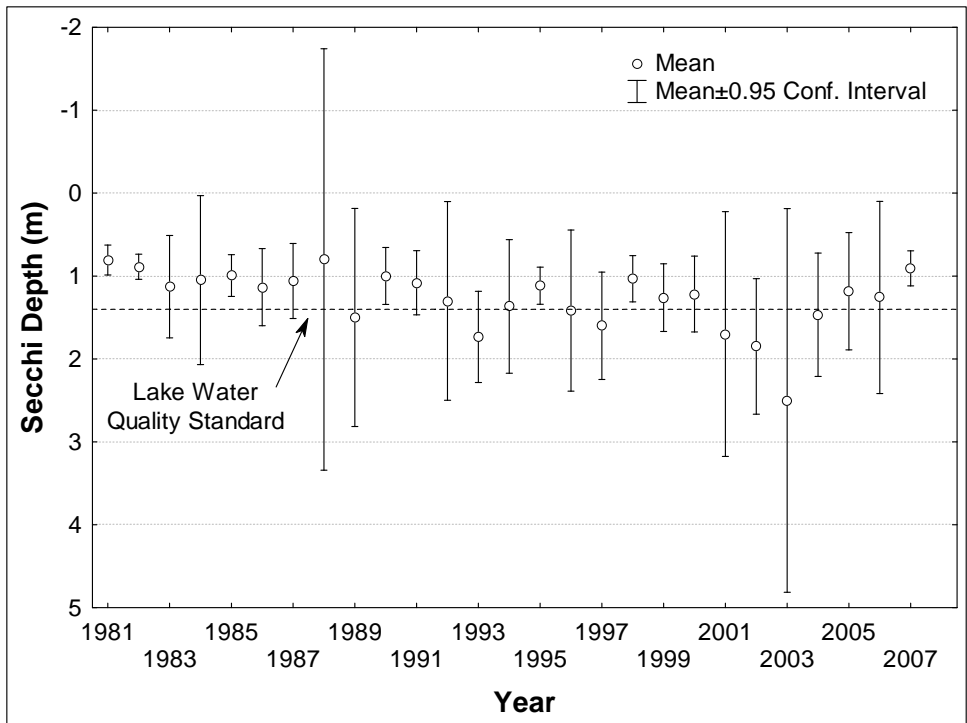


Figure 8. Long Lake South Basin Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to both basins of the lake, and an in-lake model (Bathtub) was used to predict the response of the basins to phosphorus loading. The lake model was calibrated to in-lake monitoring data.

Water quality modeling indicates that for the north basin, watershed inputs account for 96% of the nutrient load, with internal loading accounting for the remaining 4% (Figure 9). To reach the in-lake goal of 40µg/L TP, the phosphorus loading to the lake would need to be reduced by approximately 64%.

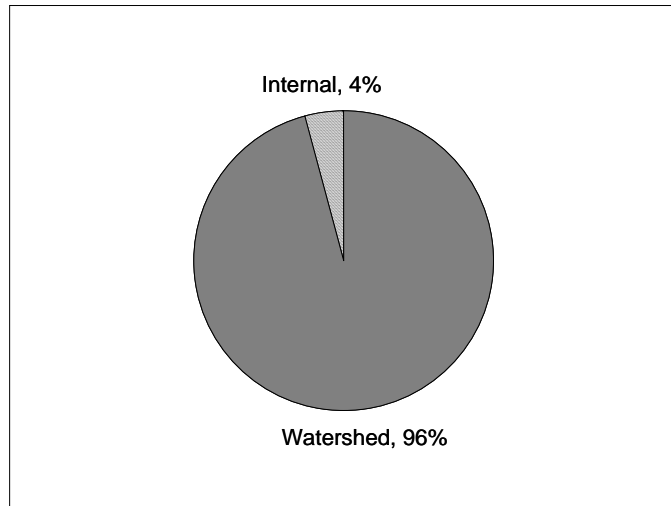


Figure 9. Long Lake North Phosphorus Load Distribution

The south basin modeling indicates that watershed inputs account for 68% of the nutrient load, with internal loading accounting for the remaining 32% (Figure 10). To reach the in-lake goal of 40µg/L TP, the phosphorus loading to the lake would need to be reduced by approximately 40%.

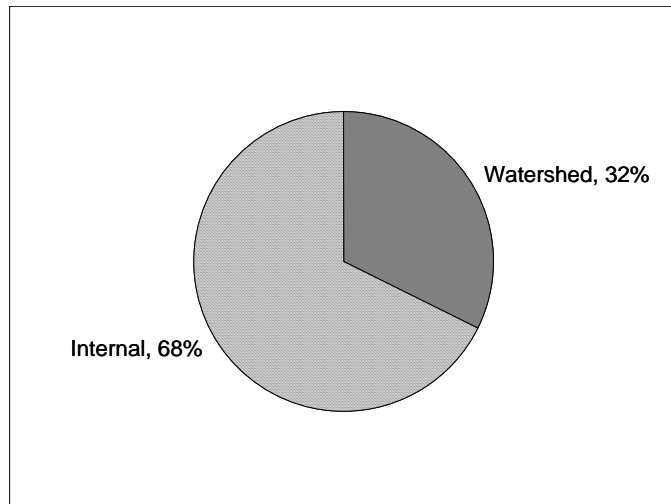


Figure 10. Long Lake South Phosphorus Load Distribution

Public Input

At the public input meetings on June 3, 2008 and January 19, 2009 issues facing Long Lake were addressed.

- The attendees were in support of continued follow-up maintenance for the many Long Lake Chain of Lakes Clean Lakes Partnership (CLP) BMPs that were installed in the 1990s. This effort is intended to keep the installed BMPs in optimum working order. Some attention to macrophyte management was also suggested to supplement the practices already in place.
- The sediment basin that treats Rice Creek inflow just prior to discharge to the lake was cleaned in early 2008. The very large load of TP entering the north basin of the lake can be reduced through effective and routine cleaning of this sediment trap. The attendees acknowledged this key maintenance operation and would like to see it happen as often as needed.
- Residents from around the lake stated their dissatisfaction with the “weedy and green” characteristic of the lake after so much attention was paid to improving it in the CLP effort. Actions they supported include additional BMPs, effective implementation of city and RCWD rules, volume control and infiltration practices, cost-share initiatives, BMP retrofits, and plan coordination. Attendees agreed with staff that no quick fixes are available, but that a long term effort is needed.
- The attendees were interested in what might happen to spur things forward as a result of the lake’s impaired status. RCWD staff explained that the Southwest RCWD Lake Study has many attributes of a pre-TMDL study and will likely set the stage for a full-scale TMDL study.
- Shoreline erosion occurs due to wakes from motorized boating.

Water Quality Issues

- The north basin of Long Lake has high phosphorus concentrations mostly due to the high load from Rice Creek, which flows through Long Lake. Both basins are impaired.
- Curly-leaf pondweed is present in moderate densities in both basins. There is a lack of vegetation in many of the shallow areas of the lake.
- High densities of both black bullhead and carp stir up bottom sediments and lead to high rates of internal loading.
- The south basin is directly adjacent to Interstate-694 and likely receives highway runoff.
- Low levels of TCE and DCE have been found in Long Lake. The concentrations are not high enough to warrant concern for human or aquatic life health; however, it appears that there is a continuing source of the chemicals into the lake and it is not known what the source is.
- The lack of aquatic shoreline vegetation coupled with water level fluctuations increases susceptibility to shoreline erosion from motorized recreation and results in additional phosphorus inputs to the lake.

Recommended Management Approach

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing the nutrient impairment. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 17 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- The entire southeast portion of the Long Lake watershed flows through Farrel's Wetland, also known as the E-2 Wetland from the Long Lake Chain of lakes CLP. This large wetland serves as a principal treatment site for the flow originating in the Lake Johanna and Valentine Lake chains. In a memo from EOR to RCWD dated January 29, 2008, the poor condition of the weir controlling flow out of the wetland was documented. Figure 11 illustrates the corrosion noted in the memo. It is clear from this picture that the level of water in the wetland is largely controlled by the corroded holes rather than the design weir elevations. Repair or replacement of this structure to its original or revised design is recommended for the treatment of Farrel's Wetland to again be effective. The recommendation in the memo was that RCWD consider replacement of the weir for an approximate cost of \$80,000. The memo also indicates that restoring the weir at a slightly higher elevation than current could remove an additional 345 pounds of TP per year, or roughly 60% of the load reductions needed to achieve the water quality standard in the south basin of Long Lake. In addition to repair/replacement of the E-2 outlet, additional assessment of the upstream wetland basins within the overall wetland complex could be completed with an eye towards additional control structures to provide added treatment storage.
- Feasibility and Benefit Level Assessment of the three potential regional BMP locations identified in the *field reconnaissance supplement*.
- Consideration of local partnerships for further assessment of the 10 potential local BMP locations identified in the *field reconnaissance supplement*.
- Follow-up inspection, operation and maintenance of all Long Lake Chain of Lakes Clean Lakes Partnership (CLP) BMPs.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.



Figure 11. Outlet Weir Corrosion at Farrel's (E-2) Wetland.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

- Develop an aquatic vegetation management plan, focusing on curly-leaf pondweed.
- Shoreline and littoral zone restoration practices should be undertaken. Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide

refugia for zooplankton, but the macrophyte communities are sparse in the shallow regions of the lake.

- Local ordinances to control motorized boating could be developed to reduce the amount of shoreline erosion occurring from boat wakes.
- A fisheries management plan should be developed that will aim to restore the balance of fish in the lake. The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality, and benthivores have been found at high densities in Long Lake. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. Work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.
- Work with MPCA and MDH to further investigate the source of TCE and DCE in Long Lake and to ensure that it does not become a human or aquatic life health risk.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Long Lake. Since there is a long record of in-lake water quality data for Long Lake, additional in-lake data collection is not a high priority at this time. Watershed phosphorus loading data are a high priority, as they will be needed for the future TMDL study.

- TP, chlorophyll, and Secchi depth data: Collect at least five sampling dates per year. The TMDL can be based on the existing monitoring data; additional data should be collected after management actions are implemented to track the response of the lake.
- Macrophyte surveys: Complete one macrophyte survey during early June to evaluate the density of curly-leaf pondweed. Complete macrophyte surveys after aquatic vegetation management practices are implemented, to monitor the success.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.
- Ramsey County Ditch 2 should be monitored close to the inlet to Long Lake South, and Rice Creek should be monitored close to the inlet to Long Lake North, to provide flow and phosphorus loading estimates. These data will be needed in order to estimate the watershed phosphorus load to the lake for the TMDL study.

Long Lake Field Reconnaissance Supplement

Regional Management BMPs



Long 1

Location: E2 wetland looking from the east

Description: E2 wetland looking from 6th Street and 1st Avenue across freeway

Potential Improvements: Enhancements or improvements throughout the E2 wetland complex. An assessment of current effectiveness of the upstream wetland systems should be completed and outlet structure should be replaced.



Long 2

Location: West of New Brighton Road and south of RR tracks

Description: Large low green space (appears to not get much use, except for some storage)

Potential Improvements: Potentially could construct a regional treatment feature (infiltration basin or wetland treatment basin) to serve the drainage area to the south.



Long 3

Location: East of Long Lake Road and south of 17th Street

Description: Large storm sewer pipe running beneath green space.

Potential Improvements: Daylight pipe and create wetland treatment/ponding area.

Local Management BMPs



Long 4

Location: South of 6th Street and west of 1st Avenue

Description: Open green space

Potential Improvements: Pick up street runoff and incorporate a large raingarden.



Long 5

Location: North of County Road E and east of New Brighton Road

Description: Large open green space (appears to be park property)

Potential Improvements: Incorporate ponding or infiltration areas, however appears slightly high and may not be able to route much drainage area to this site.



Long 6

Location: West side of Cleveland Avenue south of 2nd Street

Description: Large open green space

Potential Improvements: Incorporate ponding or infiltration areas for treatment of adjacent roads.



Long 7

Location: West side of Cleveland Avenue south of 1st Street

Description: Large open green space

Potential Improvements: Incorporate ponding or infiltration areas for treatment of adjacent roads.



Long 8

Location: West of Round Lake Road and south of County Road 96

Description: Green space along Round Lake Road

Potential Improvements: Incorporate raingardens for treatment of adjacent roadway.



Long 9

Location: North of 10th Street and east of Old Highway 8

Description: Green space at the corner.

Potential Improvements: Use area for treatment of adjacent roadways.

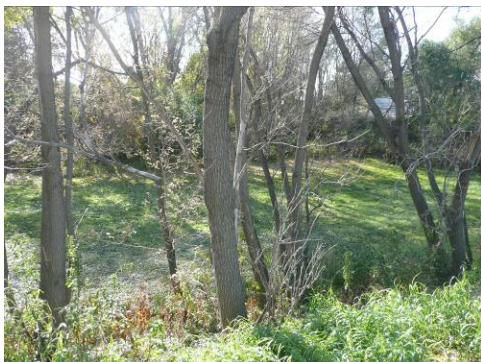


Long 10

Location: North of 10th Street and west of 9th Avenue

Description: Existing ponding basin receiving stormsewer discharges from the east and south.

Potential Improvements: Excavate to provide additional dead storage.



Long 11

Location: South of 10th Street and west of 9th Avenue

Description: Low area adjacent to a small ditch running from south to north.

Potential Improvements: Use low area for creation of a small wetland treatment feature.



Long 12

Location: North of Mississippi Street and east of Long Lake Road

Description: Open space adjacent to roadway

Potential Improvements: Install raingarden to treat a portion of Mississippi Street.



Long 13

Location: East of the intersection of Long Lake Road and 14th Street

Description: Open space adjacent to Long Lake Road.

Potential Improvements: Incorporate raingarden areas for treatment of a portion of Long Lake Road (note: this would require the removal of some trees).

Site Specific Management BMPs



Long 14

Location: East of 8th Avenue and south of 7th Street

Description: Catch basin located at the edge of the parking lot.

Potential Improvements: Use green space behind catch basin to provide treatment. Numerous areas are available onsite for treatment of impervious area.



Long 15

Location: North of 10th Street and west of 7th Street

Description: Green space adjacent to apartment parking lots.

Potential Improvements: Create raingarden or sand filter area for treatment of adjacent parking lots.



Long 16

Location: North of 10th Street and east of Old Highway 8

Description: Green space adjacent to parking lot.

Potential Improvements: Use green space for a raingarden to treat a portion of the adjacent parking lot (note: this maybe within railroad ROW).



Long 17

Location: At the east end of the I-694 service road.

Description: The service road and parking lot at the boat launch all drain to a small treatment feature before discharging to Long Lake. Feature appears undersized for its drainage area.

Potential Improvements: Expand and enhance existing feature.

Marsden Lake Management Action Plan

Marsden Lake (62-0059) is located in the City of Arden Hills, Ramsey County, Minnesota (Figure 1) and is within the boundaries of the Arden Hills Army Training Site (AHATS). Although termed a lake, Marsden is physically and ecologically closer to a wetland. The surface area of the lake is approximately 271 acres with an estimated maximum depth of 5.5 ft¹. Based on its low estimated maximum depth, it is considered a shallow lake according to MPCA's definition. The watershed draining to the lake is approximately 2285 acres.

Marsden Lake is surrounded on all sides by the AHATS facility, although its watershed extends beyond the AHATS property to the east and south. Marsden Lake has very limited public use at the current time because of its location within the AHATS boundaries. There is some limited access granted by the federal government for study and nature walks, but the general public is not allowed within the AHATS property.



¹ No bathymetric data were available for this lake. The maximum depth was estimated using depth data collected during sediment sampling. The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos.

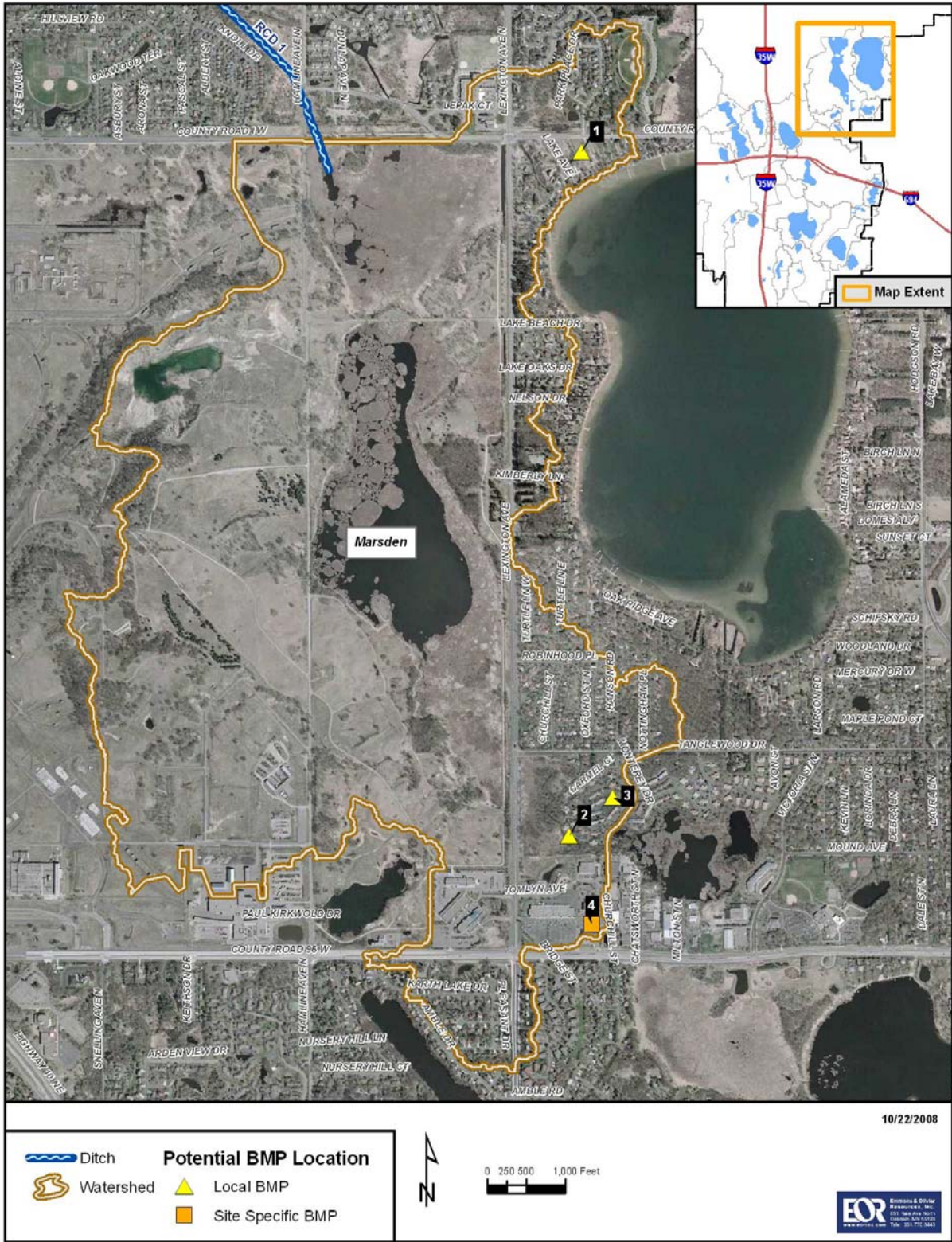


Figure 1. Marsden Lake Potential BMP Location

Water Quality Summary

Water quality and biological data are not available for Marsden Lake. Water clarity data inferred from satellite imagery suggest that the water clarity depth of Marsden Lake is approximately 3 to 6 feet. A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. There are no in-lake monitoring data to calibrate the lake model. Modeling indicates that watershed inputs account for approximately 52% of the nutrient load, with internal loading accounting for the remaining 48% (Figure 2). Without any in-lake nutrient data for the lake for model calibration, the modeling results should be considered preliminary.

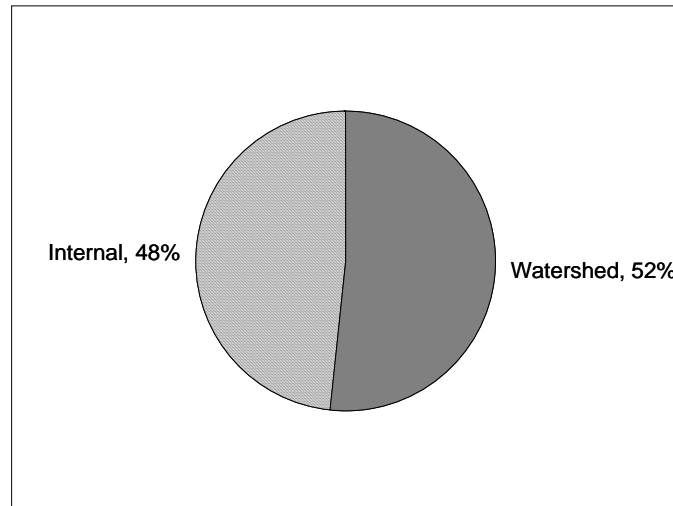


Figure 2. Marsden Lake Phosphorus Load Distribution

In 2007, the U.S. Army tested Marsden Lake for TSS (total suspended solids), total and dissolved aluminum, total and dissolved lead, and total hardness. The total lead standard was exceeded once at two of the three monitoring sites; all other lead samples and all aluminum samples were below the state standard for Class 2B waters. The U.S. Army has completed an ecological risk assessment on Marsden Lake.

Public Input

No attendees spoke on issues related to Marsden Lake at the public input meeting on May 29, 2008.

Water Quality Issues

- Sediment within the lake may be contaminated with toxic substances due to past land use.

Recommended Management Approach

Watershed Management Recommendations

Residential and commercial areas east of Lexington Avenue were developed prior to water quality BMP rules and regulations. While the City of Shoreview retrofitted a regional pond north of and to serve the Shoreview Mall site, further targeting of areas east of Lexington Avenue for future BMP retrofits or for redevelopment attention will help to improve runoff quality reaching the lake. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 4 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of the three potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowner educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.

Currently all of the area directly surrounding Marsden Lake is under the control of the U.S. Army because the lake is entirely within the AHATS boundary. The Army should maintain its existing management plan for the lake unless water quality data collected in the future dictates that a need in management is warranted.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

With very little in-lake biological data for Marsden Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Marsden Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Marsden Lake. There are no in-lake water quality data for the lake; if the implementation of management practices for the lake were to move forward, in-lake data would be needed and should be considered a high priority.

- Bathymetric data collection
- TP, chlorophyll, and Secchi depth data: Collect data for several years, with at least five sampling dates per year.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Marsden Lake Field Reconnaissance Supplement

Local Management BMPs



Marsden #1

Location: South of County Road I and west of Chatsworth Street N

Description: Large open area in front yard along County Road I.

Potential Improvements: Incorporate infiltration/biofiltration feature for treatment of County Road I (note: treatment may already be occurring in downstream wetlands and ponds)



Marsden #2

Location: Southwest of Carmel Court loop

Description: Shallow swale flowing from pavement area back to wetland.

Potential Improvements: Create raingarden for local drainage or pick up stormsewer from Carmel Court and incorporate a slightly larger treatment feature.



Marsden #3

Location: Inside Carmel Court loop

Description: Grass depressional area with catch basin at the bottom.

Potential Improvements: Retrofit to provide infiltration/water quality treatment.

Site Specific Management BMPs



Marsden #4

Location: North of County Road 96 and west of Churchill Street

Description: Appears to be an existing infiltration feature, which outlets to the road.

Potential Improvements: Might be working as is, however the vegetation and storage of features onsite could likely be enhanced to provide more infiltration and treatment.

Martha Lake Management Action Plan

Martha Lake (62-0064) is located in the City of Shoreview, Ramsey County, Minnesota (Figure 1). The surface area of the lake is approximately 34 acres with a maximum depth of 3.5 feet¹ (Figure 2). The lake is a mix of standing water in pools and vegetation (mostly cattails and lily pads).

Martha Lake meets the MPCA definition of wetland and is classified as a Class 2D (wetland) water in accordance with Minn. Rules Ch. 7050. Furthermore its designation as a Public Water Wetland [“W” 62-64] by the DNR Protected Water Inventory and the lack of an aquatic recreational resource management history (MPCA (*Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment*, 2007) substantiates the designation as a Class 2D water. The Class 2D designation means that the wetland resource is protected for the “maintenance of a healthy wetland aquatic community and for wetland based aquatic recreation.” Numeric nutrient standards developed for shallow lakes (i.e. 60 µg/L TP) do not apply to Class 2D wetlands.

The watershed draining to Martha Lake is approximately 77 acres and is primarily a mix of light industrial, neighborhood commercial, single family and multi-family residential uses. The lake drains into the Marsden Lake watershed.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from DNR files.

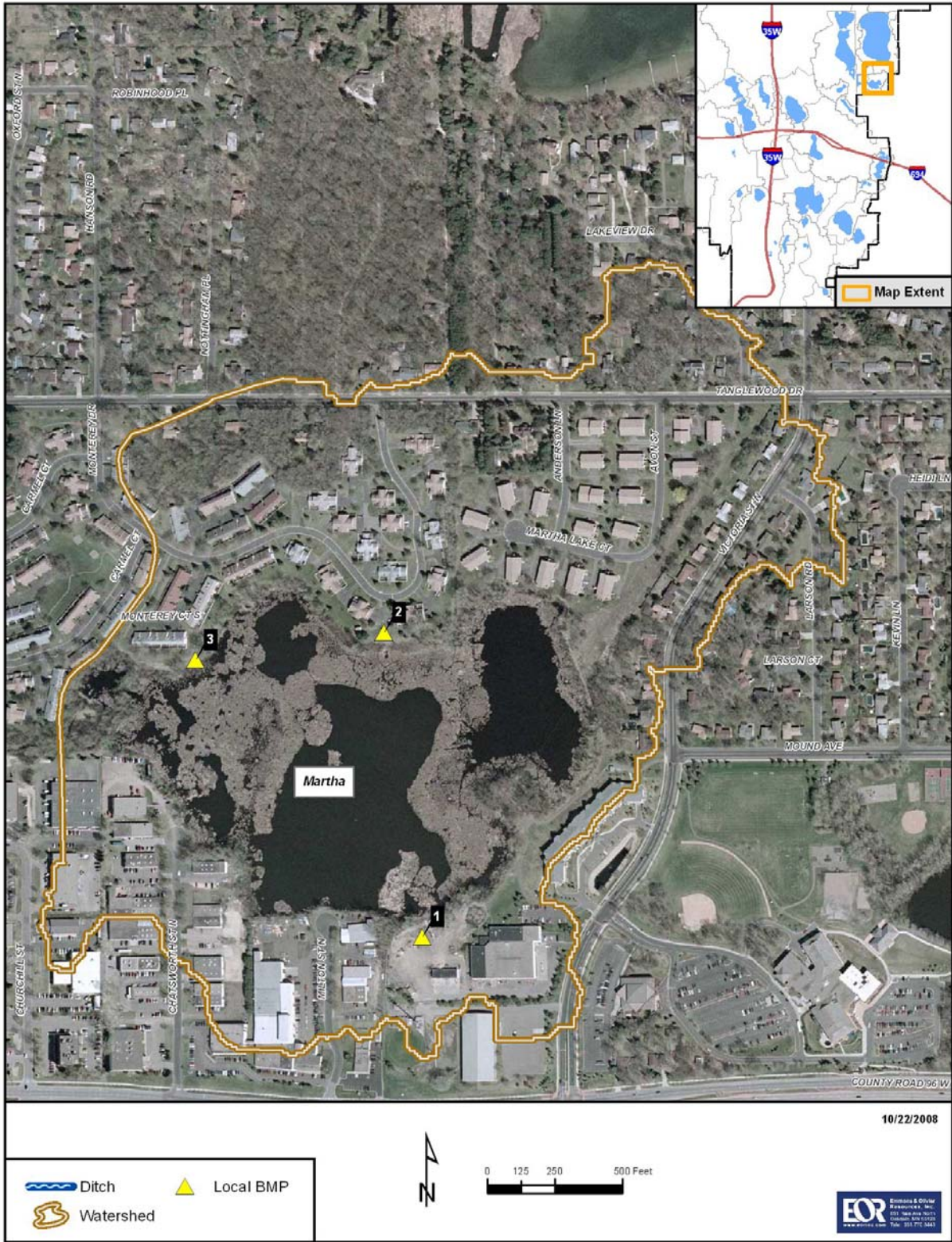


Figure 1. Martha Lake and Potential BMP Locations

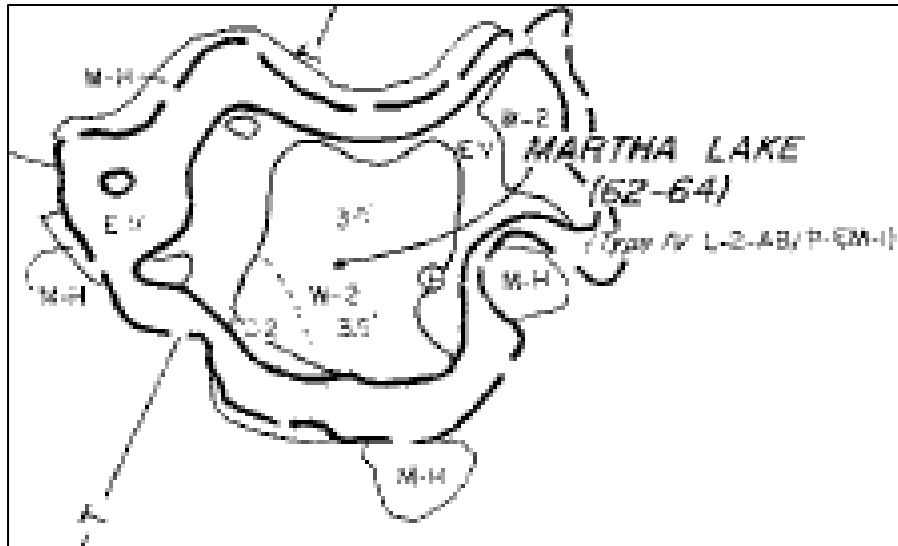


Figure 2. Martha Lake Bathymetry. Map from DNR files, unknown date.

Water Quality Summary

Water quality and biological data are not available for Martha Lake. A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. There are no in-lake monitoring data to calibrate the lake model. Water quality modeling indicates that watershed inputs account for approximately 89% of the nutrient load, with internal loading accounting for the remaining 11% (Figure 3). Without any in-lake nutrient data for the lake for model calibration, the modeling results should be considered preliminary.

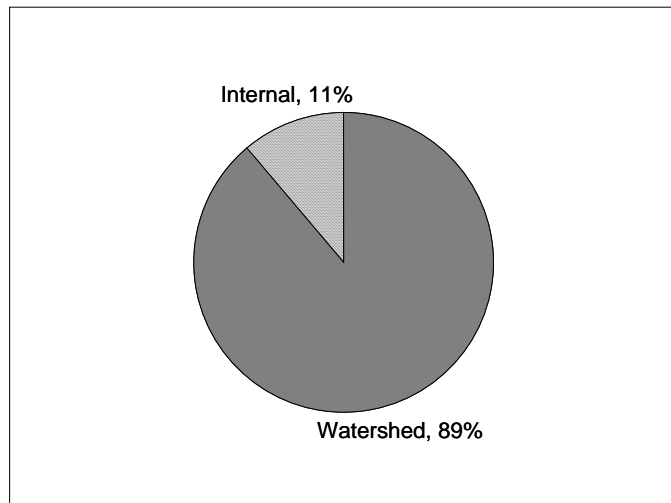


Figure 3. Martha Lake Phosphorus Load Distribution

Public Input

No attendees spoke on issues related to Martha Lake at the public input meeting on May 29, 2008.

Water Quality Issues

- The high density of cattails in Martha Lake suggests that the wetland has been impacted by nutrient enrichment and/or modified surface hydrology.

Recommended Management Approach

Watershed Management Recommendations

Because the Martha Lake watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, three BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of the three potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to landowners in the commercial/industrial area in the southwest area of the lake educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program. All of this is area running directly to the lake untreated. While there is little opportunity for easy (surface) retrofits, this area could be considered for subsurface retrofits during pavement maintenance or redevelopment activities.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

The water level fluctuations and/or the high nutrient loading presumed in Martha Lake create an environment that makes it difficult for the establishment of native plant communities and supports a dense stands of cattails. Any in-lake restoration project will have a greater likelihood of success after the rate and volume of stormwater runoff to Martha Lake is controlled.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Martha Lake. There are no in-lake water quality data for the lake; if the implementation of management practices for the lake were to move forward, in-lake data would be needed and should be considered a high priority.

- Updated bathymetric data collection
- TP and chlorophyll data: Grab water quality samples should be collected if there is cause to believe that the water body is enriched with nutrients (as evidenced by mid-summer algae blooms) AND the waterbody is contributing flow to adjacent lakes.
- Macrophyte and/or aquatic invertebrate data should be collected in cooperation with the MPCA to determine if the water body is meeting the “healthy aquatic community standards.”

Martha Lake Field Reconnaissance Supplement

Local Management BMPs



Martha #1

Location: Southeast corner of Martha Lake

Description: Backside of Shoreview Public Works / Maintenance building. The yard area is immediately adjacent to the lake and appears to be draining to the lake untreated.

Potential Improvements: Assess runoff reaching lake and install BMPs prior to discharge to the lake as needed.



Martha #2

Location: North end of Martha Lake, south of Monterey Drive

Description: Stormsewer from Monterey Drive outlets directly to Martha Lake.

Potential Improvements: Incorporate water quality BMP in green space.



Martha #3

Location: South of Monterey Drive and east of Monterey Court

Description: Stormsewer from Monterey Court outlets directly to Martha Lake.

Potential Improvements: Incorporate water quality BMP in green space.

Moore Lake Management Action Plan

Moore Lake (02-0075) is located in the City of Fridley, Anoka County, Minnesota (Figure 1). The lake is bisected by Highway 65 into eastern and western basins connected by a storm-pipe. The western basin is 70 acres, has a maximum depth of 5 feet and is 100% littoral (Figure 2)¹. Based on its low maximum depth, the western basin is considered a shallow lake according to MPCA's definition. The eastern basin of Moore Lake is approximately 30 acres with a maximum depth of 22 feet and is 79% littoral, and it is not considered a shallow lake according to MPCA's definition. East Moore Lake is listed as an impaired lake on the EPA's 303(d) list of impaired waters. It is impaired for aquatic recreation due to high nutrients.

The lake was bordered by a floating bog to the north in the 1960s but today open water is present up to the developed northern shore. East Moore Lake's watershed is 664 acres; West Moore Lake's watershed is 778 acres (including East Moore Lake and its watershed, which both drain to West Moore Lake). Both watersheds are a highly developed mix of residential and commercial uses with some areas of municipal park. There is a municipal beach on the eastern shore of the lake that is the most visited park in Fridley. There is a smaller park on the western basin connected to the larger Fridley Common Park, primarily composed of managed turf-grass sports fields.

Both East and West Moore Lakes have ditched inflows adjacent to Highway 65 at the south end of the basins, with the western basin receiving runoff from the Medtronic facility along I-694 and the eastern basin receiving runoff from commercial and residential areas. Four additional stormwater inlets to the lake were re-engineered in the late 1980s to improve water quality. These changes were effective in reducing some nutrient and sediment problems according to DNR reports.

A DNR aquatic vegetation survey was performed on Moore East during the end of July in 2004. Curly-leaf pondweed was listed as rare. Water quality in Moore Lake has been consistently recorded as poor, with eutrophic conditions prevailing and frequent fecal coliform and *E. Coli* alerts at the public beaches (mentioned in the minutes of the Fridley City Parks and Recreation Commission meeting in 2005). Excretion by waterfowl was noted by local stakeholders as the primary cause of bacterial outbreaks and beach closings. In 2005 the Fridley City Parks and Recreation Commission discussed a ban on feeding geese and other waterfowl. The City of Fridley participates in a fowl removal program and plans to continue this program as part of their 2030 Comprehensive Plan.

DNR documents show that, in the late 1980s, stormwater system changes appeared to improve total phosphorus (TP) and Secchi depth (but not algal concentrations) in both basins of the lake. In 1986 a plastic sheet was installed in the bottom of the east basin to control macrophytes, including invasive species. In 2004, the DNR reported that this sheet was present but failing.

¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos. The maximum depth was taken from the DNR Lake Finder.

The fishery of Moore Lake has been managed by the DNR and the City of Fridley as part of the Fishing in the Neighborhood (FIN) program since 1986. The FIN program creates neighborhood fishing opportunities by stocking and providing fishing access. The lake is stocked with bluegill, black crappie, largemouth bass, and channel catfish. Walleye, northern pike, and carp have been sampled in DNR fisheries surveys, but in low numbers. The most recent fisheries survey was conducted in 2004. Spawning habitat is poor for centrarchids (bluegill and crappie) and pike. The major inflow tributary in the southeast corner of East Moore Lake has been the best known spawning run, but now drains a highly developed area, and recent images show that it may no longer exist.

Bullhead dominated fish composition until 1986, when chemical agents were used to kill off fish before re-stocking with centrarchids. Both basins of Moore Lake are subject to winterkill, the western basin likely due to freezing and the eastern due to anoxic hypolimnion (suggested by 2004 data from the DNR). Aeration has been implemented by the City of Fridley for both the east and west basins. The west basin aerator is an on-shore unit that pulls water from the lake. It is under assessment for replacement and typically runs from November to April. The east basin aerator is in the lake and runs year-round.



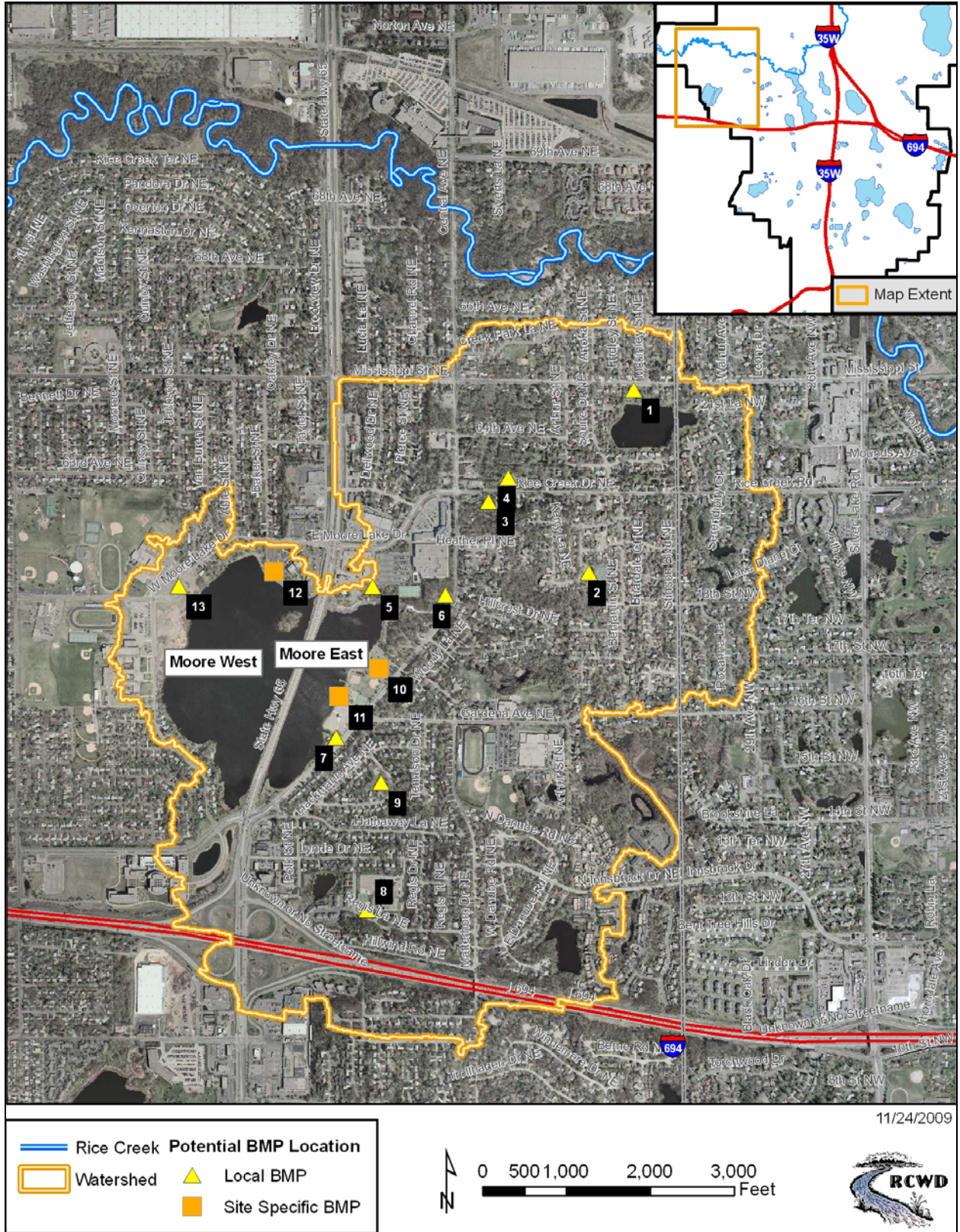


Figure 1. Moore Lake and Potential BMP Locations

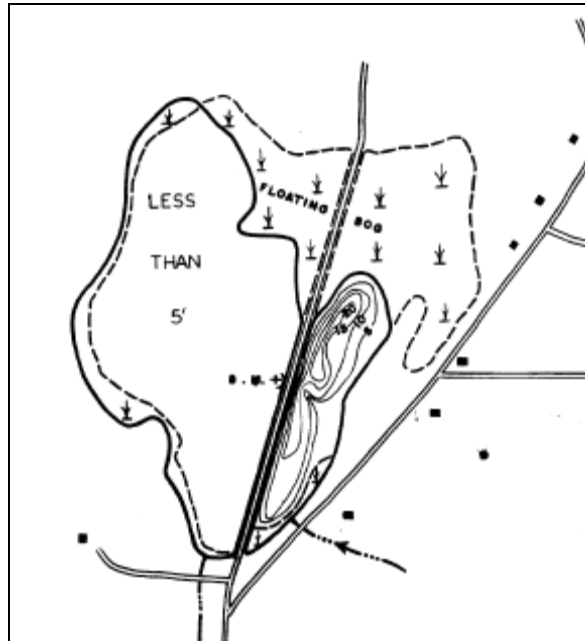


Figure 2. Moore Lake Bathymetry

Water Quality Summary

Water quality data for Moore Lake has been collected since the mid-1970s. Data were collected by the Anoka Conservation District, the MPCA, and the MPCA's Citizen Lake Monitoring Program. Table 1 summarizes the most recent 10 years of water quality information for the lake. Moore West appears to be meeting its standards for all three values, while Moore East is not meeting the standards for TP or chlorophyll-*a*.

Table 1. Average Water Quality Data (1998-2007) and Standards

Parameter	Moore East Lake	Lakes Standard
TP ($\mu\text{g/L}$)	44	40
Chl ($\mu\text{g/L}$)	18	14
Secchi Depth (m)	1.7	1.4

Parameter	Moore West Lake	Shallow Lakes Standard
TP ($\mu\text{g/L}$)	58	60
Chl ($\mu\text{g/L}$)	11	20
Secchi Depth (m)	1.3	1.0

Figures 3 through 5 show the growing season total phosphorus (TP), chlorophyll-*a*, and Secchi depth (clarity) data for the west basin of Moore Lake. The same series of data is shown in Figures 6 through 8 for the east basin. Recent trends show increasing chlorophyll concentrations in both basins.

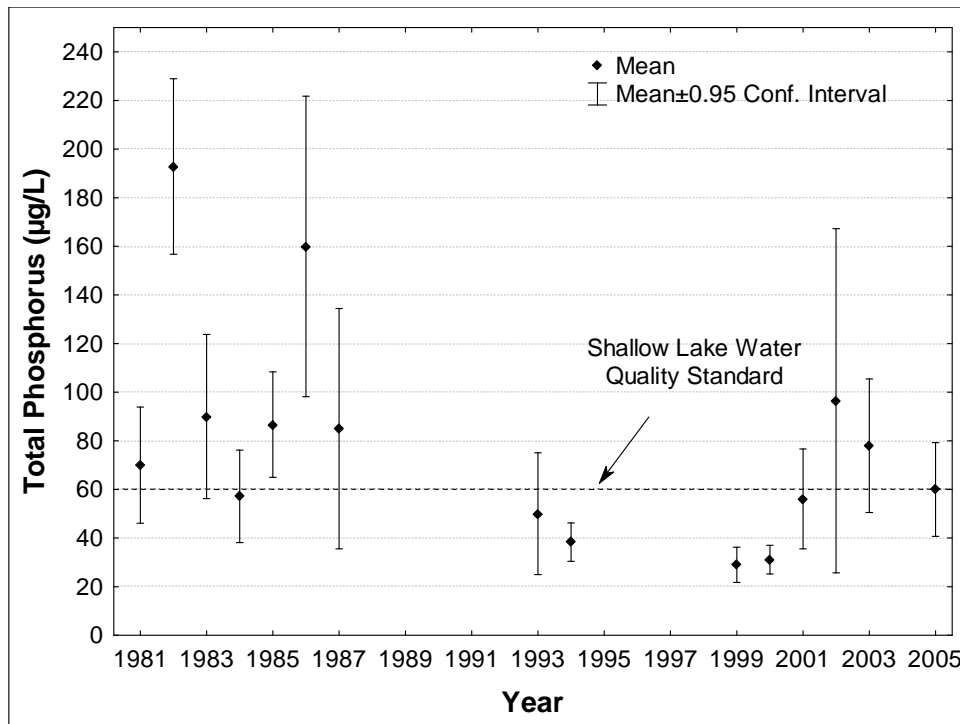


Figure 3. West Moore Lake Total Phosphorus

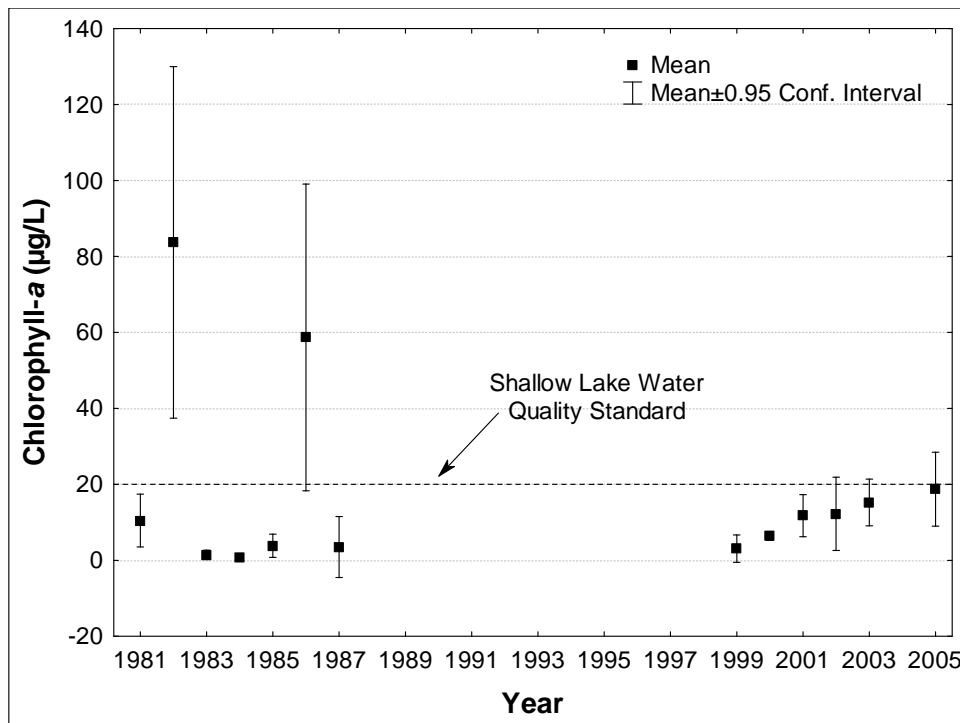


Figure 4. West Moore Lake Chlorophyll-a

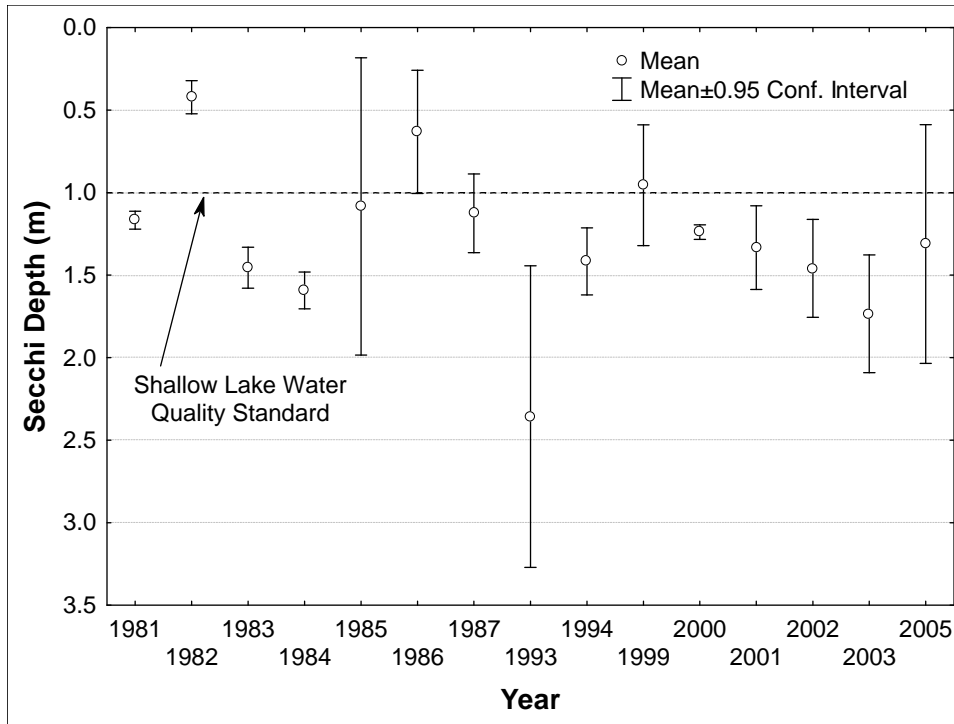


Figure 5. West Moore Lake Secchi Depth

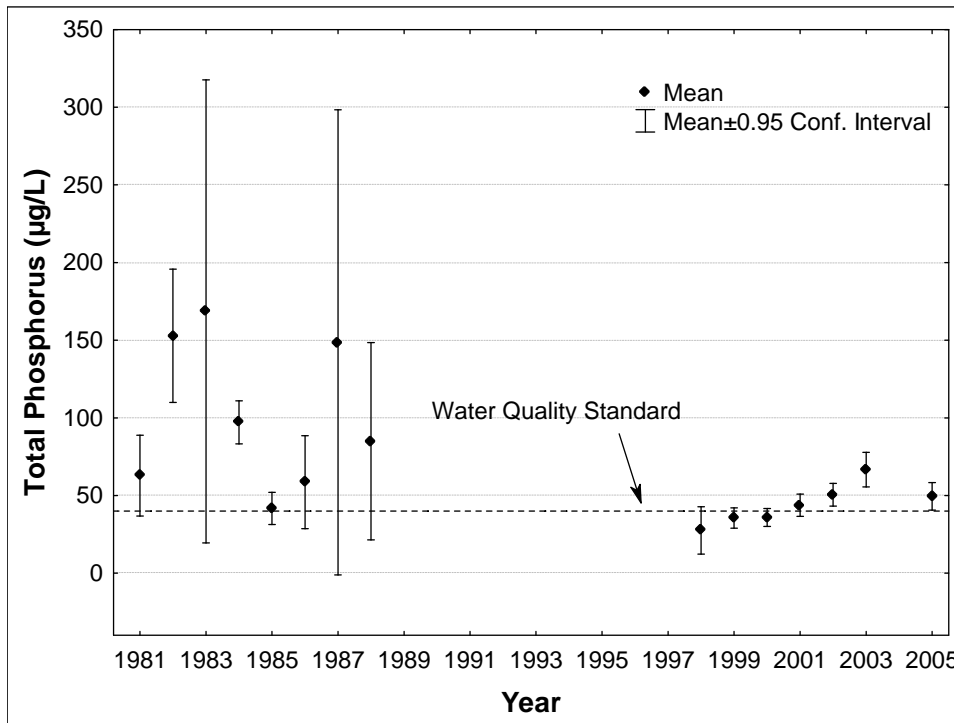


Figure 6. East Moore Lake Total Phosphorus

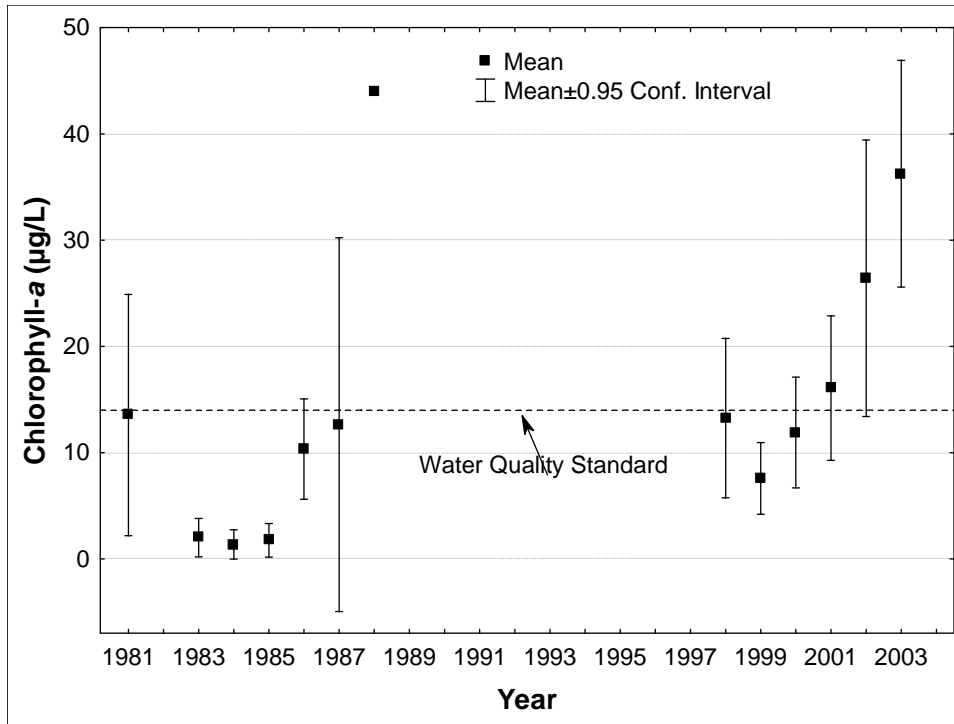


Figure 7. East Moore Lake Chlorophyll-a

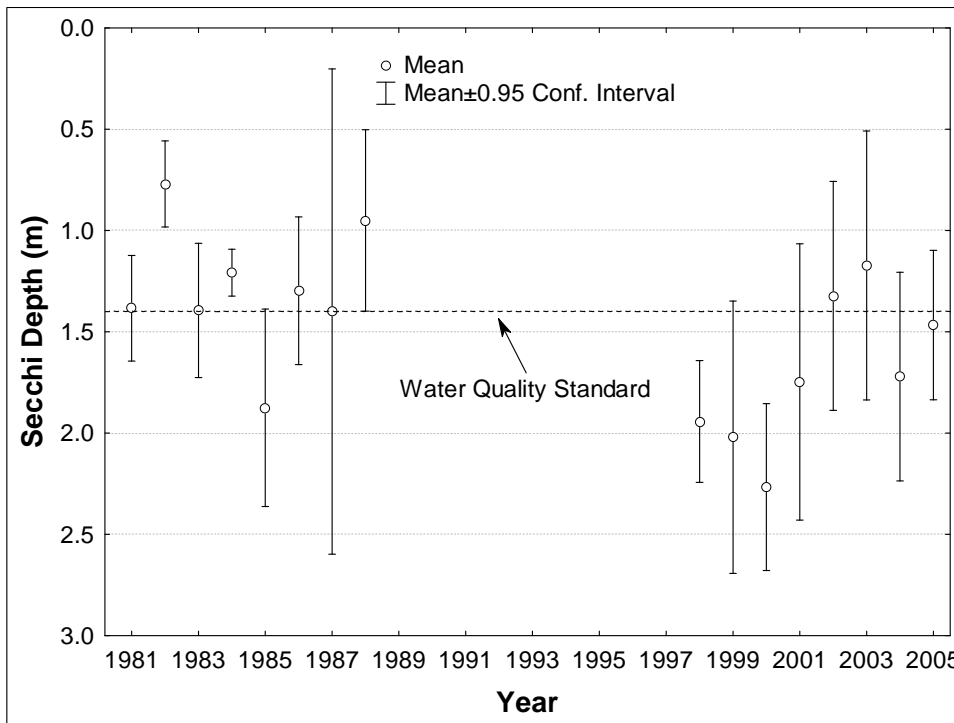


Figure 8. East Moore Lake Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to both basins of the lake, and an in-lake model (Bathtub) was used to predict the response of the basins to phosphorus loading. The lake model was calibrated to in-lake monitoring data.

Water quality modeling for West Moore Lake indicates watershed inputs account for 82% of the nutrient load, with internal loading accounting for the remaining 18% (Figure 9).

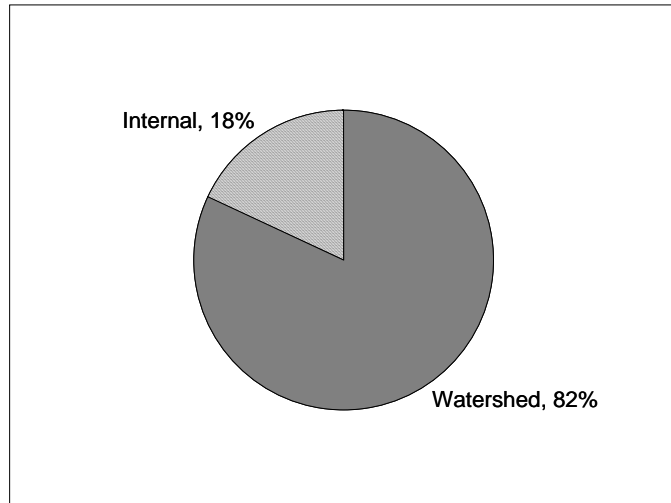


Figure 9. West Moore Lake Phosphorus Load Distribution

The modeling for East Moore Lake indicates that watershed inputs account for 84% of nutrient loading, with only 16% coming from internal loading (Figure 10). In order to achieve a water quality goal of 40 $\mu\text{g/L}$ TP, phosphorus loads in East Moore Lake need to be reduced by 25%.

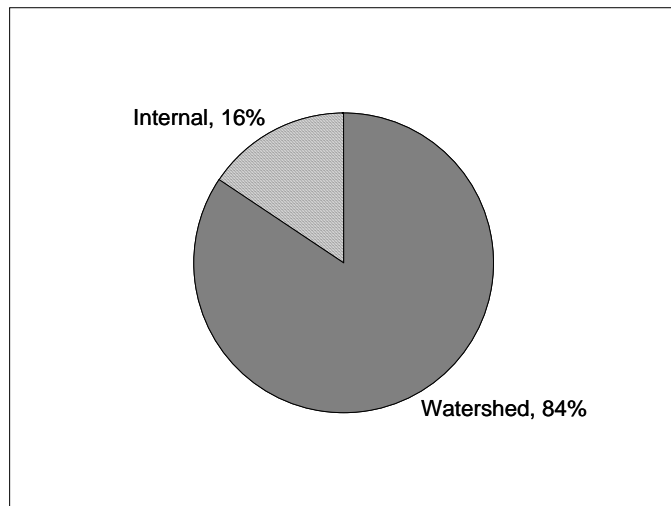


Figure 10. East Moore Lake Phosphorus Load Distribution

Public Input

At the public input meeting held on June 3, 2008, no attendees were present to comment on Moore Lake.

Water Quality Issues

- High densities of planktivorous centrarchids (panfish) can result in higher algal concentrations and/or shift algal species toward more noxious groups. Aeration to prevent winterkill and to reduce the anoxic release of sediment may agitate sediment and also keep non-target (rough) fish alive. These factors can have a large impact on internal phosphorus loading.
- Watershed phosphorus loads contribute to the high phosphorus concentrations observed in East Moore Lake.
- Waterfowl contribute to the high *E. Coli* in the lake.

Recommended Management Approach

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing the nutrient impairment. Because the Moore Lake watershed is nearly fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, twelve BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of the three potential local BMP locations identified in the *field reconnaissance supplement*.
- The City of Fridley manages the park near Moore Lake. BMPs could be implemented at the park to manage stormwater as well as serve as an example for homeowners within the watershed to institute positive changes. An example of a BMP would be conversion of the channel that drains to the lake through the south-central part of the park (Figure 11 & Field Recon Supplement BMP #7). This channel currently accommodates runoff with very little, if any, water quality treatment. Converting this to a water quality BMP, such as a bioretention swale, could yield some movement toward the 25% TP reduction needed for the lake to meet its goal.
- Identify possible retrofitting opportunities in some of the less effective detention ponds throughout the East Moore sub-watershed.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.



Figure 11. Drainage Channel through Moore Lake Park

The Moore Lake watershed is almost 70% impervious surface. There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

The internal biology of Moore Lake needs to be better understood to identify the factors mediating the causal chain from nutrient input to algal blooms. After the storm drainage changes in the late 1980s, nutrient conditions improved but algal conditions did not (based on DNR records and narrative), most likely because they were mediated by other factors. Internal recycling of phosphorus and low densities of zooplankton are likely culprits.

- Attention to aeration policy is recommended to be able to balance the benefit to fisheries of preventing winterkills and reducing the anoxic release of phosphorus with the drawbacks of sediment disturbance and the absence of winterkill (winterkills can help water quality). More detailed biological information would make a more rigorous assessment of these processes possible. Evaluate long term impacts of winter aeration, particularly if it is linked to anoxic summer stratification. Work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.
- Lake-shore development has decreased the spawning habitat for fish as well as removed buffers that reduce nutrient impacts. These changes increase eutrophication and reduce the value of the lake for fishing and swimming. Future management plans should clearly identify the target uses and coordinate efforts to improve water quality while addressing fishing concerns. Involving all the stakeholders is critical to success in this regard.
- Evaluate the benefits and costs (ecologically and economically) of the plastic lining relative to primary user objectives. In order to control non-native macrophytes, a plastic lining was installed in the 1980s in the eastern basin, but this lining is now degrading. The dominance of invasive macrophytes does not appear to have changed due to this management practice. A detailed evaluation of the relative merits of maintaining the lining should be studied and discussed publicly. Other, more natural methods of removing invasive macrophytes and encouraging native plant species ought to be discussed as well. Native macrophyte stands and buffer zones would act as refugia for zooplankton, which can help reduce algal production and increase water clarity.
- Increase buffers (particularly of native macrophytes) along the lakeshore. Waterfowl are targeted as contributing a large portion of the nutrient load and causing fecal coliform outbreaks. Managing waterfowl is notoriously difficult, but buffer zones seem to help greatly with this input as well.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Moore Lake. Since there is a long record of in-lake water quality data for Moore Lake, additional data collection is not a high priority at this time.

- TP, chlorophyll, and Secchi depth data: Collect at least five sampling dates per year. The TMDL can be based on the existing monitoring data; additional data should be collected after management actions are implemented to track the response of the lake.
- Macrophyte surveys: Complete macrophyte surveys after aquatic vegetation management practices are implemented, to monitor the success.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from fish surveys regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality. If a better understanding of internal loading is needed for an eventual TMDL, collection of these data will be a high priority.

- Fish survey: Complete a fish survey during the same year as the plankton survey to evaluate the fish species composition of the lake.
- The inlets (or a subset) to East Moore Lake should be monitored to provide flow and phosphorus loading estimates. These data will be needed in order to estimate the watershed phosphorus load to the lake for the TMDL study.
- Monitor dissolved oxygen profiles on East Moore Lake during winter and summer to evaluate effectiveness of the aerator. If the aerator is not effective at alleviating hypolimnetic anoxia during the summer, sediment-phosphorus release may be contributing to internal loading.
- Monitor TSS (with attention to volatile:non-volatile ratios) at the surface and at depth on East Moore to determine if the aerator is disturbing sediment.

Moore Lake Field Reconnaissance Supplement

Local Management BMPs



Moore 1

Location: South of Mississippi Street and west of Fridley Street

Description: Green space in Harris Lake Park

Potential Improvements: Incorporate raingardens to provide treatment of Mississippi Street.



Moore 2

Location: East of Rice Creek Drive and south of Briardale Road

Description: Green space in Briardale Park

Potential Improvements: Use open space for treatment of adjacent roadways.



Moore 3

Location: South of Rice Creek Road and east of Old Central Avenue

Description: Open wooded lot adjacent to Rice Creek Road.

Potential Improvements: Use to provide treatment for Rice Creek Road.



Moore 4

Location: North of Rice Creek Road and east of Old Central Avenue

Description: Wetland area adjacent to Rice Creek Road

Potential Improvements: Enhance and use for treatment of adjacent roadways.



Moore 5

Location: South of Moore Lake Drive and east of Highway 65

Description: Existing basin providing minimal treatment.

Potential Improvements: Enhance to provide additional water quality treatment.



Moore 6

Location: West of Old Central Avenue and south of Heather Place

Description: Large open space adjacent to Old Central Avenue

Potential Improvements: Use for treatment of adjacent roadways.



Moore 7

Location: West of Old Central Avenue and south of Gardena Avenue

Description: Stormsewer discharge through park into Moore Lake

Potential Improvements: Enhance area to provide additional treatment (note: current configuration of bridge could limit treatment capacity). If dissolved phosphorus is an issue a permeable limestone weir could potentially be considered as an option.



Moore 8

Location: East of Fillmore Street and north of Regis Lane

Description: Green space on school property

Potential Improvements: Use area for infiltration and/or ponding for adjacent roads and school parking lot.



Moore 9

Location: East of Hackman Avenue and west of Hackman Circle

Description: Open space within Hackman Park

Potential Improvements: Incorporate infiltration areas for treatment of Hackman Circle.

Site Specific Management BMPs



Moore 10

Location: West of Old Central Avenue and south of Gardena Lane

Description: Green space currently receiving runoff from the park parking lot.

Potential Improvements: Enhance area and convert to raingardens prior to discharge to Moore Lake.



Moore 11

Location: Moore Lake

Description: Looking west from park

Potential Improvements: Remove bituminous flume and incorporate treatment.



Moore 12

Location: South of Moore Lake Drive and west of Highway 65

Description: Treatment swale south of Saint Phillips Lutheran Church parking lot

Potential Improvements: Enhance vegetation and treatment storage prior to discharge to Moore Lake.



Moore 13

Location: Fridley Middle School and surrounding property

Description: Raingardens adjacent to Fridley Middle School parking lot and West Moore Lake Drive

Potential Improvements: Infiltrate stormwater from Fridley Middle school rooftop and parking lot, as well as West Moore Lake Drive. Would divert water that current is discharged to West Moore Lake without treatment

Pike Lake Management Action Plan

Pike Lake (62-0069) is located in the City of New Brighton, Ramsey County, Minnesota (Figure 1). The lake has a surface area of about 37 acres, a maximum depth of 16 feet¹ and is 91% littoral (Figure 2). Based on its high percentage of littoral habitat, it is considered a shallow lake according to MPCA's definition. Pike Lake is listed as an impaired lake on the EPA's 303(d) list of impaired water bodies. It is impaired for aquatic recreation due to high nutrients.

The watershed draining to Pike Lake is about 5,888 acres, extending all the way southward to Falcon Heights. The watershed to lake area ratio for Pike Lake is about 160:1. The watershed is fully developed; land use consists primarily of residential and industrial/utility. Interstate 694 is adjacent to the lake on the south side, and the Pike Lake watershed includes portions of Interstate 35E and Minnesota Highway 36. Pike Lake flows directly east into Long Lake, which is impaired for nutrients.

In the period from 1978 to 1990 the RCWD completed an in-depth study of the Long Lake Chain of Lakes. This federally and state funded study evaluated the entire Long Lake watershed, including Pike Lake, and implemented a channel stabilization project (Hansen Park Pond) on RCD2 in New Brighton south of the lake. A city project also increased the size of the detention pond on the south side of Pike Lake. Both of these projects likely reduce the amount of sediment reaching the lake from the watershed.

In an early August 1995 aquatic plant survey completed by the DNR, curly-leaf pondweed was identified in rare abundance. Other plants found were Canada waterweed, blue flag, and narrowleaf pondweed.

A 1995 DNR fisheries survey noted that occasional winter fish kills occurred in Pike Lake. The survey indicated that panfish (mostly black crappie and bluegill), carp, and bullhead were dominant. Some piscivores (perch, walleye, and northern pike) were present, but in small numbers; the piscivores likely migrated from Long Lake. Pike Lake has no public access and the DNR has not conducted a fish stocking program on the lake.

¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from the Rice Creek Watershed District website.

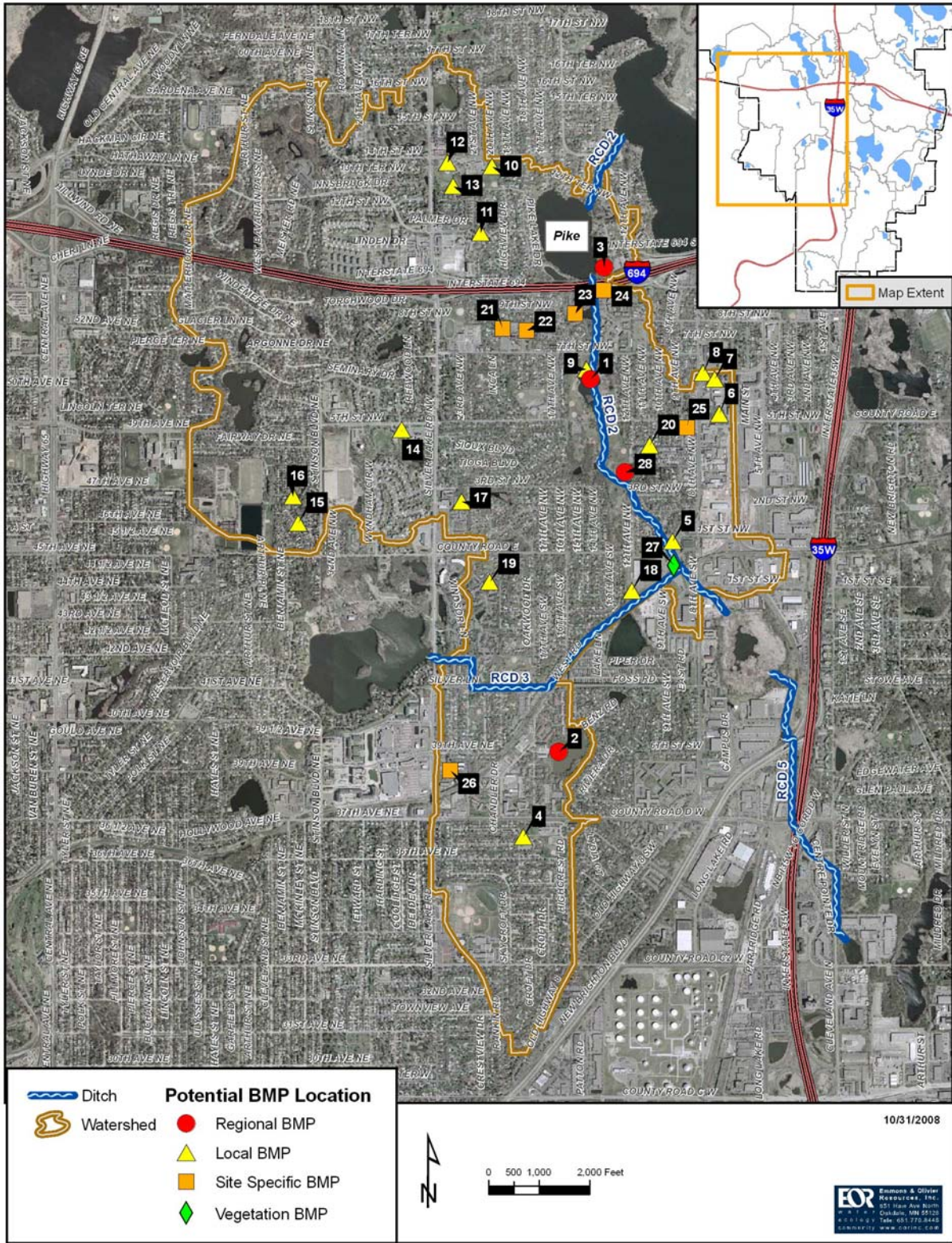


Figure 1. Pike Lake and Potential BMP Locations

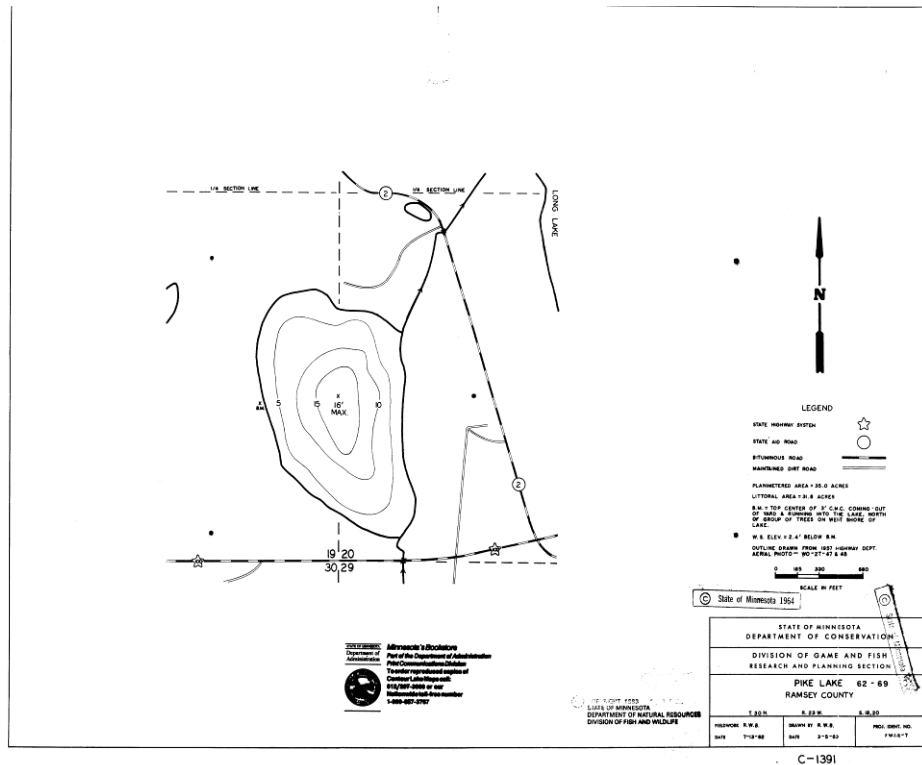


Figure 2. Pike Lake Bathymetry

Water Quality Summary

Data have been collected for Pike Lake water quality from 1980 to 2007. Data are collected by a volunteer through the Citizen Assisted Monitoring Program (CAMP). A summary of the 10 most recent years of water quality data for the lake suggest that Pike Lake is not meeting state water quality standards for any parameters (Table 1).

Table 1. Average Water Quality Data (1998 – 2007) and Standards

Parameter	Pike Lake	Shallow Lakes Standard
TP (µg/L)	91	60
Chl (µg/L)	53	20
Secchi Depth (m)	0.8	1.1

Figure 3-5 shows the growing season TP, chlorophyll-*a* and Secchi depth (clarity) data for the lake.

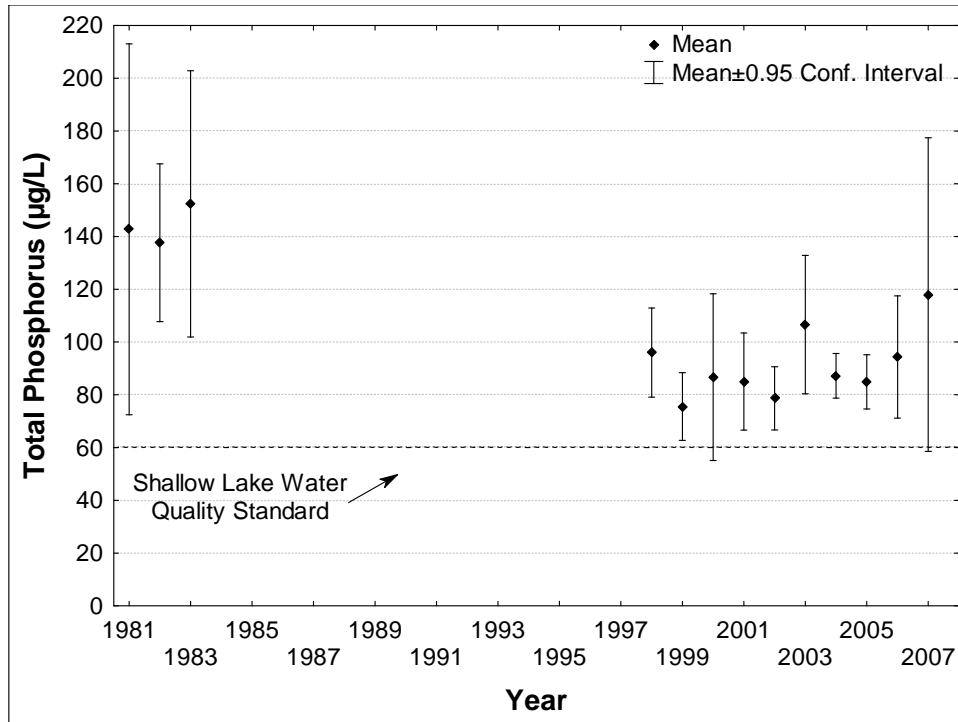


Figure 3. Pike Lake Total Phosphorus

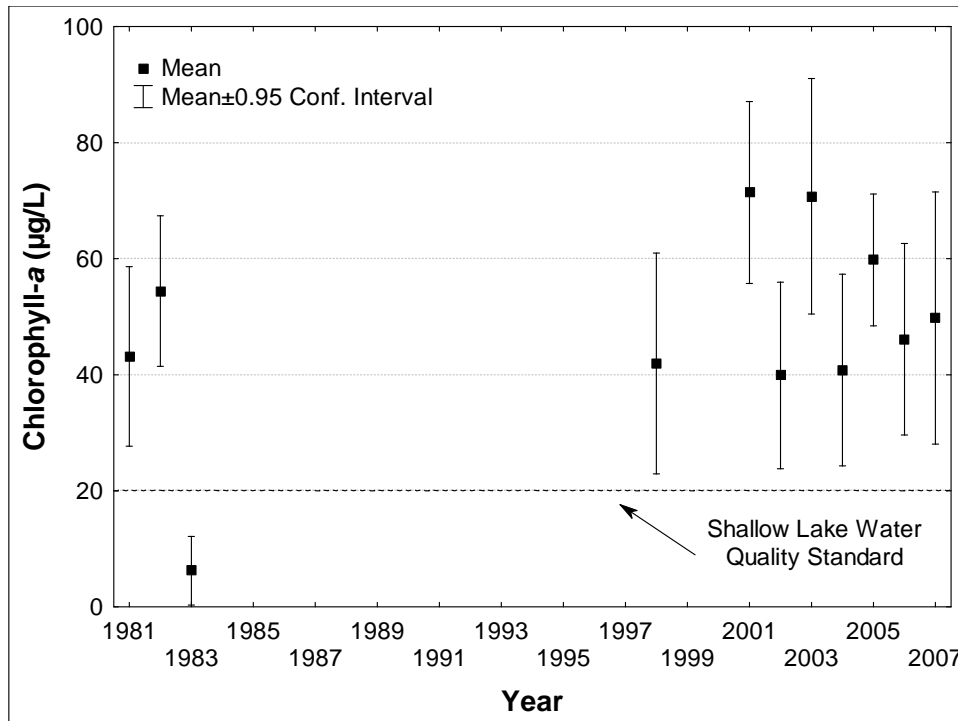


Figure 4. Pike Lake Chlorophyll-a

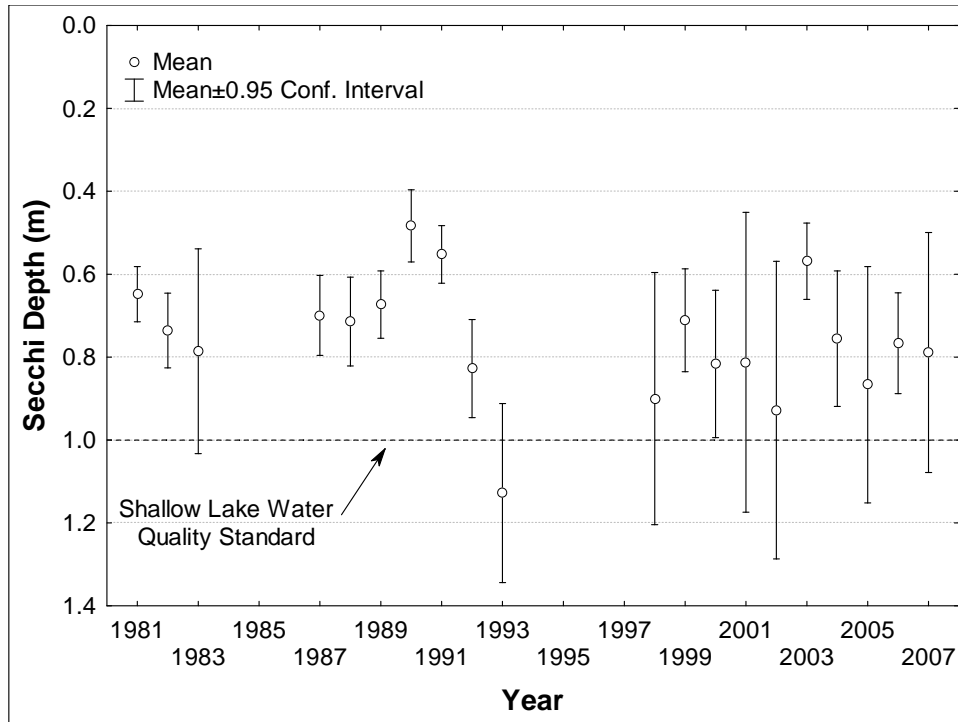


Figure 5. Pike Lake Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality modeling indicates that 82% of nutrient input to Pike Lake comes from its watershed, with the remaining 18% coming from internal lake loading (Figure 6). To reach the in-lake goal of 60 µg/L TP, the phosphorous load needs to be reduced by 43%.

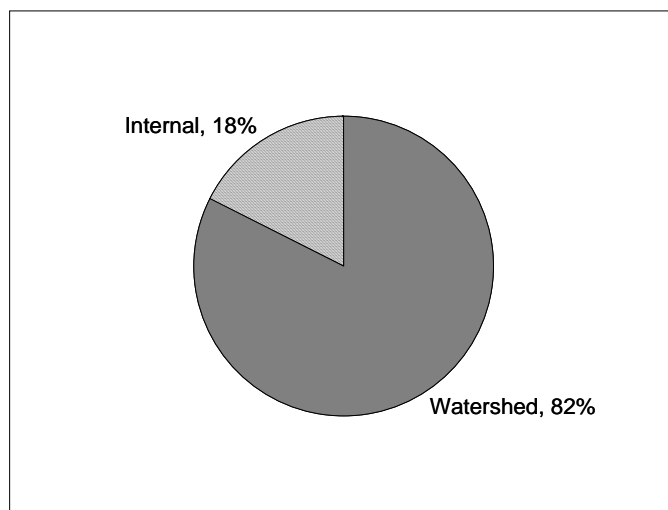


Figure 6. Pike Lake Phosphorus Load Distribution

Public Input

At the public input meeting on June 2, 2008, concerns regarding Pike Lake were addressed. Pike Lake has been impacted by its watershed as it developed. Long-time residents of the lake have remarked on its gradual slip in water quality as they watched the watershed develop.

- One attendee stated that she is still concerned about the runoff entering the lake from I-694 and the Venetian Village apartment complex south of the highway. She referenced a long list of objectionable debris and litter that move through the detention pond on the south end of the lake. She would like the RCWD to investigate measures to decrease this debris. She also requested a study of the effectiveness of the detention pond because she does not believe that it is effective in reducing any pollution. The pond is in place to treat runoff coming from I-694.
- The same attendee verified the deterioration in water quality since she has lived on the lake and mentioned that she no longer swims or fishes in the lake because of it. She asked for both a fish survey to see why the fish population is so bad and for a macrophyte survey to document why little vegetation of any kind is currently in the lake.
- The same attendee identified the need for more BMPs and for better management of those BMPs already in place. She has watched as BMPs were installed and subsequently forgotten. She hoped that more attention to BMPs might clear-up the pea-soup condition that dominates the lake during the growing season.
- She asked the RCWD to take charge and actually get something done, stating that nothing has really happened to improve the lake since she moved there in the 1970s; it continues to degrade. The resident told her story of repeated passing of the buck for responsibility for Pike Lake with none of the agencies she has contacted ever taking charge. Her requests to the city have not been followed through on behalf of the city, leading again to her frustration in trying to find an agency responsible for the lake. She reiterated several times that the lake owners are willing to do their part, but they need agency action to lead the way.
- A common theme expressed by lake residents at the public meeting dealt with government cooperation. All residents felt that state and local government entities needed to improve cooperation related to water quality monitoring, BMP maintenance, and improvement projects.

Water Quality Issues

- Pike Lake is the first lake downstream of Ramsey County Ditch 3, which would appear to be a source of high nutrient concentrations (photo below).
- Pike Lake is directly adjacent to Interstate-694 and likely receives highway runoff.
- DNR surveys and resident comments suggest a lack of aquatic vegetation in the lake. This could indicate that the lake is currently in the turbid, algal-dominated phase common in shallow lakes.
- Curly-leaf pondweed was found in the lake at a rare abundance in an early August 1995 aquatic plant survey. Since curly-leaf pondweed usually dies back after June, its presence in August could indicate that it is abundant earlier in the growing season. Curly-leaf pondweed can contribute to internal loading.
- The fish community in 1995 was composed mainly of bullhead, carp, crappie, and bluegill, with low densities of piscivorous fish. If the fish community composition is

similar today, this prevalence of rough fish and planktivorous fish could lead to high rates of internal loading due to disturbance of the lake bottom sediments and overgrazing of zooplankton.



Recommended Management Approach

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing the nutrient impairment. Because the Pike Lake watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 28 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Feasibility and Benefit Level Assessment of the four potential regional BMP locations identified in the *field reconnaissance supplement*.
- Consideration of local partnerships for further assessment of potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- Perform an evaluation of the effectiveness of the I-694 detention pond to make sure it is as effective as it was designed to be. There are also now available on the market sewer and catch basin inserts that effectively remove debris and litter from stormwater. This kind of device should be installed on all of the runoff inlets coming from the Venetian Village apartment complex.

- The original project on RCD2 (Hansen Park Pond) should be inspected by the RCWD and City of New Brighton to see if any repairs or upgrades are needed at this time. This facility (wetland enhancement) drains a very large watershed and should be removing a lot of the suspended material that otherwise makes its way to Pike Lake. Some additional retrofitted storage could be available at this facility. Additionally, RCWD staff has observed high carp densities in the pond. Re-suspension of fine sediment associated with carp feeding behavior may be limiting the pond's effectiveness. Work with DNR to develop a carp management strategy for the pond.
- The New Brighton 2000 Surface Water Management Plan mapped the areas of the city that are not treated with any runoff BMPs. The largest amount of this acreage occurs directly adjacent to Pike Lake, entering the lake from direct runoff, and in small parcels scattered throughout the city. The date on the map is 1999, so some efforts to treat this previously untreated area could have occurred since then. Work with New Brighton to update the map, and use this map to help target areas that do not currently treat stormwater runoff.
- The City of New Brighton has a street sweeping priority system that has as highest priority the sweeping of streets that directly discharge to major water bodies, which includes some streets around Pike Lake and RCD2. Work with New Brighton to continue this program and encourage additional street sweeping in the area.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management.
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs.
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control.

Internal Lake Management Recommendations

With very little in-lake biological data for Pike Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Pike Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.

- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep algae populations in check. Despite the high densities of panfish, their size structure was more balanced than other lakes in the area; 46% of crappie and 27% of bluegill were larger than 6 inches. Work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Pike Lake. Since there is a long record of in-lake water quality data for Pike Lake, additional data collection is not a high priority at this time.

- TP, chlorophyll, and Secchi depth data: Collect at least five sampling dates per year. The TMDL can be based on the existing monitoring data; additional data should be collected after management actions are implemented to track the response of the lake. Continued support of the CAMP program should ensure sufficient water quality data collection in the future.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.
- Ramsey County Ditch 2 should be monitored close to the inlet to Pike Lake to provide flow and phosphorus loading estimates. These data will be needed in order to estimate the watershed phosphorus load to the lake for the TMDL study.
- Water quality monitoring of discharge from Ramsey County Ditch 3.

Pike Lake Field Reconnaissance Supplement

Regional Management BMPs



Pike Lake #1

Location: Hanson Park

Description: Large wetland/pond treatment area previously enhanced by RCWD

Potential Improvements: An assessment of the current storage capacity versus the original design and the need for maintenance/excavation of accumulated material could be done. Other vegetation enhancements or management strategies could also be evaluated. Carp management/eradication options for small ponds should be reviewed.



Pike Lake #2

Location: North of County Road D and east of Oakwood Drive

Description: Mirror Pond – the water was very green the day of the site visit. This could potentially be a contributing source of the poor water quality at the outlet of RCD 3.

Potential Improvements: Assessment of Mirror Pond should be done. Options could be to chemically treat the outlet or seal sediments to reduce downstream loading.



Pike Lake #3

Location: Immediately southeast of Pike Lake

Description: Fenced-in play area on wooded lot.

Potential Improvements: This area could potentially be used as a regional treatment facility.

Local Management BMPs



Pike Lake #4

Location: North of Wendhurst Ave and east of Chelmsford Road

Description: Open grass area next to recently repaved church parking lot

Potential Improvements: Raingarden/water quality BMPs could be installed for runoff from the church parking area or adjacent road. The sloped nature of the area would limit the opportunities to utilize the space.



Pike Lake #5

Location: South of 1st Street and west of Old Highway 8

Description: Large grass area on corner.

Potential Improvements: This site could be used for infiltration or ponding for runoff from adjacent road ways.



Pike Lake #6

Location: North of 5th Street and east of 8th Avenue

Description: Open grass area at New Brighton Public works building.

Potential Improvements: Raingarden/water quality BMPs could be installed for runoff from adjacent roads/buildings.



Pike Lake #7

Location: East of 8th Avenue and north of 6th Street

Description: Large open areas

Potential Improvements: Install ponding or infiltration areas for runoff from adjacent roads



Pike Lake #8

Location: East of 8th Avenue and north of 6th Street

Description: Large open areas.

Potential Improvements: Install ponding or infiltration areas for runoff from adjacent roads.



Pike Lake #9

Location: South of 7th Street and east of 17th Avenue

Description: Open grass area (current use is unclear).

Potential Improvements: Pick up pipe inlet from southwest and provide additional treatment prior to discharge to the regional pond. This area could also be used to treat 7th Street runoff.



Pike Lake #10

Location: South of 14th Street and west of 20th Avenue

Description: Open grass area on school grounds.

Potential Improvements: Utilize this area to treat school runoff or adjacent roads.



Pike Lake #11

Location: Northwest of intersection of Robin Lane and 12th Street

Description: Dry ponding area along with additional swales/green space onsite.

Potential Improvements: Incorporate water quality treatment prior to discharge (e.g. infiltration and/or ponding).



Pike Lake #12

Location: South of 14th Street and east of Silver Lake Road

Description: Greenspace on school property behind baseball field.

Potential Improvements: Use this area to treat runoff from school or adjacent streets.



Pike Lake #13

Location: West of the intersection of Robin Lane and 13th Street

Description: Large dry pond.

Potential Improvements: Retrofit this site to include water quality treatment and infiltration.



Pike Lake #14

Location: South of the intersection of 5th Street and Driftwood Road

Description: Large open green space.

Potential Improvements: Incorporate a large infiltration area for adjacent road runoff (area is likely already treated by water quality ponds).



Pike Lake #15

Location: East of Heights Drive and south of Maiden Lane

Description: Open green space.

Potential Improvements: Utilize to treat runoff from the adjacent roadway.



Pike Lake #16

Location: East of the intersection of Heights Drive and Golf Place

Description: Open green space.

Potential Improvements: Utilize to treat runoff from the adjacent roadway.



Pike Lake #17

Location: South of 3rd Street and west of 23rd Avenue

Description: Wooded lot

Potential Improvements: Utilize to treat runoff from the adjacent roadways or impervious areas from the south and west (note: the lot has significant grade change from south to north).



Pike Lake #18

Location: South of 1st Street and east of 13th Avenue

Description: Large unused green space.

Potential Improvements: Possibly use the area to treat runoff from the adjacent neighborhood to the west.



Pike Lake #19

Location: South of Windsor Way and west of 20th Avenue

Description: Large grass area at Winsor Park (private common area)

Potential Improvements: Incorporate a large infiltration/filtration feature for treatment of runoff from adjacent roadways.



Pike Lake #20

Location: 11th Avenue looking north from 4th Street

Description: A general example of a neighborhood that would be easy to retrofit raingardens into.

Potential Improvements: Incorporate raingardens throughout the area during road reconstruction projects.

Site Specific Management BMPs



Pike Lake #21

Location: North of 7th Street and east of 22nd Avenue

Description: Existing ponding area on church site.

Potential Improvements: Clean out and expand the pond for additional treatment.



Pike Lake #22

Location: North of 7th Street and west of Oakwood Drive

Description: Grass swale on church site.

Potential Improvements: Retrofit the swale to an infiltration area treating runoff from the adjacent drive.



Pike Lake #23

Location: North of 7th Street and east of Patton Road

Description: Ramsey County Ditch #2 and offline pond (in the background), parking lot flumes straight to ditch (in the foreground). The adjacent Venetian Village apartment complex and parking drains directly to RCD-2 and receives no treatment prior to reaching Pike Lake

Potential Improvements: Assess options that would, at a minimum, remove debris before entering the ditch.



Pike Lake #24

Location: South of 694 and east of Patton Road

Description: Swale adjacent to apartment drive with exposed soils.

Potential Improvements: Improve/enhance the swale to provide treatment for runoff from the adjacent drive.



Pike Lake #25

Location: West of 8th Avenue and south of 5th Street

Description: Roof drainage directed to parking area @ J & B Auto Repair

Potential Improvements: Green space could easily be converted into a raingarden area that could treat the roof top and possibly some of the parking area.



Pike Lake #26

Location: West of Macalaster Drive and south of 39th Avenue

Description: Open green space areas around apartment complex.

Potential Improvements: This location along with other areas onsite could be converted to raingarden areas for treatment of the adjacent apartments and associated parking.

Vegetation Management/Stabilization BMPs



Pike Lake #27

Location: West of Old Highway 8 and south of 1st Street

Description: Confluence of Ramsey County Ditch #2 and Ramsey County Ditch #3

Potential Improvements: Bank Stabilization is needed at the outlet of Ramsey County Ditch #3.

Additional Regional BMP suggested by New Brighton



Pike Lake #28

Location: West of 3rd Terrace NW

Description: Future treatment area suggested by City of New Brighton, existing open space area in Hansen Park

Potential Improvements: Excavation of large, shallow biofiltration feature potentially receiving runoff from redirected stormsewer outfalls currently discharging directly to Ramsey County Ditch 2 from 3rd and 4th Streets NW.

Poplar Lake Management Action Plan

Poplar Lake (62-0077) is located in the City of New Brighton, Ramsey County, Minnesota (Figure 1). The lake has a surface area of 13 acres and a maximum depth of 5 feet¹ (Figure 2). Based on its low maximum depth, it is considered a shallow lake according to MPCA's definition. Poplar lake watershed is approximately 108 acres and is tributary to Jones Lake, Pike Lake, and Long Lake, which are all on the EPA's 303(d) list of impaired waters.

The area immediately surrounding the lake is a mobile home park on the west and south sides, with railroad tracks on the north and a commercial facility on the northeast. The rest of the watershed area, predominantly to the south, is single family residential.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from DNR files.

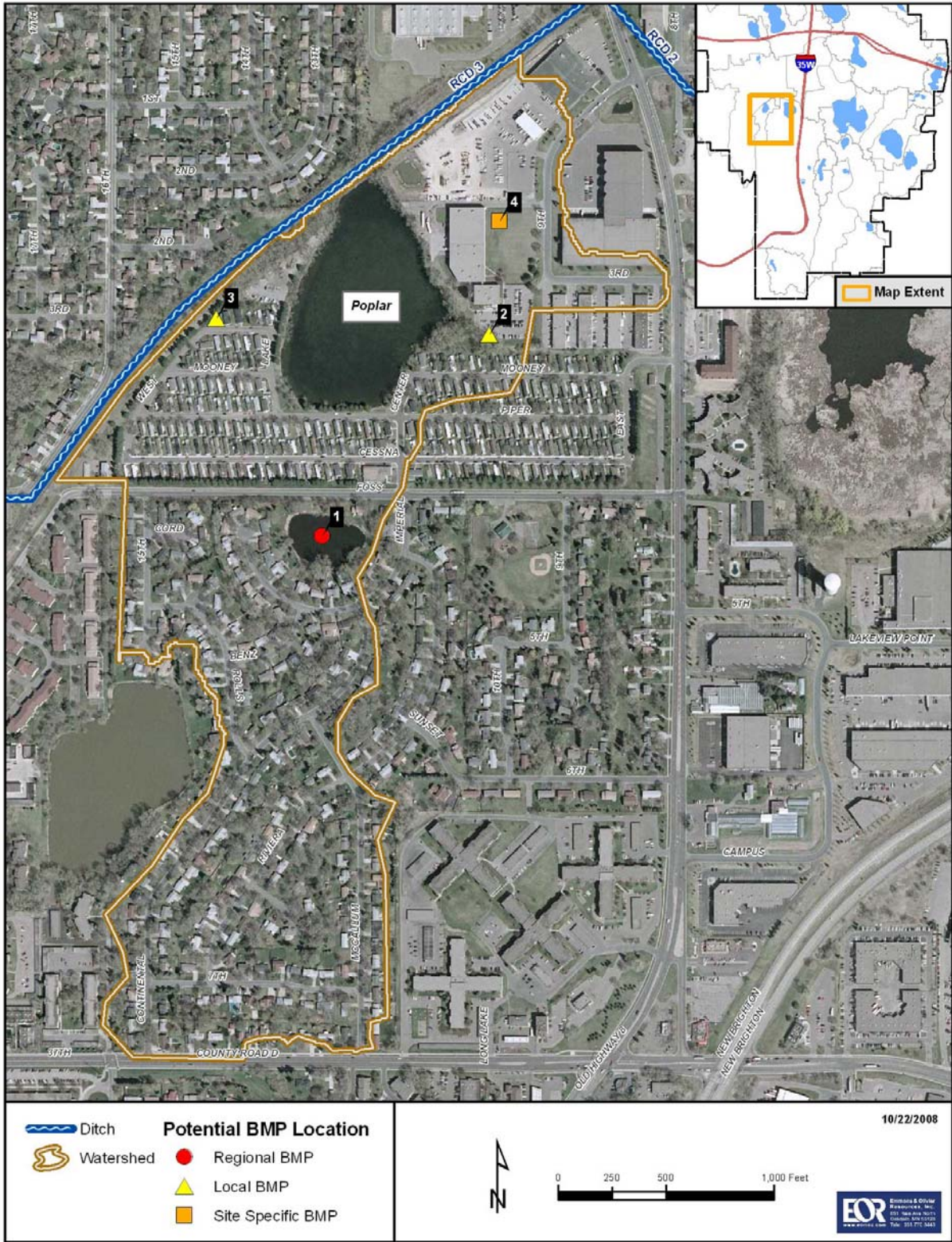


Figure 1. Poplar Lake and Potential BMP Locations

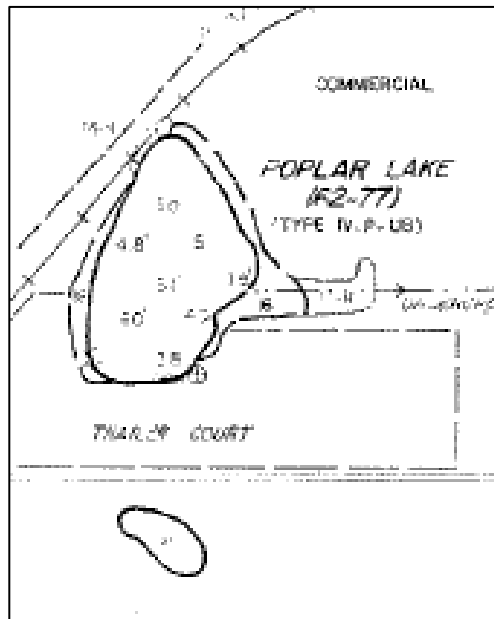


Figure 2. Poplar Lake Bathymetry. Map from DNR files, unknown date.

Water Quality Summary

Water quality and biological data are not available for Poplar Lake. A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. There are no in-lake monitoring data to calibrate the lake model. Water quality modeling indicates that watershed inputs account for approximately 88% of the nutrient load, with internal loading accounting for the remaining 12% (Figure 3).

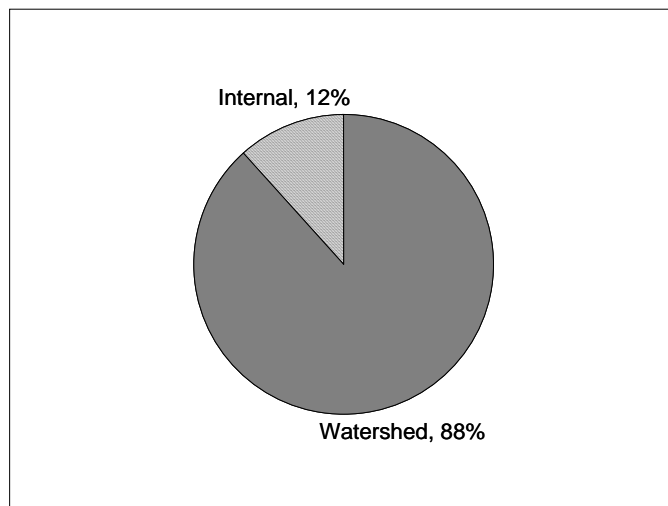


Figure 3. Poplar Lake Phosphorus Load Distribution

Public Input

At the public input meeting held on June 2, 2008, no attendees were present to discuss Poplar Lake. In a phone conversation, a representative of Lakeside Homes, Inc., the mobile home park, mentioned there is a well/pump appropriating water from the lake for the industrial area on the northeast side of the lake. He wondered if the appropriations were related to the low water levels observed in the lake that year (2007).

Water Quality Issues

- Without further data or public input, water quality issues were not able to be defined.

Recommended Management Approach

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing the water quality of Poplar Lake. Because the Poplar Lake watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 4 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Feasibility and Benefit Level Assessment of the potential regional BMP location identified in the *field reconnaissance supplement*.
- Consideration of local partnerships for further assessment of potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- Re-establishing a vegetated buffer strip around the lakeshore would help stabilize the shoreline and prevent erosion and sediment wash-off.
- The existing BMPs on the south side of the lake and in the southern part of the watershed should be evaluated as to their effectiveness in reducing nutrient inflow to the lake.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management

- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

With no in-lake biological data for Poplar Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Poplar Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Poplar Lake. There are no in-lake water quality data for the lake; if the implementation of management practices for the lake were to move forward, in-lake data and bathymetric data would be needed and should be considered a high priority

- Updated bathymetric data collection
- TP, chlorophyll, and Secchi depth data: Collect data for several years, with at least five sampling dates per year.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Poplar Lake Field Reconnaissance Supplement

Regional Management BMPs



Poplar Lake #1

Location: South of Foss Road and west of Imperial Lane

Description: Large ponding area receiving runoff from neighborhoods to the south. Pond was pea-soup green the day of the photo.

Potential Improvements: Assess the effectiveness and perform maintenance or other improvements as needed to ensure that the pond is providing the treatment needed before discharging to Poplar Lake.

Local Management BMPs



Poplar Lake #2

Location: Near parking area north of Mooney Drive and just east of Poplar Lake

Description: Curb cut from parking area and an additional piped discharge enter a grassed swale that then flows through a small patch of woods before reaching Poplar Lake.

Potential Improvements: A raingarden could be incorporated in the available green space. Removal of some trees would allow for a larger feature. Appropriate sizing would be dependent on a determination of the drainage area from the piped discharge.



Poplar Lake #3

Location: Intersection of Champion Drive and West Road

Description: Stormsewer discharge into swale area flows into wooded swale and eventually discharges at the northwest corner of Poplar Lake.

Possible Improvements: Swale could easily be expanded into a treatment feature providing storage or infiltration as needed.

Site Specific Management BMPs



Poplar Lake #4

Location: Trend Enterprises west of 9th Avenue SW

Description: Site has swales and low areas currently collecting stormwater.

Possible Improvements: Some fairly simple retrofits and vegetation enhancements onsite may provide water quality/quantity benefits for Poplar Lake.

Round Lake Management Action Plan

Round Lake (62-0070) is located in the City of Arden Hills, Ramsey County, Minnesota (Figure 1). The lake has a surface area of 130 acres, a maximum depth of 7 feet and is 100% littoral¹. Based on its low maximum depth, it is considered a shallow lake according to MPCA's definition. The watershed draining into Round Lake is 465 acres.

Round Lake is located within a transportation triangle bounded by Highway 10 to the east and north, I-35W to the west, and I-694 to the south. It has some homes located along its shoreline and in the watershed to the north, and commercial uses to the west. It also drains the southwest corner of the Twin Cities Army Ammunition Plant (TCAAP), which is under consideration for re-development by the City of Arden Hills.

Round Lake drains southeast into the Valentine Lake sub-watershed, which eventually drains to Long Lake. Both Long Lake and Valentine Lake are on the EPA's 303(d) list of impaired waters, due to excessive nutrients.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from the Rice Creek Watershed District website.



Figure 1. Round Lake and Potential BMP Locations

Water Quality Summary

Water quality and biological data are not available for Round Lake within the past 10 years. MPCA collected water quality data between 1985 and 1992. The mean TP concentration over that time period was 49 µg/L.

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. Water quality modeling indicates that watershed inputs account for approximately 70% of the nutrient load, with internal loading accounting for the remaining 30% (Figure 2). The model suggests that the in-lake goal of 60 µg/L TP is being met. Without current in-lake nutrient data for the lake for model calibration, the modeling results should be considered preliminary.

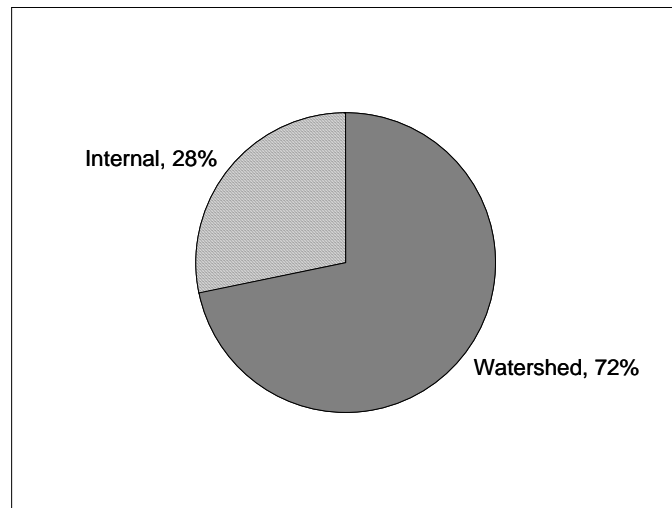


Figure 2. Round Lake Phosphorus Load Distribution

Public Input

At the public input meeting on June 3, 2008 issues facing Round Lake were addressed.

- Round Lake has received toxic material input from past industrial land use in its watershed related to the production of ammunition. It was stated that the U.S. Army still controls the lake surface and that use of the surface for any recreation is not allowed because of the potential to disturb bottom sediments and re-introduce settled contaminants. This was not verified with the US Army.
- A City of Arden Hills employee spoke about the purchase of TCAAP land by the city. Arden Hills is in the process of acquiring over 500 acres from the western part of TCAAP. A portion of this property drains into Round Lake.

Water Quality Issues

- Sediment within the lake may be contaminated with toxic substances due to past land use.
- The purchase of TCAAP land by the City of Arden Hills may lead to increased development in the watershed.

Recommended Management Approach

Watershed Management Recommendations

The primary management recommendation for the lake's watershed is to make sure strict application of RCWD and local runoff related regulations are followed throughout the watershed draining to the lake, especially during the future re-development of the TCAAP site. RCWD and the city should also look for BMP retrofit opportunities as they review other re-development and transportation projects within the watershed. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, three BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of the potential local BMP location identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

Any assessment of internal management control should include the consideration of possible re-suspension of toxic contamination from the sediment. With no in-lake biological data for Round Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Round Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are

determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.

- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep algae populations in check. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Round Lake. There are no in-lake water quality data for the lake; if the implementation of management practices for the lake were to move forward, in-lake data and bathymetric data would be needed and should be considered a high priority.

- Sediment analysis: If in-lake management practices are implemented, further study of the lake sediments should be completed to determine the extent of the contamination and the possibilities of containing the contamination so as not to release it or transport it downstream. This work would be done in cooperation with state agencies, such as the MPCA and MN Department of Health.
- Bathymetric data collection
- TP, chlorophyll, and Secchi depth data: Collect data for several years, with at least five sampling dates per year.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Round Lake Field Reconnaissance Supplement

Local Management BMPs



Round 1

Location: North of County Road 96 and west of Highway 10

Description: Cul-de-sac at the south end of the Highway 10 service road. Southern end of road (and cul-de-sac) does not appear to serve any homes or businesses.

Possible Improvements: Shorten roadway and remove or relocate cul-de-sac. Use current cul-de-sac area for treatment of Highway 10.

Site Specific Management BMPs



Round 2

Location: South of County Road 96 and west of Snelling Avenue

Description: Open space adjacent to church parking lot.

Possible Improvements: Incorporate raingardens (likely filtration) to treat sheet flow runoff from the northern North Heights Lutheran Church parking lot.



Round 3

Location: East of Round Lake Road and north of Gateway Court

Description: Green space east of parking lot

Possible Improvements: Incorporate raingarden to treat adjacent parking lot.

Rush Lake Management Action Plan

Rush Lake (62-0068) is located in the City of New Brighton, Ramsey County, Minnesota (Figure 1). The surface area of the lake is about 55 acres, with a maximum depth estimated at 6 feet¹. Based on its low estimated maximum depth, it is considered a shallow lake according to MPCA's definition. Rush Lake drains to the north, eventually into Rice Creek.

The watershed draining to Rush Lake is approximately 277 acres and includes Long Lake Regional Park and surrounding commercial/residential land. A portion of the drainage area contains the Northwest Quadrant re-development project in New Brighton. This effort involves the re-development of underutilized land into a mixed-used neighborhood with retail, residential, office, and parkland uses. The project also addresses some long-standing contamination problems from a previous dump site.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos. No bathymetric data were available for this lake. The maximum depth was estimated using depth data collected during sediment sampling.



Figure 1. Rush Lake and Potential BMP Location

Water Quality Summary

Water quality and biological data are not available for Rush Lake. A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. There are no in-lake monitoring data to calibrate the lake model. Water quality modeling indicates that watershed inputs account for approximately 55% of the nutrient load, with internal loading accounting for the remaining 45% (Figure 2). Without any in-lake nutrient data for the lake for model calibration, the modeling results should be considered preliminary.

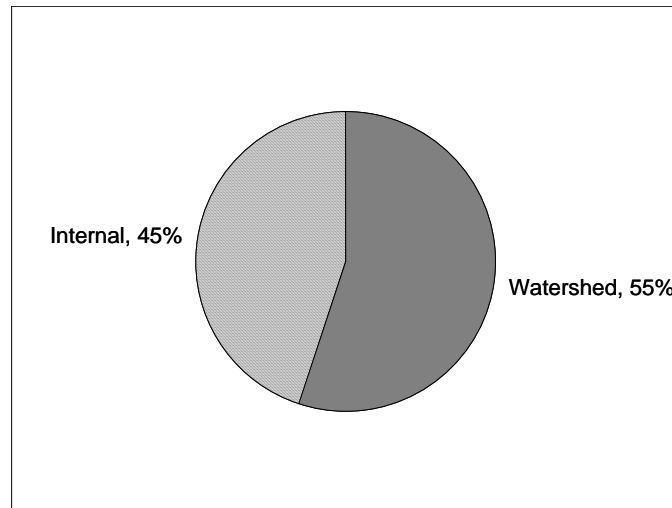


Figure 2. Rush Lake Phosphorus Load Distribution

Public Input

At a public meeting held on June 3, 2008 by the RCWD, an attendee offered his opinion that the former stockyards surrounding Rush Lake likely contributed a large amount of nutrient-laden runoff that probably still resides in the lake sediments.

Water Quality Issues

- Without further data or public input, water quality issues were not able to be defined.

Recommended Management Approach

Watershed Management Recommendations

The primary management recommendation for the lake's watershed is to make sure strict application of RCWD and local runoff related regulations are followed throughout the watershed draining to the lake, especially during the future re-development of the TCAAP site. RCWD and the city should also look for BMP retrofit opportunities as they review other re-development and transportation projects within the watershed. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, four BMP retrofit

opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of the four potential local BMP locations identified in the *field reconnaissance supplement*.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

With no in-lake biological data for Rush Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Rush Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Rush Lake. There are no in-lake water quality data for the lake; if the implementation of management practices for the lake were to move forward, in-lake data and bathymetric data would be needed and should be considered a high priority.

- Bathymetric data collection
- TP, chlorophyll, and Secchi depth data: Collect data for several years, with at least five sampling dates per year.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Rush Lake Field Reconnaissance Supplement

Local Management BMPs



Rush 1

Location: West of the intersection of Old Highway 8 and Mound Street

Description: Large open space behind an existing home.

Possible Improvements: Use for treatment of adjacent businesses or Old Highway 8.



Rush 2

Location: West of the intersection of Old Highway 8 and County Road 96

Description: Open space near outlet of stormsewer from Old Highway 8

Possible Improvements: Incorporate wetland treatment/ponding area.



Rush 3

Location: West of Old Highway 8 and south of County Road 96

Description: Open space near outlet of stormsewer from Old Highway 8

Possible Improvements: Incorporate wetland treatment/ponding area.



Rush 4

Location: West of Old Highway 8 and north of 1st Avenue

Description: Open space near outlet of stormsewer from Old Highway 8

Possible Improvements: Incorporate wetland treatment/ponding area.

Spring Lake Management Action Plan

Spring Lake (02-0071) is located in the Cities of Spring Lake Park and Mounds View, on the boundary of Anoka and Ramsey Counties, Minnesota (Figure 1). The lake has a surface area of approximately 46 acres, a maximum depth of 18 feet and is over 95% littoral (Figure 2). Based on its high percentage of littoral habitat it is classified as a shallow lake according to MPCA's definition.¹ The watershed draining to Spring Lake is approximately 303 acres and consists of primarily residential, with some commercial, institutional, and mixed use areas. Much of the north western shoreline is Lakeside Park, a park managed by the City of Spring Lake Park, which includes a swimming beach and a fishing dock.

A presence of curly-leaf pondweed has been reported by residents. A macrophyte survey completed in late June of 2007 by RCWD did not show a presence of curly-leaf pondweed, but instead an abundance of coontail, white water lily, and clasping leaf pondweed. Another macrophyte survey completed by DNR in early June 2008 found curlyleaf at nearly all sampling locations throughout the lake, but in moderate density. A 2003 DNR lake survey found the lake to have northern pike and abundant populations of bluegill and black bullheads. Largemouth bass have also been observed by RCWD staff. The lake is susceptible to winterkill. In 2007 a winter aeration pump was installed in the lake to prevent winterkill.

Water level in Spring Lake has fluctuated dramatically over the years (Figure 3). Most of the periods of low water level are preceded by periods of low precipitation, suggesting that the lake is fed by surficial groundwater and that water levels are tied to long-term precipitation patterns. Historical records show that water levels in the lake used to be maintained by the county through groundwater pumping. However, after this practice contributed to the spread of several non-native plant and animal species in other water bodies, the DNR restricted pumping of groundwater for the maintenance of surface water levels in the late 1980s. Currently, other than encouraging practices that infiltrate water in the watershed, there are few (if any) options for augmenting surface water levels.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos. The maximum depth was taken from the Rice Creek Watershed District website.

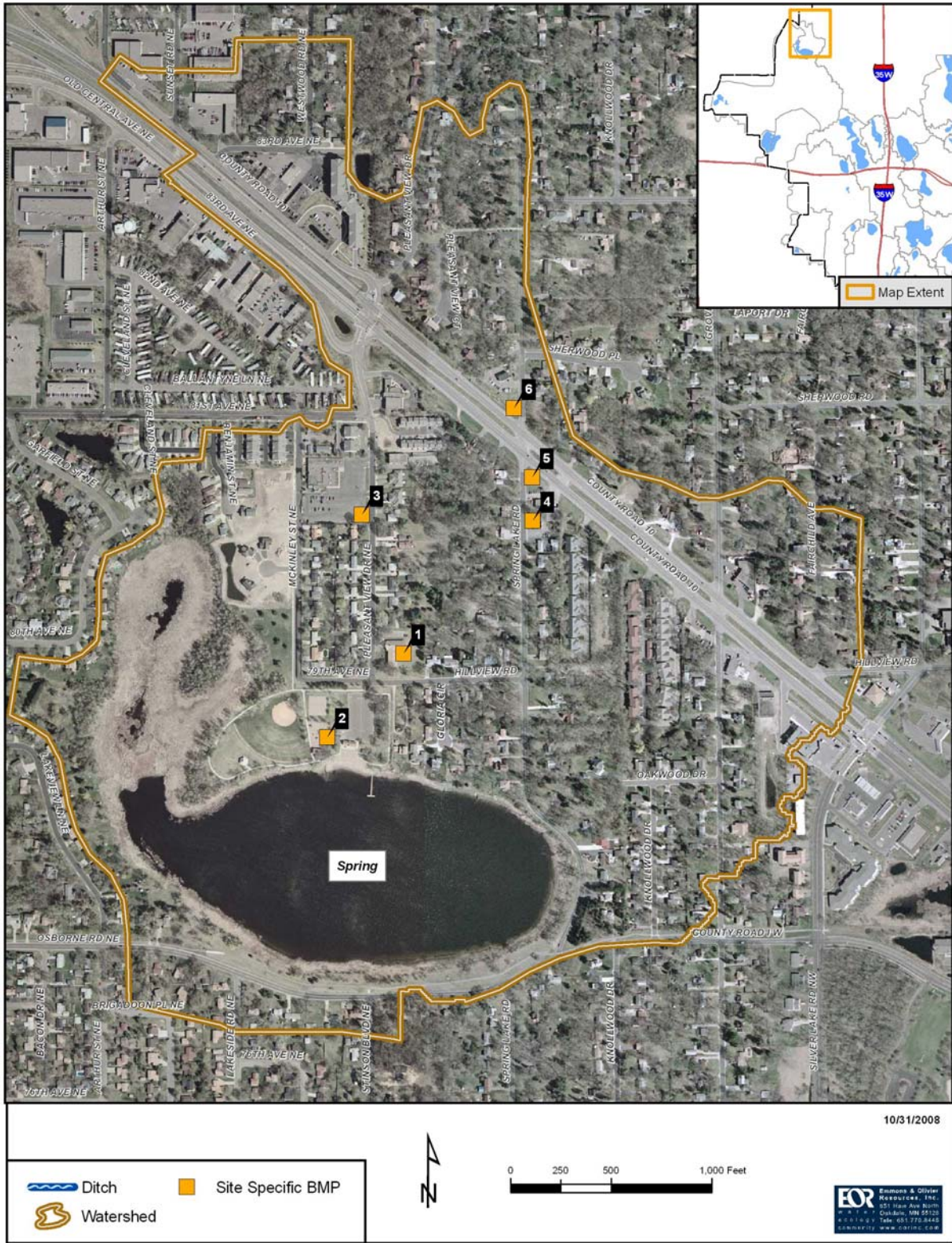


Figure 1. Spring Lake and Potential BMP Locations

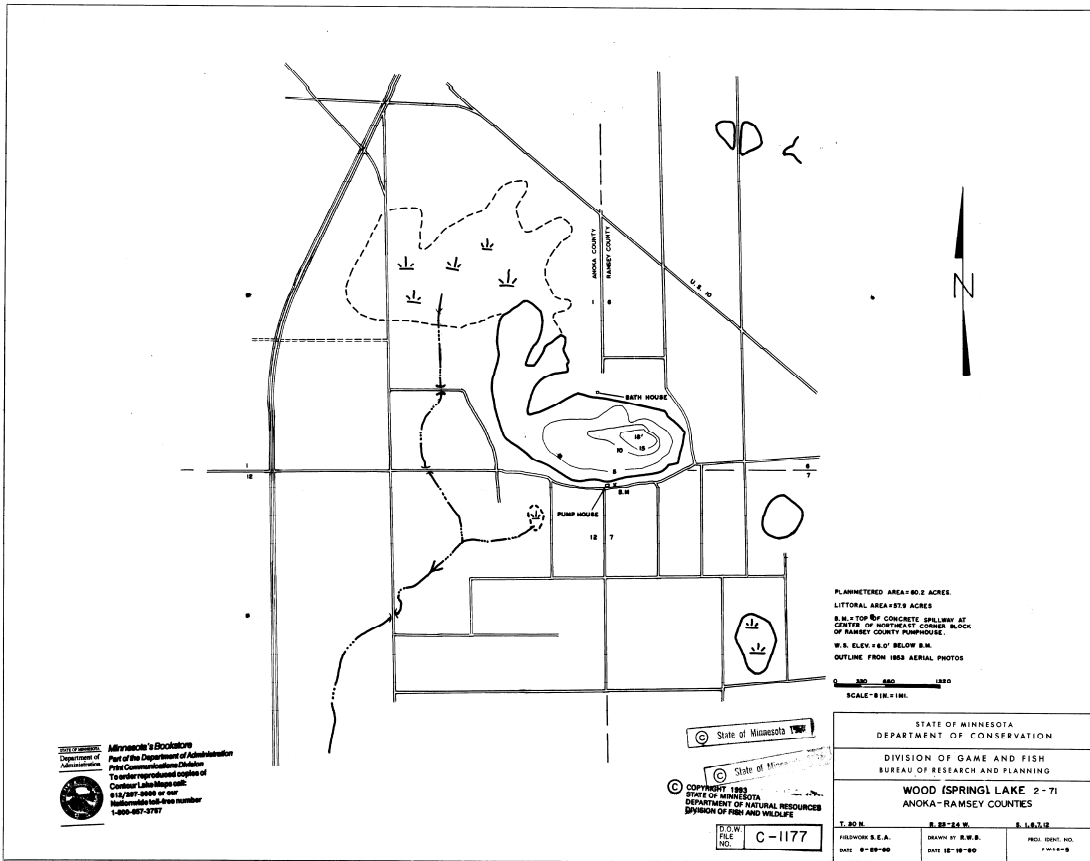


Figure 2. Spring Lake Bathymetry

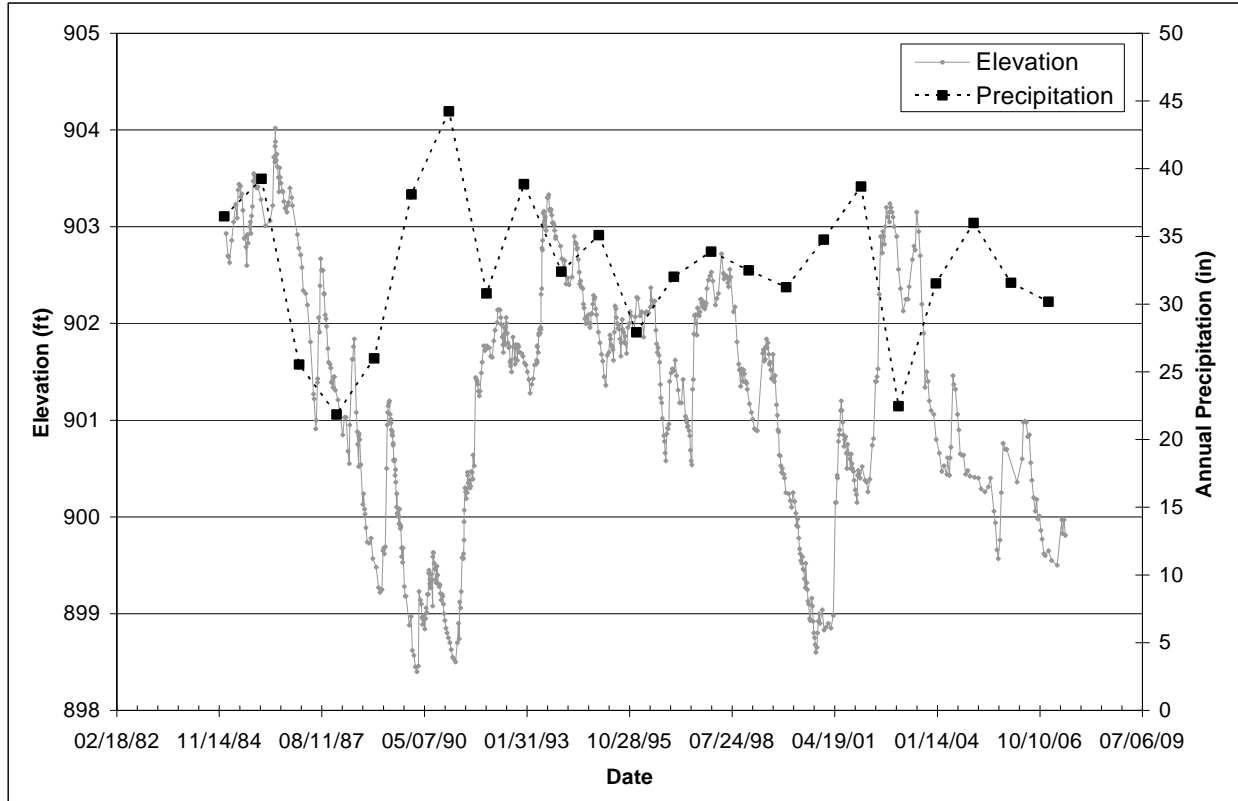


Figure 3. Spring Lake Water Levels

Water Quality Summary

One full year of water quality data exist for Spring Lake. Data were collected by MPCA. Water quality data were also collected in 2008 by RCWD, although only the phosphorus data were ready in time for this report. A summary of data from 2001 suggests that the lake is meeting all of the shallow lake water quality standards (Table 1).

Table 1. Average Water Quality Data (2001) and Standards

Parameter	Spring Lake	Shallow Lakes Standard
TP (µg/L)	33 ²	60
Chl (µg/L)	2.9	20
Secchi Depth (m)	2.4	1.0

Figures 4-6 show the growing season available TP, chlorophyll-*a*, and clarity (Secchi depth) data from Spring Lake.

² Includes preliminary data collected in 2008 by RCWD.

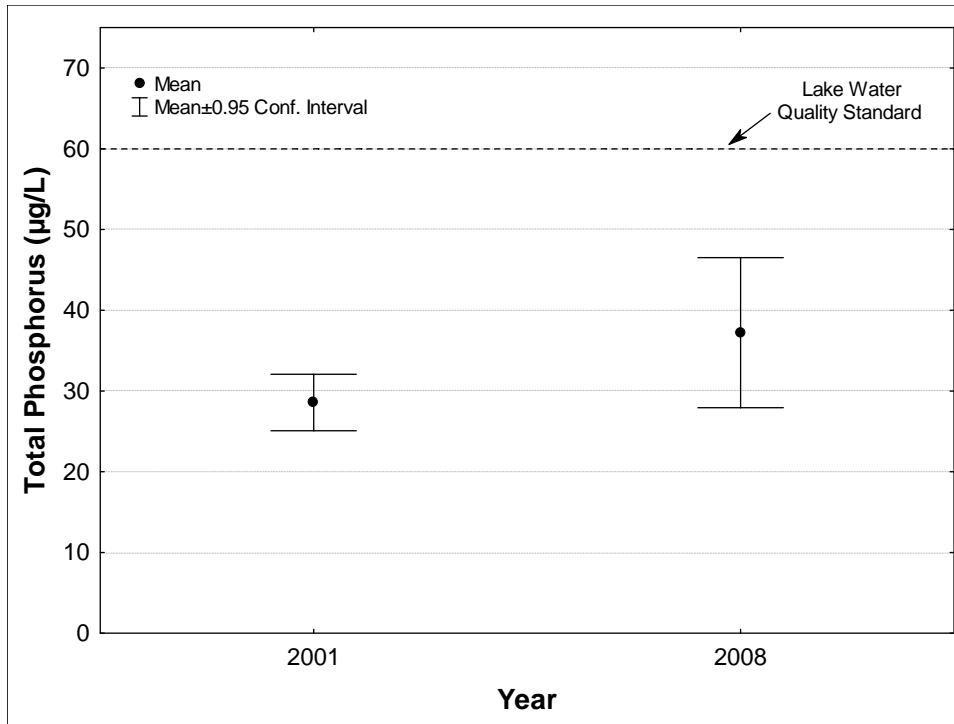


Figure 4. Spring Lake Total Phosphorus

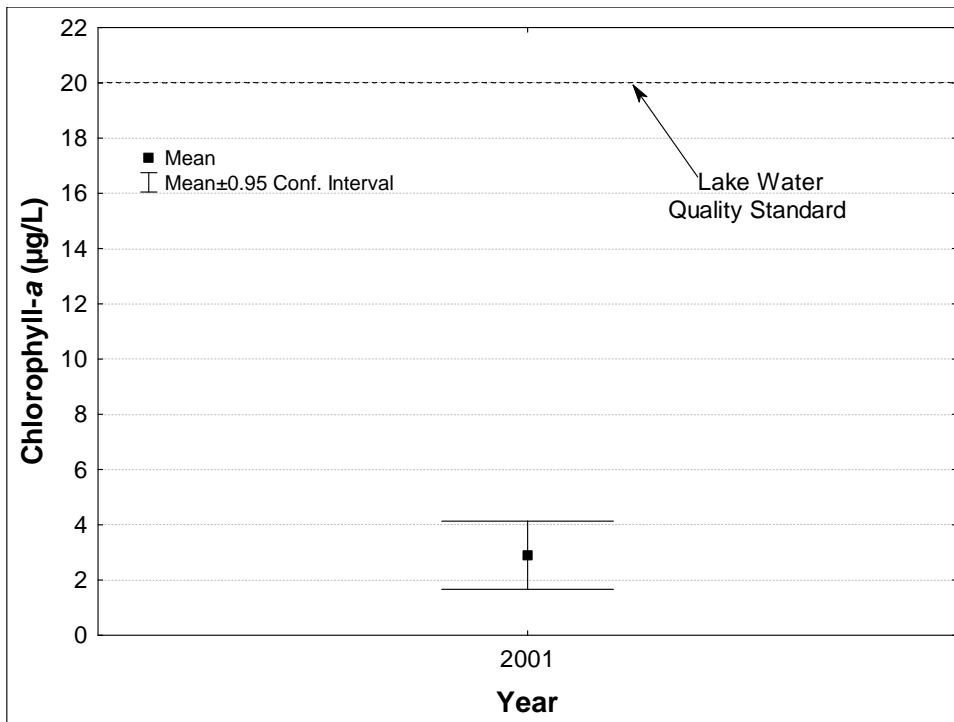


Figure 5. Spring Lake Chlorophyll-a

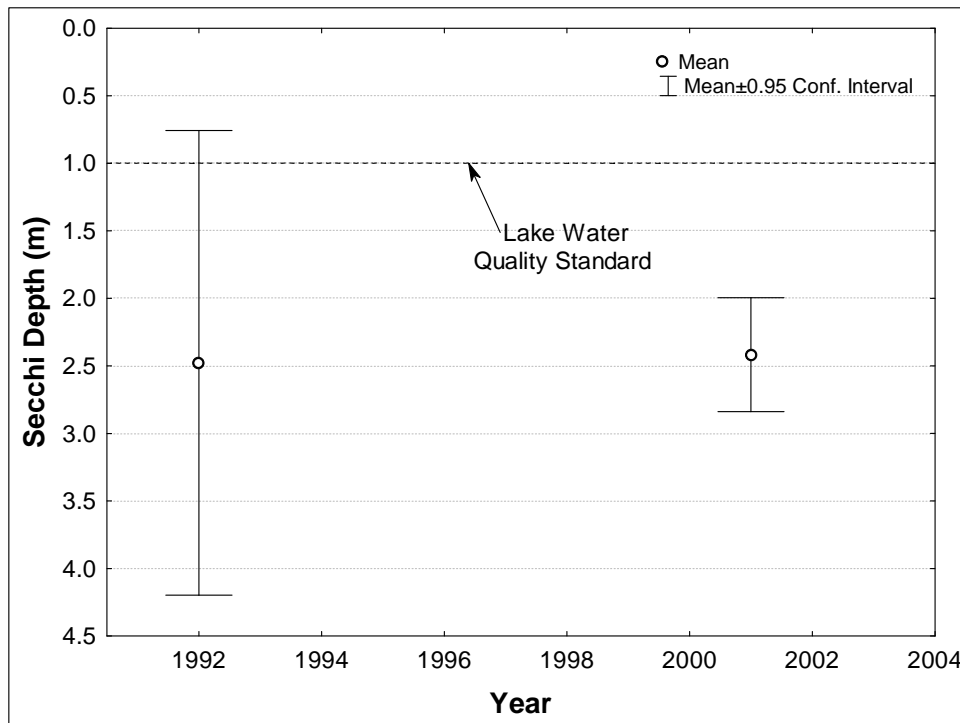


Figure 6. Spring Lake Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality modeling indicates that the primary source of nutrients affecting the lake's quality originates from watershed runoff. Watershed inputs account for about 98% of the nutrient load, with internal loading accounting for the remaining 2% (Figure 7). With only one year of monitoring data for model calibration, these results should be considered preliminary.

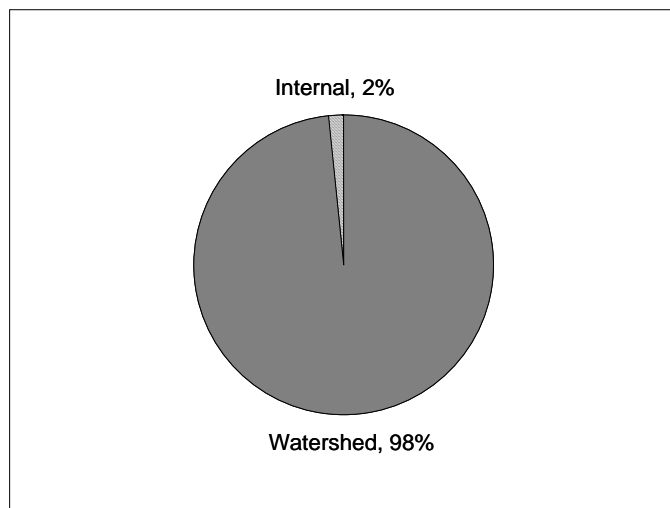


Figure 7. Spring Lake Phosphorus Load Distribution

Public Input

The water level of Spring Lake has been a point of discussion for the past few years and is a main concern of residents.

- The decrease in water levels is promoting the growth of vegetation that does not support the recreational goals of the lake.
- Residents suggest that curly-leaf pondweed is present in the lake.
- According to a certificate of title from 1955, the county is responsible for maintaining or attempting to maintain the water level at 903 feet above sea level. The most current water level data from the MPCA from June of 2007 has the water level at 899.81 feet above sea level. Data show that, over time, there is a natural fluctuation in the water levels of Spring Lake. Further study needs to be done to look into what the natural water level should be and what is a natural amount of water level fluctuation for this particular lake.
- Residents have discussed that if water is needed to bring the lake level up, water could be supplied to the lake from the Mississippi River with DNR approval. RCWD felt this option was not feasible, and it was unlikely that DNR would permit it.
- Additional concerns have been shared over erosion filling in the northwest portion of the lake and continued development in that area. Residents feel that the increased runoff and sediment coming from the northwest area could be causing the decrease in water levels. It should be noted that these areas were developed in accordance with RCWD stormwater management rules.
- Residents worked to get a winter aerator to prevent the winter kill of fish due to the low water levels.

Water Quality Issues

- Water levels in the lake fluctuate over time, impeding certain recreational uses of Spring Lake. These fluctuations have been determined to be driven by natural changes in groundwater levels and precipitation.
- Curly-leaf pondweed is present in the lake, and contributing to internal loading.

Recommended Management Approach

Watershed Management Recommendations

Because the Spring Lake watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, six BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of the two potential local BMP locations identified in the *field reconnaissance supplement*.

- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Given the concerns regarding lake levels, and the likelihood that lake levels are dependent on surficial groundwater, RCWD should work to educate local land owners on the importance of infiltration features. Infiltrating rainwater in hopes of boosting local surficial groundwater levels is likely the best course of action for increasing lake water levels.

Internal Lake Management Recommendations

- Develop an aquatic vegetation management plan. Shoreline restoration should be undertaken and actively managed to improve the habitat of the areas of the lake that dry up under low water conditions.
- A model and monitoring plan could be developed that would predict changes in lake level based on parameters such as precipitation and nearby groundwater levels. This would allow proactive management of the lake's shoreline in anticipation of low surface water levels.
- Assess the feasibility and cost of curly-leaf pondweed control options. Whole lake treatments would require an aquatic vegetation management plan. Controlling curlyleaf pondweed may be the key to reducing internal loading. (The internal loading estimate presented here is based solely on sediment phosphorus release and does not include internal loads from curlyleaf pondweed senescence. The actual internal load therefore may be greater than indicated here.)

Recommended Data Collection

With two years of in-lake data showing that Spring Lake has high water quality, additional data collection is not a high priority at this time.

- TP, chlorophyll, and Secchi depth data: Collect data for several years, with at least five sampling dates per year.

- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the density of curly-leaf pondweed and other invasive aquatic vegetation. . Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.

Although the focus of this study is on water quality, water levels are also addressed here since it is an issue that local residents are concerned about. To confirm the cause of the water level fluctuations, groundwater data could be collected to better identify the surrounding shallow groundwater depths, flow patterns, natural fluctuations, and the groundwater connection to Spring Lake. From the results of the study, targeted BMP recommendations addressing water level fluctuations could be made.

Spring Lake Field Reconnaissance Supplement

Site Specific Management BMPs



Spring 1

Location: North of Hill View Road and east of Pleasant View Drive

Description: Open space adjacent to church.

Possible Improvements: Incorporate raingarden area for treatment of church and/or adjacent roadways.



Spring 2

Location: South of the intersection of Pleasant View Drive and 79th Avenue

Description: Swale receiving runoff from the Lakeside Park parking lot located within the park north of Spring Lake.

Possible Improvements: Incorporate raingarden prior to discharge to Spring Lake.



Spring 3

Location: West of Pleasant View Drive and south of 81st Avenue

Description: Large bituminous parking lot at VFW

Possible Improvements: Remove east stalls or southeast corner of parking and incorporate treatment feature.



Spring 4

Location: East of Spring Lake Road and south of County Road 10

Description: Green space adjacent to parking lot

Possible Improvements: Incorporate raingarden area for treatment of adjacent parking lot.



Spring 5

Location: East of Spring Lake Road and south of County Road 10

Description: Green space adjacent to parking lot at Spring Lake Park Auto

Possible Improvements: Incorporate raingarden area for treatment of adjacent parking lot.



Spring 6

Location: West of Spring Lake Road and north of County Road 10

Description: Green space adjacent to parking lot at Thrifty Car Rental

Possible Improvements: Incorporate raingarden area for treatment of adjacent parking lot.

Sunfish Lake Management Action Plan

Sunfish Lake (02-0065) is located in the City of Arden Hills, Ramsey County, Minnesota (Figure 1) and fully within the borders of the Arden Hills Army Training Site (AHATS). The surface area of the lake is about 14 acres, with a maximum depth of approximately 5 feet (Figure 2)¹. Based on its low maximum depth, it is considered a shallow lake according to MPCA's definition.

The watershed draining into Sunfish Lake is approximately 112 acres and contains a stretch of Highway 96 and part of the Ramsey County Public Works facility. The majority of runoff from impervious surfaces is served by the treatment pond located on the southeast corner of the Public Works facility before discharge to Sunfish Lake.

Sunfish Lake has very limited public use at the current time because of its location within the AHATS boundaries. There is some limited access granted by the federal government for study and nature walks, but the general public is not allowed within the AHATS property.

A significant portion of the Sunfish Lake watershed is impervious, most notably the Ramsey County government building complex to the west. This facility stores large salt piles in the winter and all stormwater from this complex is routed through a large stormwater pond, located just west of Hamline Avenue, to Sunfish Lake.



¹The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from DNR files.

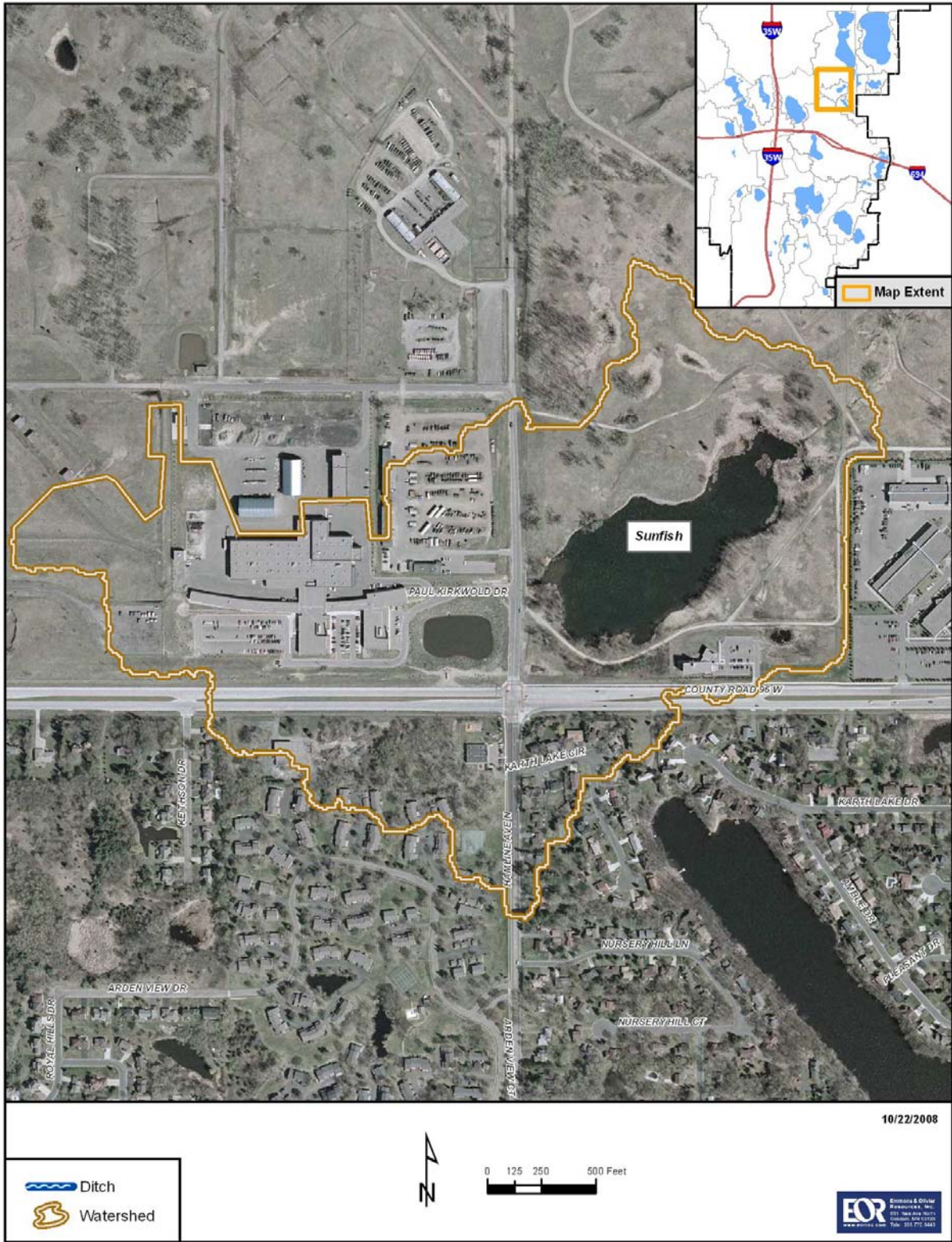


Figure 1. Sunfish Lake

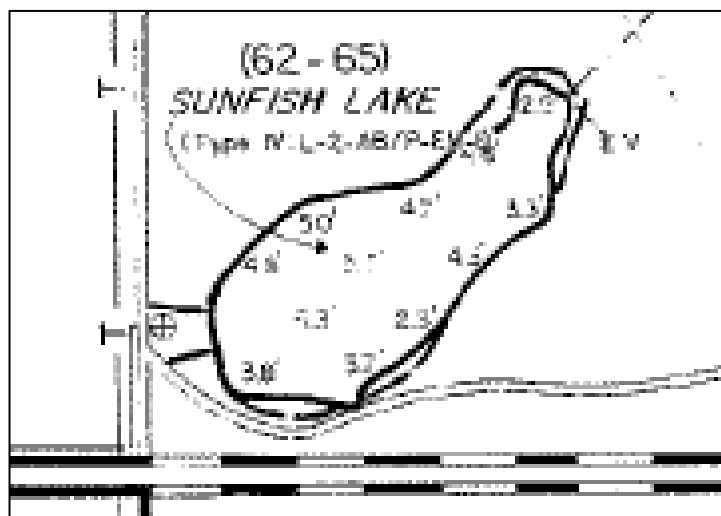


Figure 2. Sunfish Lake Bathymetry. Map from DNR files, unknown date.

Water Quality Summary

Water quality in Sunfish Lake was monitored by the RCWD in 2008. A preliminary data summary (Table 1) suggests that that lake is meeting the state water quality standards for total phosphorus (TP). Chlorophyll-a data were not available at the time of the report. Secchi depth (clarity) data were deemed unreliable; dense macrophyte growth in the lake prevented accurate readings. Field observations suggest good clarity, generally 3 to 5 feet. Water clarity data inferred from satellite imagery suggest that the water clarity depth of Sunfish Lake is approximately 3 to 6 feet, and it has ranged from the 1.5 to 3 feet category to the 6 to 12 feet category since 1985. Low phosphorus concentrations, good clarity, and abundant macrophyte growth suggest that Sunfish Lake is functioning as a healthy shallow lake in the “clear-water” state.

Table 1. Average Water Quality Data (2008) and Standards

Parameter	Sunfish	Standard
TP (µg/L)	37	60
Chl (µg/L)	n/a	20
Secchi Depth (m)	n/a	1.0

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. There were no in-lake monitoring data available to calibrate the lake model. Water quality modeling indicates that watershed inputs account for approximately 88% of the nutrient load, with internal loading accounting for the remaining 12% (Figure 3). Without any in-lake nutrient data for the lake for model calibration, the modeling results should be considered preliminary.

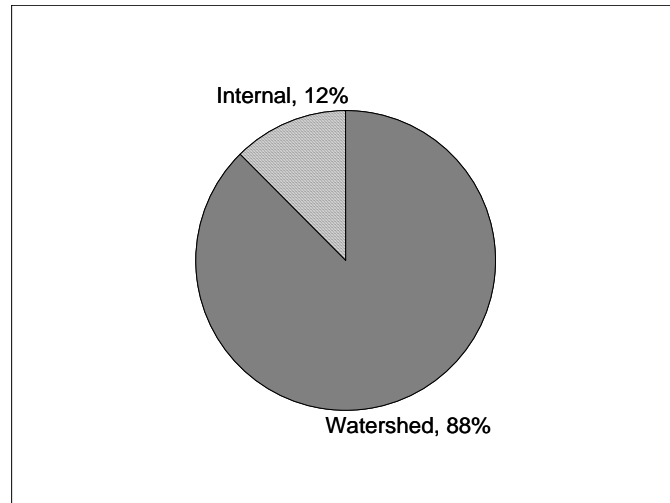


Figure 3. Sunfish Lake Phosphorus Load Distribution

In 2008, high levels of conductivity (~750 to 780 $\mu\text{S}/\text{cm}$) were measured in Sunfish Lake. It is not known if the high conductivity is due to high chloride concentrations in the lake or due to other dissolved solids. Chloride should be sampled in the lake to help identify the cause of the high conductivity.

Public Input

At the public input meeting held on May 29, 2008, the following was brought up by the participants:

- Some speculation was heard that the sediment in the lake is contaminated from past waste on the AHATS property.

Water Quality Issues

- Sediment within the lake may be contaminated with toxic substances due to past land use.
- There is some evidence of a sediment delta in the stormwater pond pipe inlet at the west end of the lake.
- High conductivity has been observed in the lake, although cause is unknown.

Recommended Management Approach

Watershed Management Recommendations

Currently all of the area directly surrounding Sunfish Lake is under the control of the U.S. Army because the lake is entirely within the AHATS boundary. The Army should maintain its existing management plan for the lake unless water quality data collected in the future dictates that a need in management is warranted.

The following are general practices will decrease nutrient loads to the lake:

- Nutrient and stormwater volume absorbing raingardens
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management

- Active inspection programs for and routine maintenance of previously installed stormwater BMPs

Internal Lake Management Recommendations

With very little in-lake biological data for Sunfish Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Sunfish Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- The balance of benthivores, planktivores, and piscivores in the lake can influence the lake's water quality. Benthivores disturb the bottom sediments and release phosphorus into the water column, and high densities of planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.
- If it is determined that there is a sediment delta on the west inlet to the lake, removal should be considered.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Sunfish Lake. There is currently only one year of in-lake water quality data for Sunfish Lake; if the implementation of management practices for the lake were to move forward, updated bathymetric data and at least an additional year of in-lake data (including chloride data) would be needed and should be considered a high priority.

- Updated bathymetric data collection
- TP, chlorophyll, and Secchi depth data: Collect data for several years, with at least five sampling dates per year.
- Chloride data: Collect data for at least one year (including early spring during snowmelt runoff) to determine if chloride in the lake is high.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.

Turtle Lake Management Action Plan

Turtle Lake (62-0061) is located in the City of Shoreview, Ramsey County, Minnesota (Figure 1). The lake has a surface area of 447 acres, a maximum depth of 28 feet, and a mean depth of about 10 feet¹ (Figure 2). Turtle Lake is on the state's 303(d) list of impaired water bodies due to the mercury content in fish. The MPCA has completed a statewide TMDL study and implementation plan to address the state's mercury impairments.

The watershed draining to Turtle Lake is approximately 288 acres. The watershed is relatively small compared to the surface area of the lake. This leads to a smaller amount of surface water runoff into the lake, but also means water levels can be hard to maintain. The surrounding watershed area is primarily residential with some commercial uses nearby. Turtle Lake Park is on the southeast side of the lake and is a major recreation attraction for swimming, boating, and picnicking.



A macrophyte survey performed by the DNR during the first week of July in 2002 indicated that Eurasian watermilfoil is present but rare.

The lake is popular as a recreational fishing lake. A 2007 DNR fisheries survey indicates that bluegills are the most abundant species in the lake, although the average size is smaller than normal. Crappies, sunfish, largemouth bass, and northern pike are also present. The lake has been stocked by the DNR in the past with walleye. The lake has been managed as a largemouth bass experimental lake since 1997. The goal of this program is to establish a population characterized by 40% of the bass exceeding 16 inches in length. A DNR regulation requires the release of all largemouth bass. Overall, Turtle Lake has a healthy and balanced fish population that helps maintain the lake's excellent quality.

¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth and percent littoral were taken from the DNR Lake Finder website.

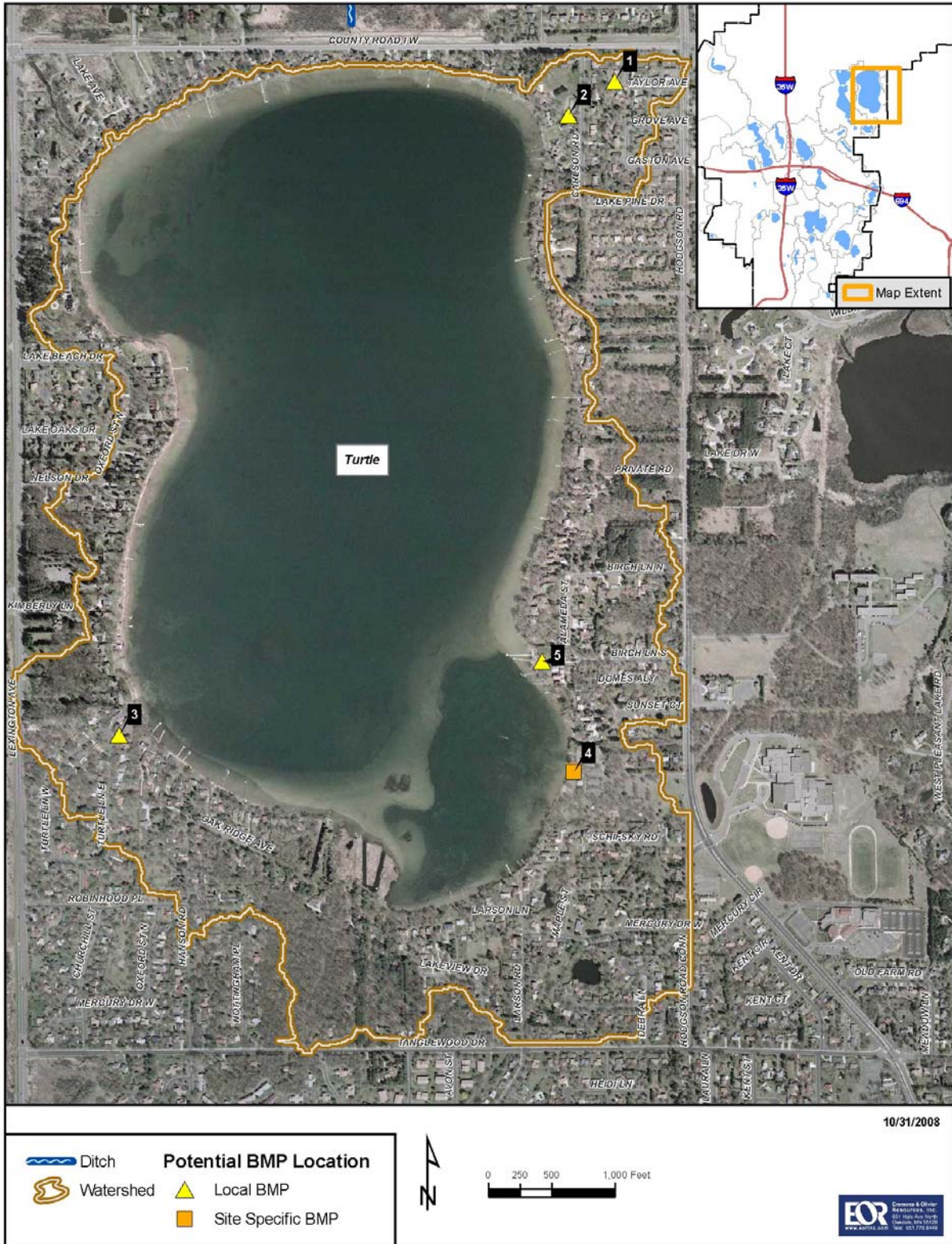


Figure 1. Turtle Lake and Potential BMP Locations

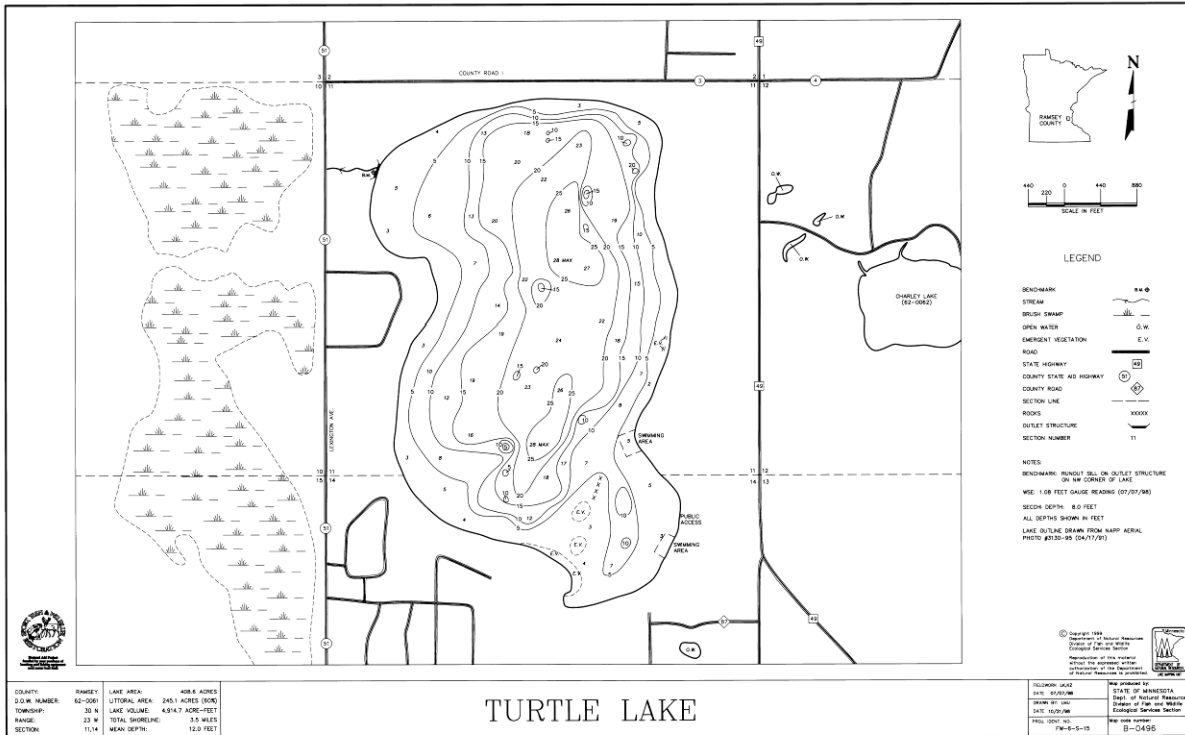


Figure 2. Turtle Lake Bathymetric Map

Water Quality Summary

Turtle Lake has an abundance of water quality data that have been collected over recent years. Data are collected by Ramsey County Public Works and Metropolitan Council Environmental Services. A summary of the most recent ten years of water quality data suggest that it is meeting all of the state standards. The lake is the second highest quality lake in the RCWD (behind only White Bear Lake).

Table 1. Average Water Quality Data (1998-2007) and Standards

Parameter	Turtle Lake	Standard
TP (µg/L)	20	40
Chl (µg/L)	4.9	14
Secchi Depth (m)	2.4	1.4

Figures 3 through 5 show the TP, chlorophyll-*a* and Secchi depth (clarity) data from Turtle Lake for the period of record for the CAMP data. Turtle Lake has exceeded the TP standard of 40 µg/L only once since 1980 (Figure 3), and it has never exceeded the chlorophyll or Secchi depth standards.

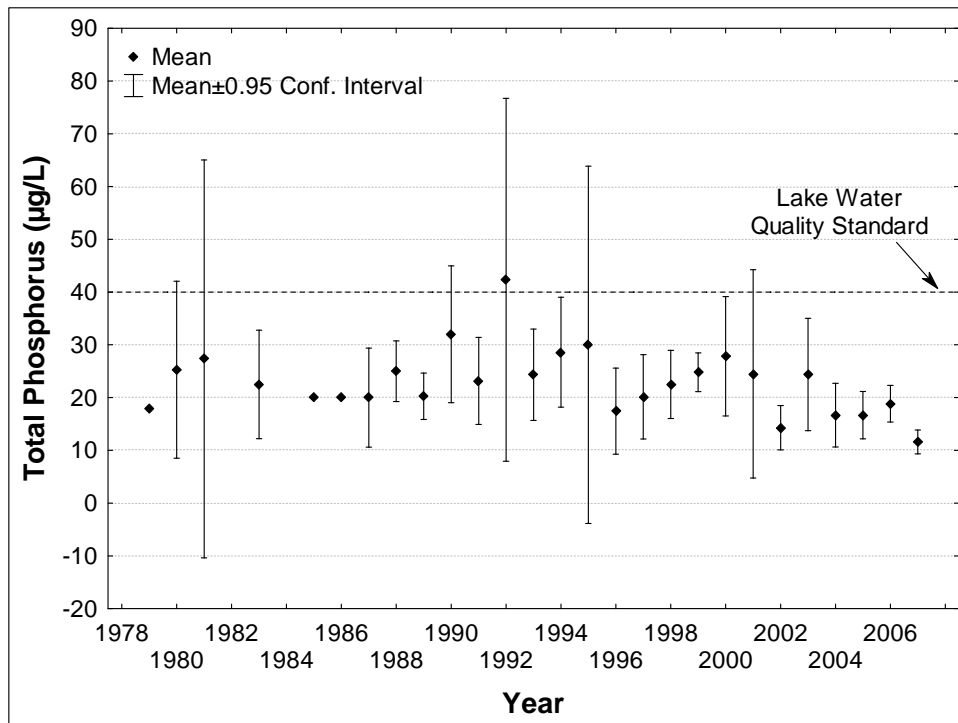


Figure 3. Turtle Lake Total Phosphorus

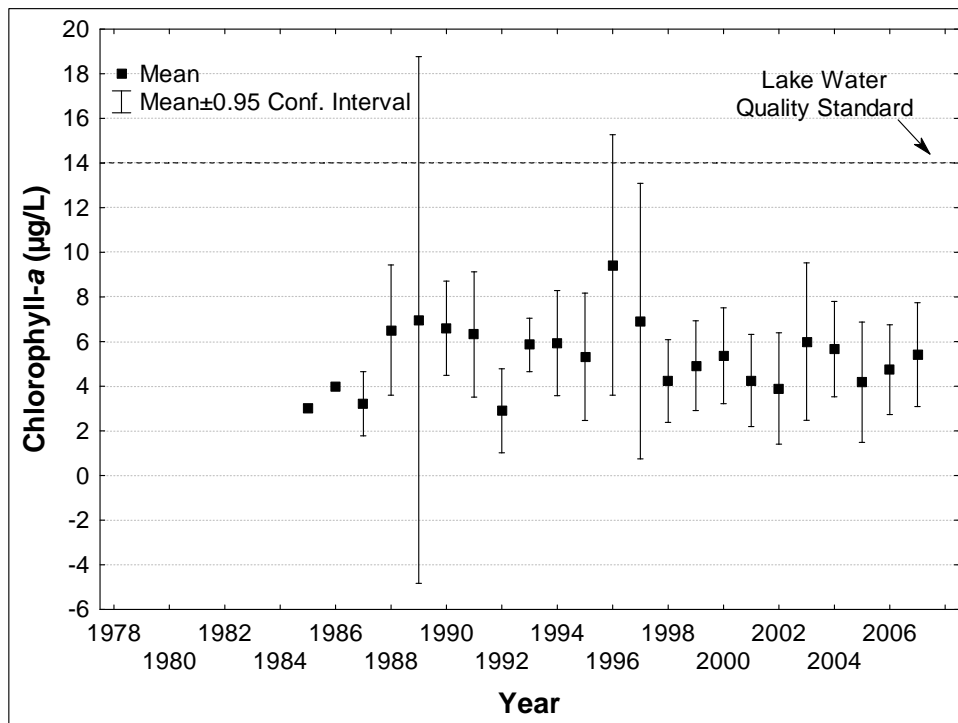


Figure 4. Turtle Lake Chlorophyll-a

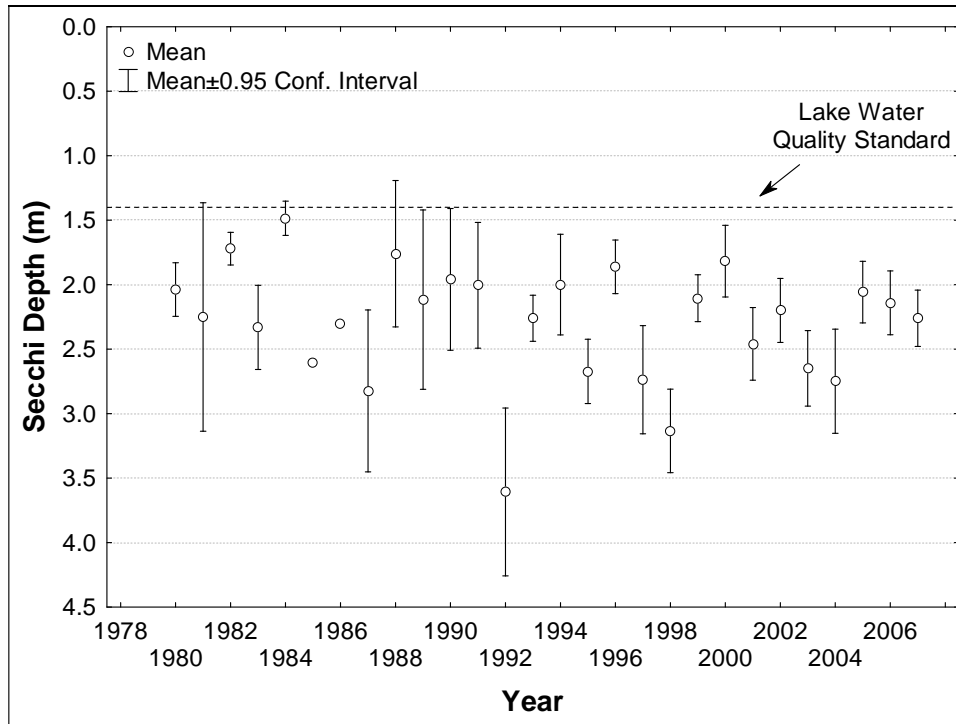


Figure 5. Turtle Lake Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality modeling indicates that the sources of nutrients affecting overall lake quality are almost evenly split between watershed runoff (53%) and internal (47%) loading (Figure 6).

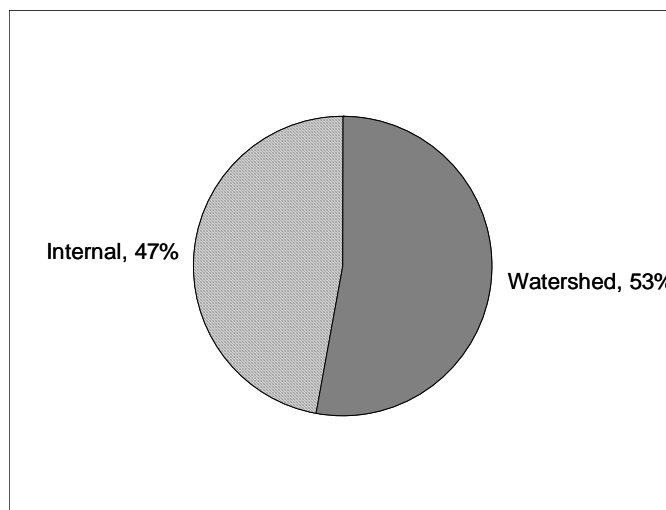


Figure 6. Turtle Lake Phosphorus Load Distribution

Public Input

At the public input meeting held on May 29, 2008, lake residents offered local insight into Turtle Lake. Residents are very interested in keeping the lake at its current excellent quality, recognizing the value that this lake holds for the watershed.

- Attendees noted that there are some opportunities for BMP retrofitting that could yield further nutrient load reductions for the lake. The northeast corner of the lake receives runoff that passes through what was referred to as a treatment chamber. The resident noted that the chamber is very ineffective and that it could be supplemented with additional treatment possibly via a bioretention system. The resident also referenced the Lexicon BMP system as likely an effective approach and suggested that the RCWD work with Ramsey County (Terry Noonan) to monitor its effectiveness. The Lexicon BMP system was installed in 2008 near the SW stormwater inlet to the lake.
- Residents at the meeting also wondered if water levels in the lake decrease as a result of pervious lake sediment in the southeast corner of the lake and if this could be sealed. RCWD and EOR staff discussed the small watershed draining to the lake and the difficulty of maintaining lake levels with the small contributing drainage area. Under these situations, it is not likely that lowered lake levels result from seepage out the bottom of the lake.
- Also with respect to water levels in the lake, residents question whether the reconstruction of County Road I has limited the influx of groundwater from the north. Based on the information available, shallow groundwater flow in this area is northwest towards Rice Creek. Therefore it is unlikely that the reconstruction of County Road I have negatively impacted the groundwater influx to Turtle Lake.
- Subsequent communications from one of the attendees indicates that he is interested in seeing if the pump and treat system at TCAAP is affecting the water level of Turtle Lake. Figure 7 shows the water levels for the lake: the top graph illustrates data since 1929, and the bottom graph focuses in on the last ten years of data. An overall fluctuation of over 2.5 feet has occurred over this ten year period.

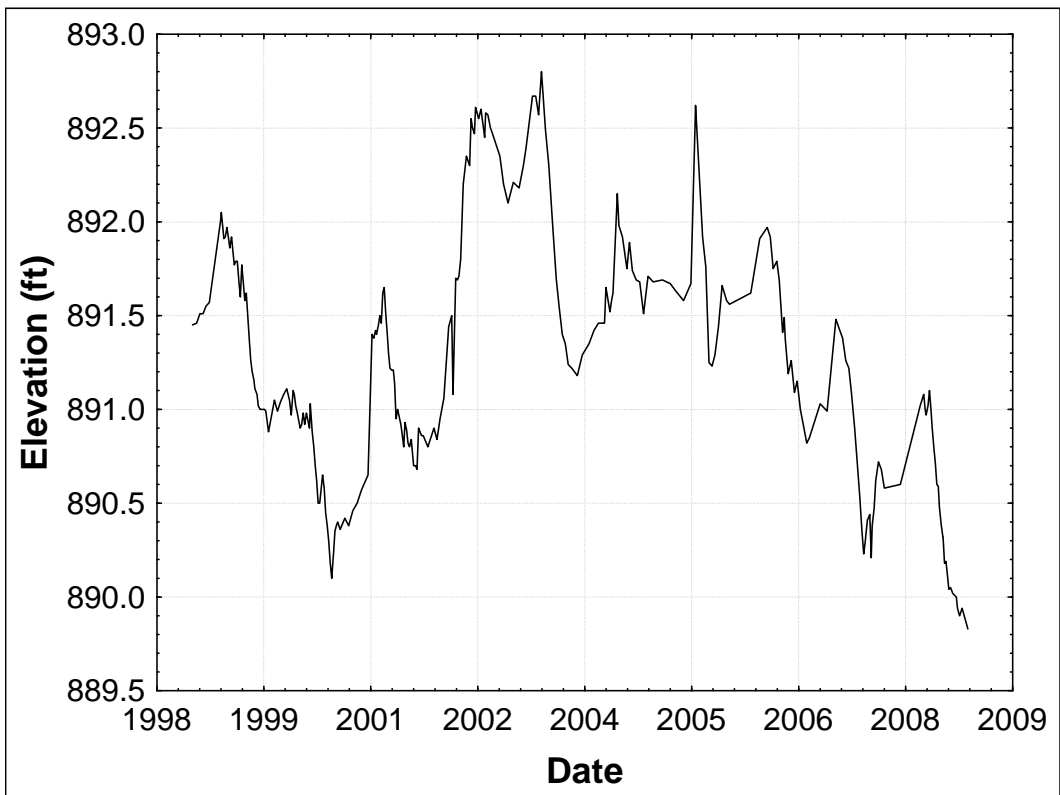
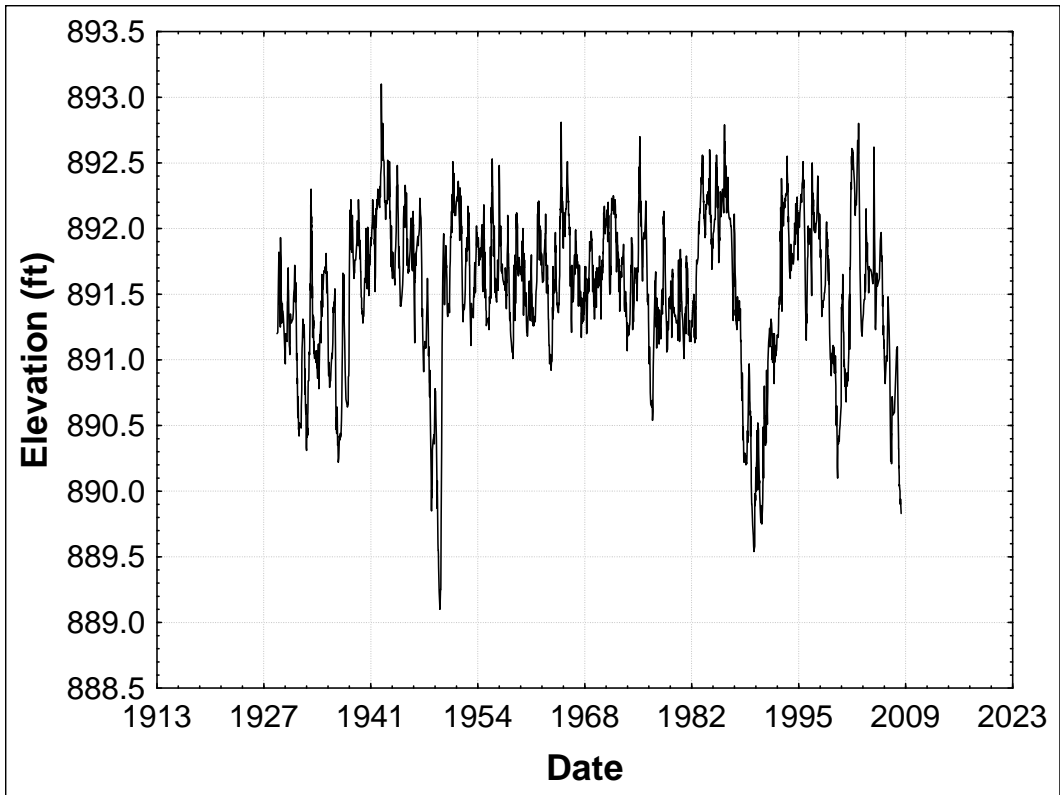


Figure 7. Turtle Lake Water Levels

Water Quality Issues

- Residents are concerned about water level fluctuation. However, water levels have fluctuated over the years, and the current downward trend in water level fits within the historical range of water levels observed since the 1930s. Precipitation has been low over the last several years, and, due to the lake's small watershed size, the lake takes longer than other nearby lakes to return to higher water levels.
- The lake sediment data suggests that internal loading rates in Turtle Lake are high. However, due to the good water quality of the lake, internal loading does not appear to be an issue.

Recommended Management Approach

Turtle Lake is overall a high quality lake that is used for different types of recreation. New runoff control efforts are not needed to meet state standards, but managers and residents should protect the existing water quality conditions and prevent any degradation of lake water quality. Effective enforcement of RCWD Rules should help protect the lake as development and re-development occur.

Watershed Management Recommendations

Some of the runoff entering Turtle Lake is untreated or under-treated. Opportunities to incorporate or improve BMPs would ensure that the existing conditions are at least maintained or potentially improved. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local, and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, four BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- The Turtle Lake Pre-treatment Facility Project (Local BMP #3) was recently constructed by the City of Shoreview for the southwest side of the lake, through the RCWD Urban Remediation Grant Program. This project on Turtle Lane treats stormwater from an 11-acre area via an underground infiltration system. The RCWD predicts that about 65% of the TP from this area would be eliminated. Survey of the pavement elevations is warranted to ensure that runoff is not bypassing the infiltration system.
- Another possibility is in the Birch St. neighborhood on the east side of the lake (BMP#5). Although some infiltration tubes exist in this neighborhood, residual stormwater enters the lake via a rip-rap channel. Retrofit of this rip-rap channel to incorporate biofiltration could improve the runoff from this sub-watershed and help to further improve the lake.

The following general practices will decrease nutrient loads to the lake:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

No specific internal lake management recommendations are warranted, due to the high quality of Turtle Lake. The existing water quality conditions should be protected to prevent any degradation of lake water quality.

Recommended Data Collection

Turtle Lake is fortunate to have a large amount of water quality and fish data collected in the past. At this time, continuing the current level of data collection is sufficient. If problems persist with water levels and citizens remain concerned, a water level study looking at runoff into the lake and losses from it could be undertaken to quantify the fluctuation and its causes.

Turtle Lake Field Reconnaissance Supplement

Local Management BMPs



Turtle #1

Location: West of Saint Albans Street and north of Taylor Avenue

Description: Open area in front/side yard

Potential Improvements: Incorporate large raingarden to treat adjacent roadways.



Turtle #2

Location: West of Carlson Street and south of County Road I

Description: Stormwater discharge into Turtle Lake from adjacent neighborhood.

Potential Improvements: Incorporate infiltration/biofiltration BMPs at this location. This site would require using areas that already appear to have uses (e.g. tennis court or garden areas).



Turtle #3

Location: North end of Turtle Lane Loop

Description: Catch basin intended to route water across the street to an underground infiltration feature. It appears that some of the runoff may bypass to the inlet behind the catch basin that flow directly to Turtle Lake.

Potential Improvements: Assess whether flows are bypassing the treatment feature, and if so, modify grades to ensure that runoff is directed to the treatment feature prior to discharge to Turtle Lake.

Site Specific Management BMPs



Turtle #4

Location: West of Hodgson Road and north of Schifsky Road

Description: Existing small treatment feature (4-6 inches of storage with a skimming structure) treating a large amount of the park's drives and parking lots

Potential Improvements: Increase treatment capacity. The onsite oak trees are an issue; however, with some creativity another cell could be added to the south of the existing feature.



Turtle #5

Location: Western terminus of Birch Lane South

Description: Existing grouted rip rap open channel with dead pool storage

Potential Improvements: Retrofit this channel to incorporate biofiltration in lieu of dead pool storage.

Valentine Lake Management Action Plan

Valentine Lake (62-0071) is located in the City of Arden Hills, Ramsey County, Minnesota (Figure 1). The lake has a surface area of about 64 acres, with a maximum depth of 14 feet and a mean depth of 4.5 ft¹ (Figure 2). Based on its low maximum depth, it is considered a shallow lake according to MPCA's definition.

The watershed that flows into Valentine Lake is approximately 2,566 acres and is fully developed with mixed use commercial, transportation, industrial and residential land uses. Valentine Lake is directly surrounded on three sides by Bethel University.

Valentine Lake is listed as an impaired lake on the EPA's 303(d) list of impaired water bodies. It is impaired for aquatic recreation due to high nutrients. High chloride concentrations may also be an issue. Valentine Lake is the only monitored lake in Ramsey County that has an average chloride concentration near the state standard.

Bethel University has collected data on plants in or near Lake Valentine from 1986 through 2000. Of the species identified, curly-leaf pondweed has the potential to become a nuisance species.

A 2000 fish survey available from Bethel University shows a presence of bluegills, bullhead, pumpkinseed sunfish, crappie, perch, and shiners. In 2001, the university reported a partial winter fish kill that included carp, northern pike, and bluegills.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; the maximum depth was taken from the Rice Creek Watershed District website.

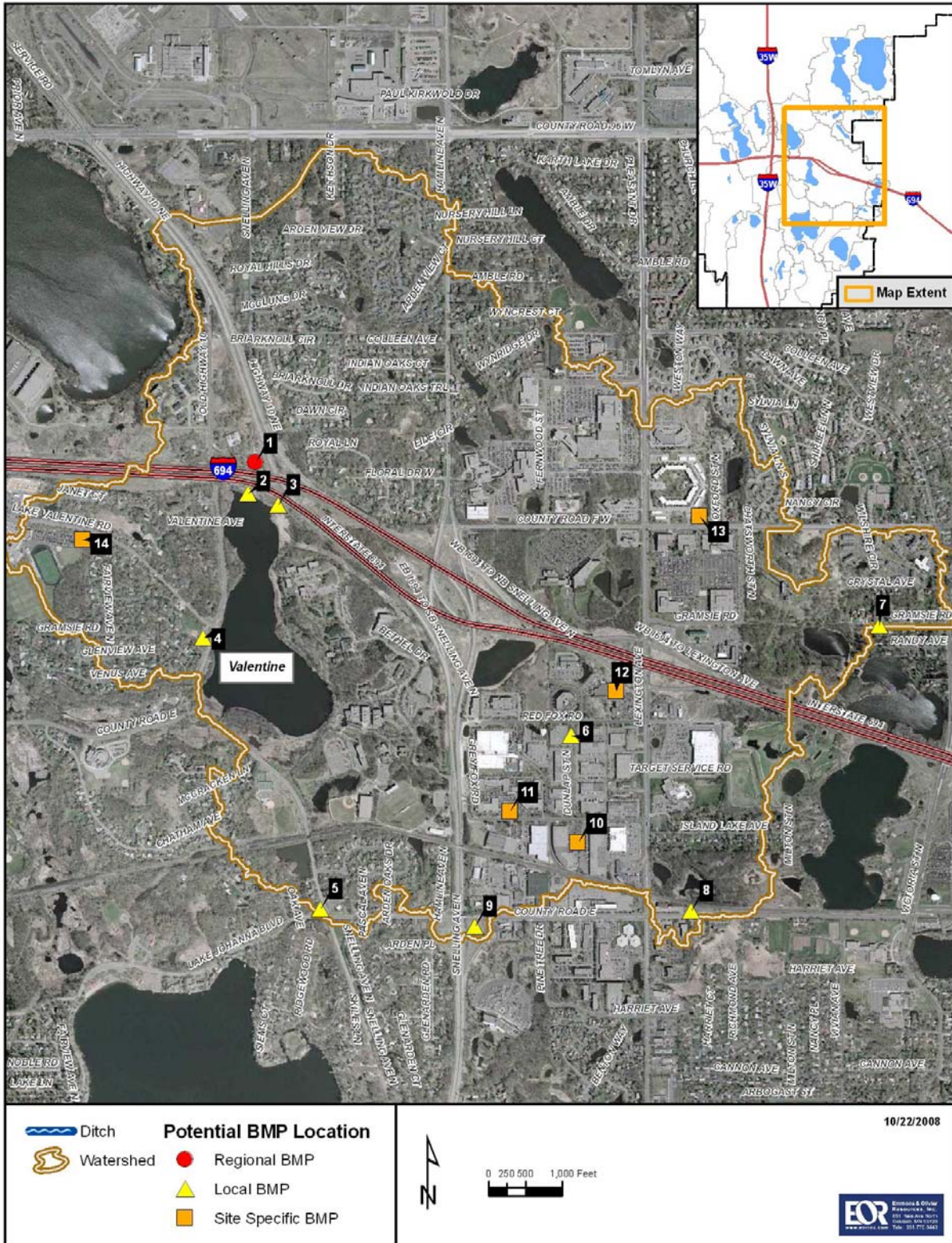


Figure 1. Valentine Lake and Potential BMP Locations

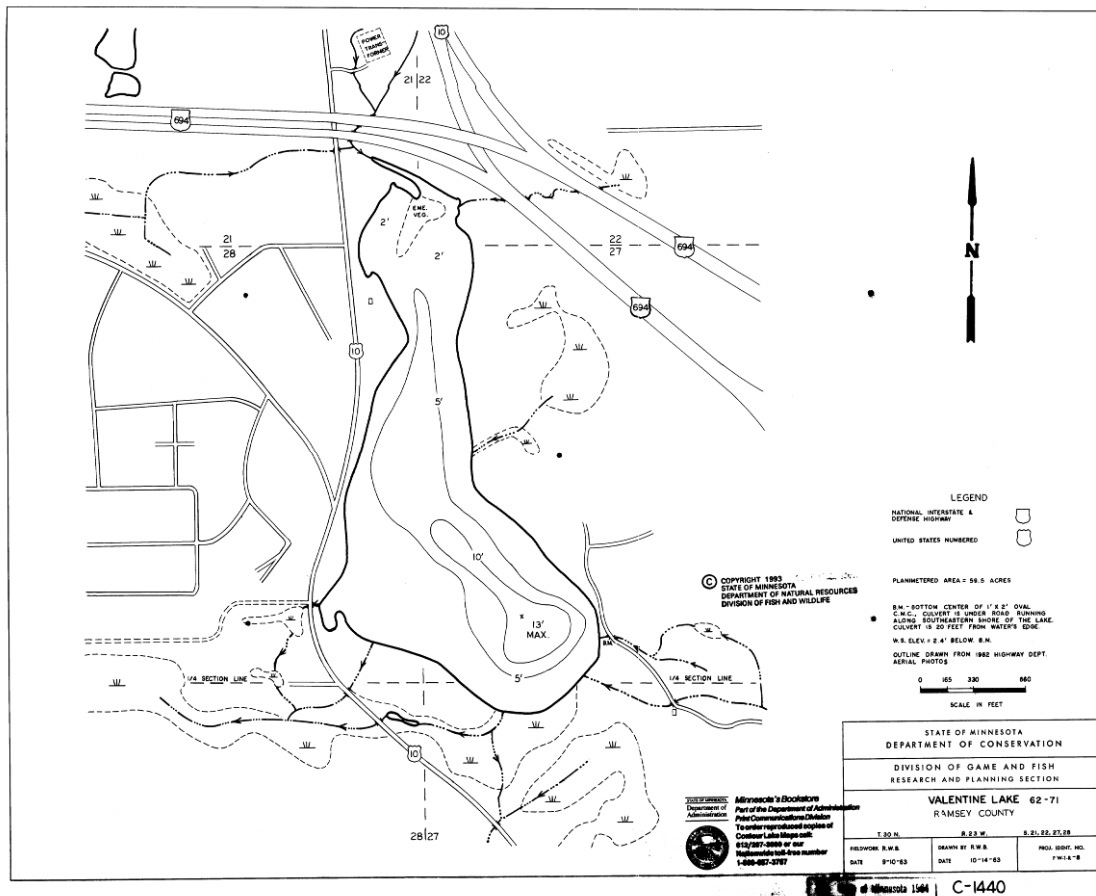


Figure 2. Valentine Lake Bathymetry

Water Quality Summary

Water quality data for Valentine Lake are available from 1980-2007. Data are collected by Ramsey County Public Works and through the Citizen Assisted Monitoring Program (CAMP). A summary of the most recent 10 years of water quality information for the lake suggest that Valentine Lake is meeting water quality standards for chlorophyll-*a* and Secchi depth (clarity) but not for total phosphorus (TP). Although the TP is moderately high, the lake appears to be functioning as a healthy shallow lake, with suspended algal growth under control and relatively high water clarity.

Table 1. Average Water Quality Data (1998-2007) and Standards

Parameter	Valentine Lake	Shallow Lakes Standard
TP (µg/L)	70	60
Chl (µg/L)	18	20
Secchi Depth (m)	1.7	1.0

Figures 3-5 show the growing season TP, chlorophyll-*a* and Secchi depth (clarity) data over that period. Water quality was poorer in the early 1990s and has improved since then.

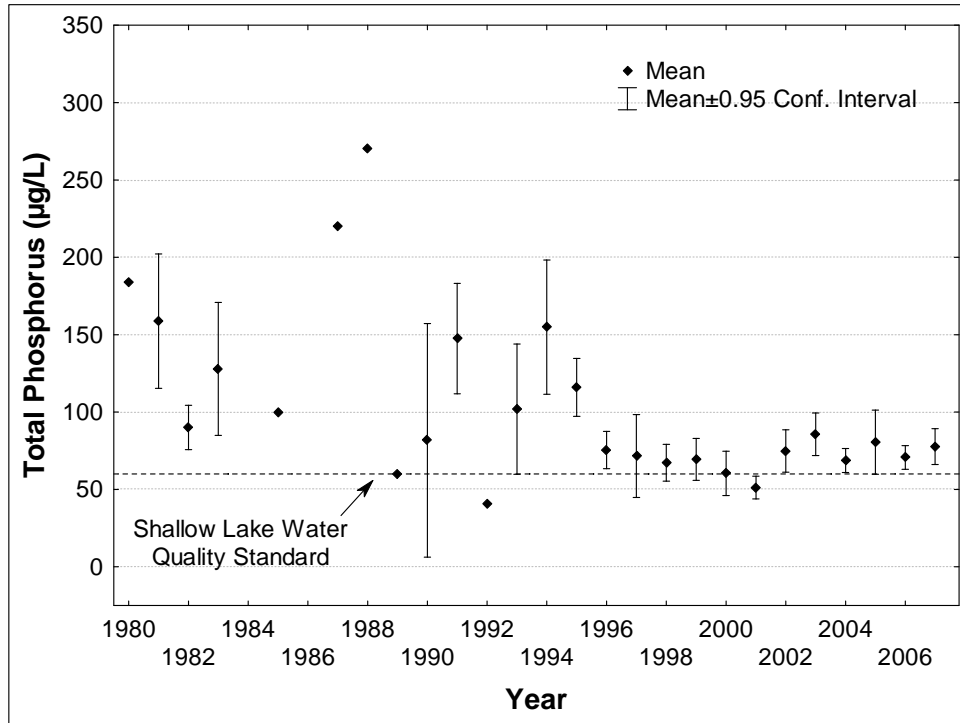


Figure 3. Valentine Lake Total Phosphorus

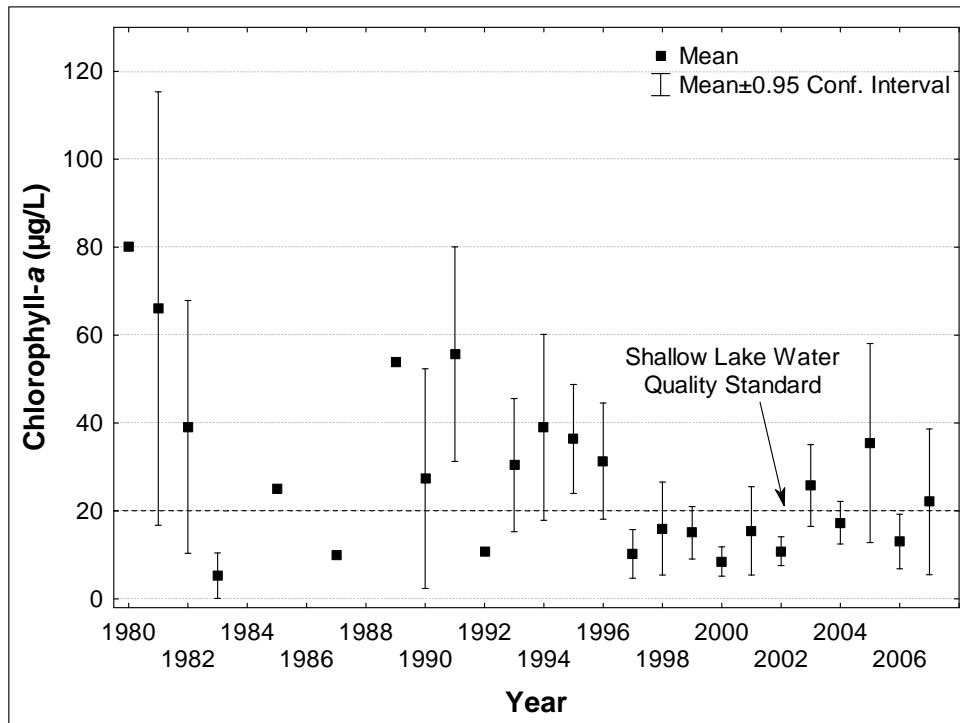


Figure 4. Valentine Lake Chlorophyll-a

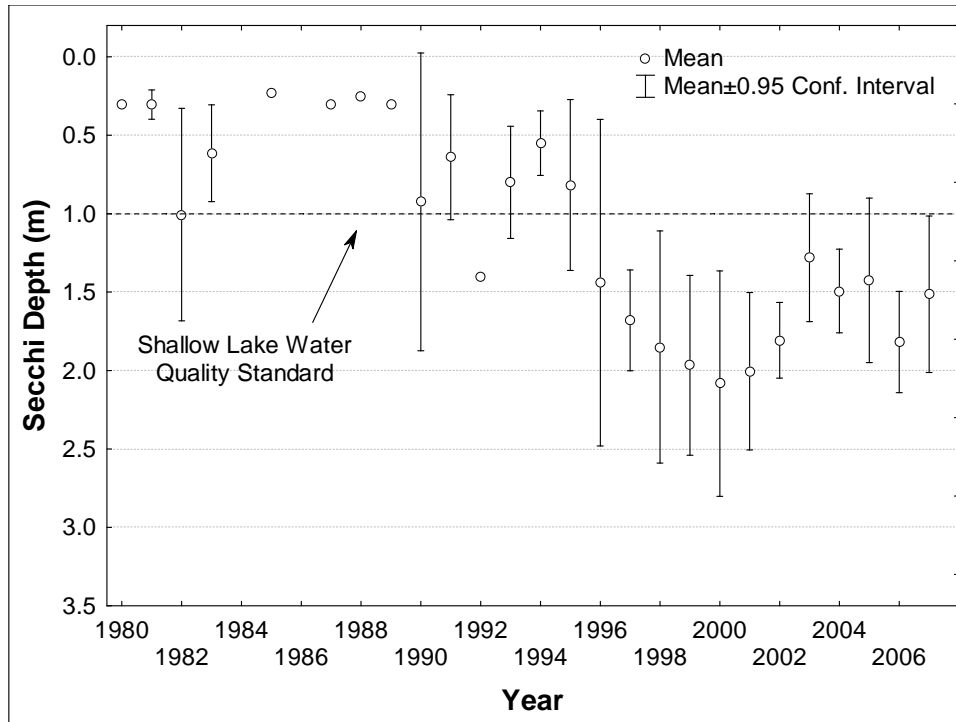


Figure 5. Valentine Lake Secchi Depth

A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. The lake model was calibrated to in-lake monitoring data. Water quality indicates that watershed inputs account for approximately 80% of the nutrient load, with internal loading accounting for the remaining 20% (Figure 6). To reach the in-lake goal of 60 µg/L TP, the phosphorus load needs to be reduced by 13%.

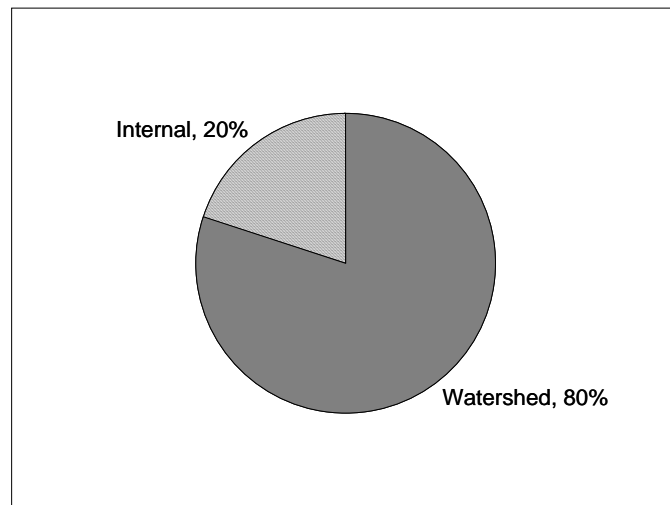


Figure 6. Valentine Lake Phosphorus Load Distribution

Average chloride concentrations are available in Valentine Lake from 1990 – 2007 (Figure 7). The data seems to indicate an upward trend, with the most recent year's data exceeding the water

quality standard. However, the state chloride standard is based on a 4-day average, not a seasonal average; it is possible that the chloride concentrations exceeded the 4-day standard in many years during spring runoff. Prolonged chloride concentrations exceeding approximately 230 mg/L can have lethal effects for fish and invertebrates.

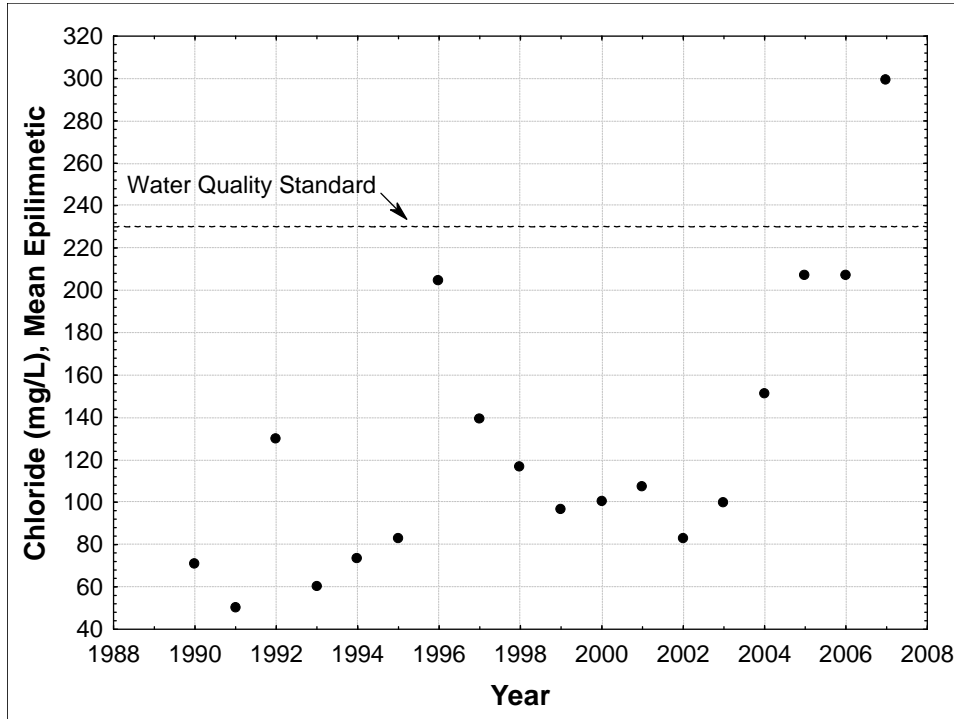


Figure 7. Valentine Lake Chloride Concentrations

Public Input

At the public input meeting on May 29, 2008, concerns surrounding Valentine Lake were addressed.

- A possible shift from a turbid lake condition to a clear lake condition might have occurred when a new diversion cut off flow from a large portion of the watershed to the east and was diverted through a wetland treatment system prior to discharge into the lake. Concerns were expressed over the possible change back to turbid conditions since the lake is still over the 60 µg/L TP goal. Continued careful monitoring of the lake’s condition, with some additional ecological monitoring was noted as important.
- The possible shift from the turbid- to clear-water state was observed in the late 1980s – these observations are consistent with observed changes in the water quality dataset. At the time of the “switch,” large colonies of filamentous blue-green algae were replaced with coontail.
- A Bethel University representative discussed some of the efforts underway on the campus to improve water quality of runoff to the lake. The university is also undertaking a buckthorn removal effort on the lake shoreline.

- It was noted that occasional high flow and assumedly high nutrient input problems have occurred when the outflow of Round Lake (tributary to Valentine) is plugged and suddenly releases. The outflow from Valentine similarly plugs.

Water Quality Issues

- Total phosphorus concentrations in the lake exceed the standard and the lake is listed as impaired.
- Bullhead are present in the lake and may contribute to high internal loading rates.
- Bluegill are the most abundant fish found in Valentine Lake. Without any piscivorous fish, the bluegill density may get high enough to overgraze the lake's zooplankton.
- Sudden inflows from Round Lake may be leading to water quality problems within Lake Valentine.
- Curly-leaf pondweed is present in the lake, potentially contributing to internal phosphorus loading.
- The north lobe of the lake is directly adjacent to Interstate-694 and likely receives highway runoff.
- High concentrations of chloride have been measured in Valentine Lake, possibly having negative effects on biota.

Recommended Management Approach

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing the nutrient impairment. Because the Valentine Lake watershed is nearly fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 14 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Feasibility and Benefit Level Assessment of the potential regional BMP location identified in the *field reconnaissance supplement*.
- Consideration of local partnerships for further assessment of potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- Continue working with Bethel University on water quality stewardship to Valentine Lake. In 2001, a study was done by the RCWD looking at infiltration BMP feasibility on the Bethel University Campus. After finding that the soils were not conducive for large-scale infiltration BMPs, the report suggests a number of non-infiltration BMPs, such as bio-swales, rain gardens and biofiltration, along with stability measures to control swale slope.
- Continue working with Boston Scientific (formerly Guidant Campus) on the Master Stormwater Management Plan for phased redevelopment of the site.

- Work with the Minnesota Department of Transportation during road improvement projects to provide additional treatment for sections of Interstate 694 and Highway 10.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

A number of shallow lake management principles likely apply to Valentine Lake:

- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- A more recent fisheries survey will indicate the balance of benthivores, planktivores, and piscivores in the lake. Benthivores disturb the bottom sediments thereby releasing phosphorus into the water column, and planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as bullhead, which were found in the 2000 survey) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Valentine Lake. Since there is a long record of in-lake water quality data for Valentine Lake, additional in-lake data collection is not a high priority at this time. Watershed phosphorus loading data are a high priority, as they will be needed for the future TMDL study

- TP, chlorophyll, and Secchi depth data: Collect at least five sampling dates per year. The TMDL can be based on the existing monitoring data; additional data should be collected after management actions are implemented to track the response of the lake.
- Chloride data: Collect chloride data for at least one year (including early spring during snowmelt runoff) to determine if chloride in the lake is high. Due to the proximity of the northern part of the lake to highways and other roads, samples should be taken from this northern lobe, in addition to the main sampling location. Since high chloride can be due to road salt in watershed runoff or to high chloride concentrations in the groundwater, samples should be taken throughout the year to examine fluctuations in chloride and how they relate to weather and road salt.
- Macrophyte surveys: Complete one macrophyte survey during June to evaluate the presence/absence of curly-leaf pondweed and other invasive aquatic vegetation. Complete another survey during August to evaluate the quality of the macrophytes after senescence of curly-leaf pondweed, when native macrophytes may dominate.
- Fish survey: Complete a fish survey to evaluate the fish species composition of the lake.
- Plankton survey: Collect zooplankton and phytoplankton data for one full season. This will supplement the information from the fish survey regarding the food web, which influences nutrient cycling within the lake. Management recommendations can then be targeted towards manipulating the food web dynamics to improve water quality.
- The following inlets to Valentine Lake should be monitored to provide flow and phosphorus loading estimates. These data will be needed in order to estimate the watershed phosphorus load to the lake for the TMDL study; the data will also provide guidance on site selection for larger scale improvement projects.
 - Northern inlet from Round Lake: This inlet also receives drainage from the developed area to the northeast of Valentine Lake. Additional data collection could be undertaken further upstream in this subwatershed to differentiate the Round Lake load from the northeast load.
 - Eastern inlet from Bethel Ditch: This inlet receives drainage from the large portion of the subwatershed to the east of the lake, including Bethel University. Additional data collection could be undertaken further upstream in this subwatershed to differentiate loads between the two branches of the ditch.

There are multiple other smaller-scale inlets (ditches and pipes) to the lake that have a lower monitoring priority.

Valentine Lake Field Reconnaissance Supplement

Regional Management BMPs



Valentine #1

Location: North of I-694 and west of Highway 10

Description: Large open space with ditch running to the south under I-694 and then into Valentine Lake (large contributing drainage area).

Potential Improvements: Use space for large regional facility to treat the highways and upstream discharges. An assessment should first be done to assess the effectiveness of the upstream treatment features and determine if this ditch is a significant source of phosphorous to the Lake. Additional treatment may not be needed for upstream discharges because portions of the drainage area are already routed through wetland treatment features, however the area should at a minimum be considered for treatment of the adjacent highways when this area is reconstructed.

Local Management BMPs



Valentine #2

Location: North end of Valentine Lake

Description: Area receiving stormwater from I-694.

Potential Improvements: Enhance area to provide better treatment prior to discharge to Valentine Lake



Valentine #3

Location: North end of Valentine Lake

Description: Rusted out pipe delivering runoff from Mn/DOT right-of-way

Potential Improvements: Repair pipe and look into upstream BMPs to reduce sediment transport from I-694 to Valentine Lake.



Valentine #4

Location: West of Snelling Avenue and south of Valentine Road

Description: Swale/ditch draining neighborhood from the west and draining under Snelling Avenue to Valentine Lake. Parking lot is in poor shape and not much higher than Valentine Lake. Water in photo is backwater from Valentine Lake.

Potential Improvements: Enhance/expand swale or remove parking and incorporate larger wetland treatment feature. Parking could be potentially moved out along Valentine Road.



Valentine #5

Location: West of Snelling Avenue and north of Lake Johanna Boulevard

Description: Low open space northwest of the intersection of Snelling Avenue and Lake Johanna Boulevard

Potential Improvements: Use for infiltration/treatment of adjacent roadway



Valentine #6

Location: Dunlap street between Grey Fox Road and Red Fox Road

Description: Large green spaces between road and adjacent businesses

Potential Improvements: Use green spaces to treat impervious from adjacent businesses.



Valentine #7

Location: South of Gramsie Road and west of Randy Avenue

Description: Open space

Potential Improvements: Use to provide treatment for Gramsie Road



Valentine #8

Location: North of County Road E

Description: Large gravel area adjacent to County Road E

Potential Improvements: Use area for a new treatment feature when County Road E is repaired or upgraded.



Valentine #9

Location: SE Loop at Snelling and County Road E

Description: Both loops at Snelling and County Road E could be better used for stormwater treatment.

Potential Improvements: Provide additional treatment within loops (e.g. infiltration or ponding)

Site Specific Management BMPs



Valentine #10

Location: South of Grey Fox Road and east of Dunlap Street

Description: Treatment swale receiving runoff from adjacent parking areas.

Potential Improvements: Maintain/enhance to provide additional treatment.



Valentine #11

Location: North of Grey Fox Road and west of Dunlap Street

Description: Existing treatment pond

Potential Improvements: Maintain and retrofit to provide additional treatment. Remove concrete, add native vegetation, and get rid of geese.



Valentine #12

Location: North of Red Fox Road and east of Northwoods Drive

Description: Open areas adjacent parking lot.

Potential Improvements: Incorporate infiltration/ water quality treatment BMPs



Valentine #13

Location: North of County Road F and east of Lexington Avenue

Description: Apartment complex, no onsite treatment. This area is treated by a downstream pond; however, infiltration/biofiltration could be incorporated in the onsite green spaces to provide volume control and additional water quality treatment for a large amount of impervious area routed directly to stormsewer.

Potential Improvements: Incorporate infiltration/ biofiltration BMPs.



Valentine #14

Location: Mounds View High School

Description: Large swale running to a dry pond

Potential Improvements: Enhance swale and dry pond to provide additional infiltration/water quality treatment.

Walsh Lake Management Action Plan

Walsh Lake (62-0214) is located in the City of Roseville, Ramsey County, Minnesota (Figure 1). The lake has a surface area of about 8.5 acres, a maximum depth of 16 ft¹, and a watershed of 372 acres.

Walsh Lake meets the MPCA definition of wetland and is classified as a Class 2D (wetland) water in accordance with Minn. Rules Ch. 7050. Furthermore its designation as a Public Water Wetland [“W” 62-214] by the DNR Protected Water Inventory and the lack of an aquatic recreational resource management history (MPCA (*Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment*, 2007) substantiates the designation as a Class 2D water. The Class 2D designation means that the wetland resource is protected for the “maintenance of a healthy wetland aquatic community and for wetland based aquatic recreation.” Numeric nutrient standards developed for shallow lakes (i.e. 60 µg/L TP) do not apply to Class 2D wetlands.

The watershed draining to Walsh Lake includes residential area, the Midland Hills Country Club golf course, and the University of Minnesota Les Bolstad golf course. The lake consists of a north and smaller south basin. The lake has two outlets to control water levels on the lake with the lift station utilized to control the bounce of Walsh Lake. The lift station pumps water north into the Jones Lake watershed and a small gravity pipe drains west leaving the Rice Creek Watershed District. The drainage to the north eventually drains to Jones Lake via a series of holding ponds and drainage ditches entering Jones Lake just after joining RCD 5. Jones Lake is on the EPA’s 303(d) list of impaired waters as an impaired wetland, and therefore Walsh Lake and its watershed will be addressed in the Jones Lake TMDL study.

Walsh Lake is at times used by the Midland Hills Country Club for golf course irrigation.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos; No bathymetric data were available for this lake. The maximum depth was estimated from the depth data collected during sediment sampling.

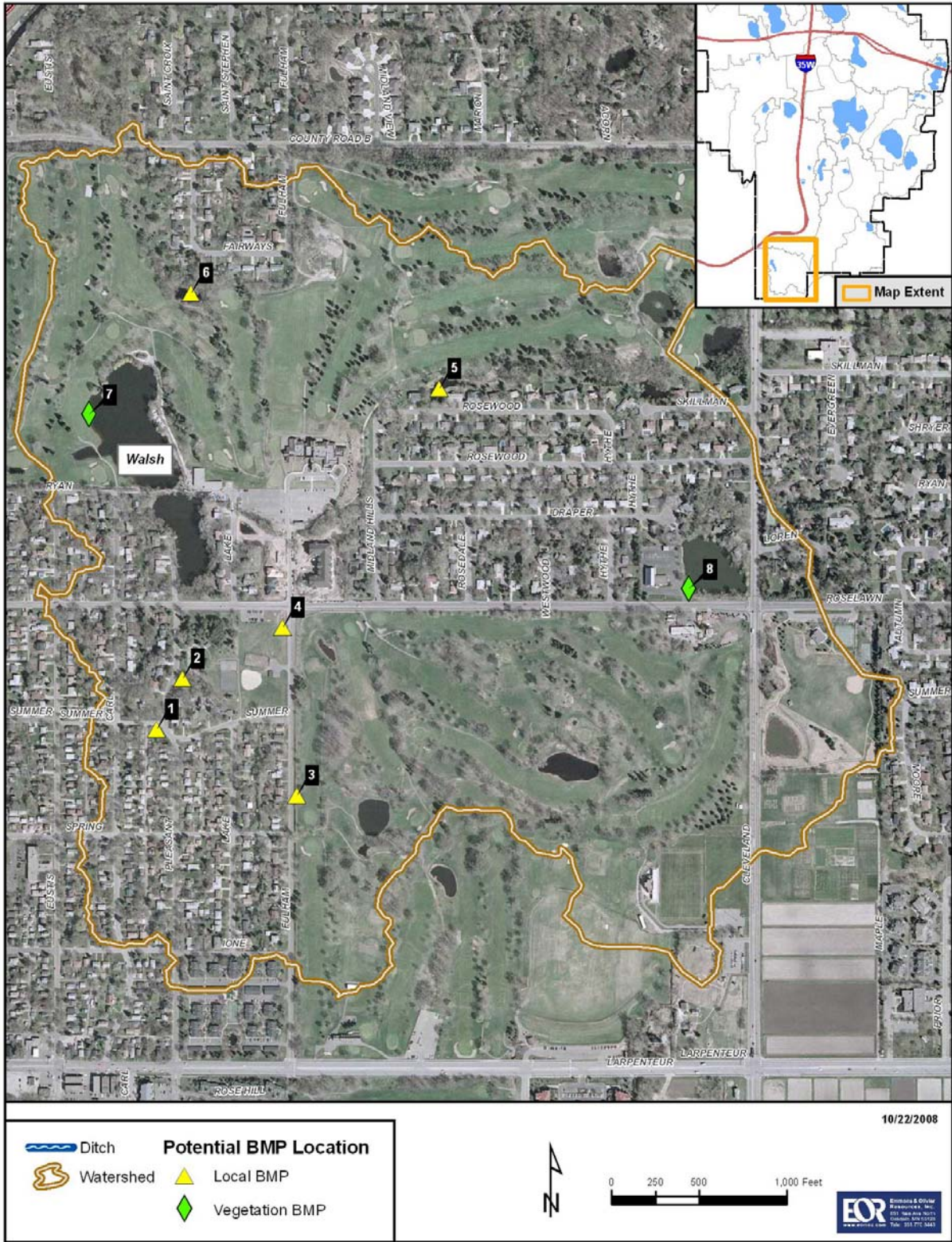


Figure 1. Walsh Lake and Potential BMP Locations

Water Quality Summary

Water quality and biological data are not available for Walsh Lake. A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. There are no in-lake monitoring data to calibrate the lake model. Water quality modeling indicates that watershed inputs account for approximately 86% of the nutrient load, with internal loading accounting for the remaining 14% (Figure 2). Without any in-lake nutrient data for the lake for model calibration, the modeling results should be considered preliminary.

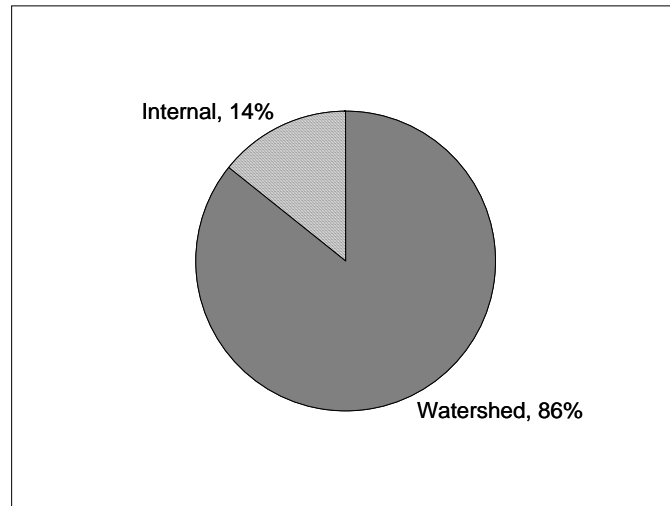


Figure 2. Walsh Lake Phosphorus Load Distribution

Public Input

No attendees spoke on issues related to Walsh Lake at the public input meeting on June 5, 2008. However, a resident lakeshore homeowner indicated in the past that there is occasional flooding of the west side of the south basin. The homeowner described flow coming from Roselawn Avenue and north on Pleasant Street. The homeowner has seen water mid-way up his driveway on past flooding occasions. The property is located in Roseville, with runoff water causing the problem originating in both Roseville and Falcon Heights adjacent to Roselawn Ave. It is the District's understanding that this concern has been minimized to the extent feasible through a modeling and pump operation assessment by the City of Lauderdale.

Water Quality Issues

- Without further data or public input, water quality issues were not able to be defined.

Recommended Management Approach

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing the water quality of Walsh Lake. Because the Walsh Lake watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, 8 BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- The primary management recommendation for the lake's watershed is to make sure strict application of RCWD and local runoff related regulations are followed throughout the watershed draining to the lake. BMP retrofit opportunities should be identified during future re-development processes within the watershed.
- Nutrient management for the two golf courses (Midland Hills Country Club and the University of Minnesota) with tributaries to the lake should be considered. The U of M course is located to the east of the lake, on the south side of Roselawn Ave. and is slightly buffered from directly discharging to the lake. It does, however, contribute runoff to the lake via runoff down Roselawn. The Midland Hills Country Club directly surrounds the north basin of the lake. Nutrient management practices on this course directly affect the quality of the lake.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

With very little in-lake biological data for Walsh Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Walsh Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- A fisheries survey will indicate the balance of benthivores, planktivores, and piscivores in the lake. Benthivores disturb the bottom sediments thereby releasing phosphorus into the water column, and planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Walsh Lake. There are no in-lake water quality data for the lake; if the implementation of management practices for the lake were to move forward, in-lake data would be needed and should be considered a high priority.

- Bathymetric data collection
- TP and chlorophyll data: Grab water quality samples should be collected if there is cause to believe that the waterbody is enriched with nutrients (as evidenced by mid-summer algae blooms) AND the water body is contributing flow to adjacent lakes.
- Macrophyte and/or aquatic invertebrate data should be collected in cooperation with the MPCA to determine if the water body is meeting the “healthy aquatic community standards.”

Walsh Lake Field Reconnaissance Supplement

Local Management BMPs



Walsh Lake #1

Location: South of Summer Street and east of Carl Street

Description: Private corner lot

Potential Improvements: Create stormwater treatment feature for adjacent street runoff.



Walsh Lake #2

Location: West side of Lauderdale Community Park off of Pleasant Street

Description: Open park space

Potential Improvements: Create stormwater treatment feature for adjacent street runoff.



Walsh Lake #3

Location: Fulham Street-between Ione St. and Roselawn Avenue

Description: Swales/green space in right-of-way

Potential Improvements: Maintain/improve routing of runoff through green space or convert to raingarden areas.



Walsh Lake #4

Location: East side of Lauderdale Community Park off of Fulham Street

Description: Large grass swale areas both north and south of parking lot drive. The swale north of the entrance is supposed to be filled with sandy soils and a large raingarden was to be created in northeast corner to promote infiltration per RCWD Permit 00-001.

Potential Improvements: Verify presence of sandy soils in swale, and improve treatment via excavation of depressional storage and vegetation enhancement in northeast corner.



Walsh Lake #5

Location: East of Midland Hills Road and North of Rosewood Lane North

Description: Wetland area

Potential Improvements: Looks fairly good as is, however an assessment could be made to determine the benefit of increasing storage or other modifications that could be made to provide additional treatment. (Note: there may have low floor issues with 2211 Rosewood Lane.) Roseville has identified this area for implementation of an expansion project in 2009.



Walsh Lake #6

Location: Midland Hills Golf course, north of Walsh Lake

Description: Ponding area that receives several stormsewer inputs and discharges to Walsh Lake

Potential Improvements: Excavation/maintenance to increase storage, native vegetation around pond perimeter, and the addition of a skimming structure at the outlet.

Vegetation Management BMPs



Walsh Lake #7

Location: West side of Walsh Lake

Description: Golf course area immediately adjacent to Walsh Lake

Potential Improvements: Replace turf with native vegetation buffer along western shore of the lake.



Walsh Lake #8

Location: Pond at the corner of Roselawn Avenue and Cleveland Avenue

Description: Large pond, very green, and several geese on the day of the site visit.

Potential Improvements: Replace grass with native vegetation along the shoreline on the adjacent church property.

Zimmerman Lake Management Action Plan

Zimmerman Lake (62-0053) is located in the City of Roseville, Ramsey County, Minnesota (Figure 1). The lake has a surface area of about 13 acres with a mean depth of approximately 4 feet.¹

Zimmerman Lake meets the MPCA definition of wetland and is classified as a Class 2D (wetland) water in accordance with Minn. Rules Ch. 7050. Furthermore its designation as a Public Water Wetland [“W” 62-53] by the DNR Protected Water Inventory and the lack of an aquatic recreational resource management history (MPCA (*Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment*, 2007) substantiates the designation as a Class 2D water. The Class 2D designation means that the wetland resource is protected for the “maintenance of a healthy wetland aquatic community and for wetland based aquatic recreation.” Numeric nutrient standards developed for shallow lakes (i.e. 60 µg/L TP) do not apply to Class 2D wetlands.

The watershed draining to Zimmerman Lake is 531 acres and is a heavily developed mix of commercial, transportation, and residential uses. It drains northward through Ramsey County Ditch 4, eventually draining to Little Johanna Lake, which is on the EPA’s 303(d) list of impaired waters.

Zimmerman Lake provides an amenity to the golf course located to its east and the Mn/DOT office building to its west.



¹ The lake areas were determined by digitizing lake boundaries using 2006 1-foot resolution air photos. No bathymetric data were available for this lake. The maximum depth was estimated using depth data collected during sediment sampling.

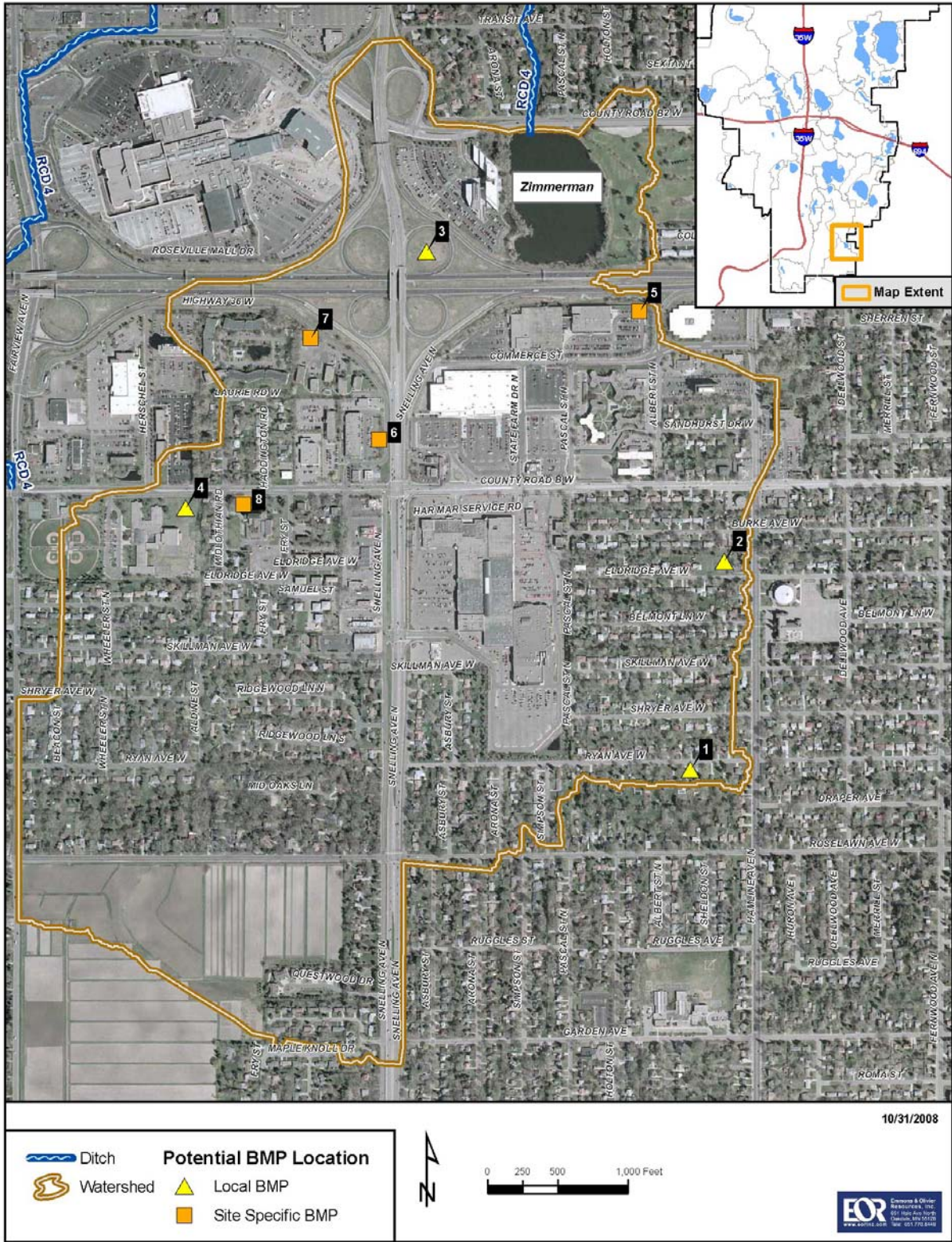


Figure 1. Zimmerman Lake and Potential BMP Locations

Water Quality Summary

There are no nutrient or biological data for Zimmerman Lake. A watershed model (P8) was used to estimate the watershed phosphorus load to the lake, and an in-lake model (Bathtub) was used to predict the response of the lake to phosphorus loading. There are no in-lake monitoring data to calibrate the lake model. Water quality modeling indicates that watershed inputs account for approximately 96% of the nutrient load, with internal loading accounting for 4% (Figure 2). Without any in-lake nutrient data for the lake for model calibration, the modeling results should be considered preliminary. Water clarity data inferred from satellite imagery suggest that the water clarity depth of Zimmerman Lake is less than 1.5 feet.

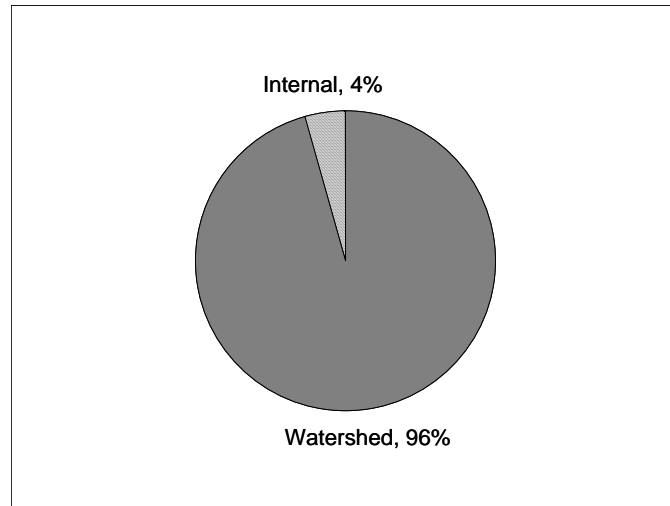


Figure 2. Zimmerman Lake Phosphorus Load Distribution

Public Input

No attendees spoke on issues related to Zimmerman Lake at the public input meeting on June 5, 2008.

Water Quality Issues

- Without further data or public input, water quality issues were not able to be defined.

Recommended Management Approach

Watershed Management Recommendations

Management of land in the watershed is a critical element in addressing downstream impairments. Because the Zimmerman Lake watershed is fully developed, opportunities for retrofitting BMPs into the watershed as it re-develops or as routine maintenance occurs should be sought. To that end, a preliminary field reconnaissance was conducted to identify likely regional, local and site-specific retrofit opportunities. Potential BMP locations identified during this field investigation are identified on Figure 1 and detailed in the *field reconnaissance supplement* at the end of this report. In summary, eight BMP retrofit opportunities were identified in this preliminary field reconnaissance. The following are specific actions that could be pursued to reduce external loading.

- Consideration of local partnerships for further assessment of the four potential local BMP locations identified in the *field reconnaissance supplement*.
- Notice/letter to potential site-specific BMP landowners educating them of potential grant funding through the District's Urban Stormwater Remediation Cost-Share Program.
- Ensure that strict application of RCWD and other local stormwater regulations are followed throughout the watershed draining to the lake.

There are several options known to successfully reduce nutrient runoff that can be suggested even before data are available that will allow more targeted management. These general practices include:

- Stormwater management retrofits for better nutrient, volume, rate, and erosion control
- Nutrient and stormwater volume absorbing raingardens
- Increased frequency of street-sweeping and targeted prioritization to direct runoff areas
- Buffer zones of native vegetation along the lake-shore (good for both runoff problems and fish survival)
- Public education programs to encourage voluntary land-owner changes in landscaping, lawn fertilization, and runoff management
- Active inspection programs for and routine maintenance of previously installed stormwater BMPs
- Compliance monitoring and inspection of active construction sites for adequate erosion and sediment control

Internal Lake Management Recommendations

With no biological or water quality data for Zimmerman Lake, specific in-lake management recommendations can not be made at this time. However, a number of shallow lake management principles will likely apply to Zimmerman Lake:

- If curly-leaf pondweed is present in high densities, it likely contributes to internal loading, and curly-leaf pondweed removal activities should be considered. Curly-leaf pondweed releases a pulse of phosphorus into the water column in June when the plants senesce.
- Submerged and emergent aquatic macrophytes in the lake normally stabilize the sediments and provide refugia for zooplankton. If the macrophyte communities are determined to be sparse, shoreline and littoral zone restoration practices should be undertaken.
- A fisheries survey will indicate the balance of benthivores, planktivores, and piscivores in the lake. Benthivores disturb the bottom sediments thereby releasing phosphorus into the water column, and planktivores can overgraze zooplankton, which normally graze on phytoplankton and keep chlorophyll concentrations in balance. If there is an overabundance of benthivorous fish (such as carp or bullhead) or an overabundance of planktivores, a fisheries management plan should be developed that will aim to restore the balance of these types of fish in the lake. If cooperation is possible, work with DNR to promote a fisheries management strategy that places importance on water quality, while maintaining a viable fishery.

Recommended Data Collection

The following in-lake data collection will help tailor the management recommendations for Zimmerman Lake. There are no in-lake water quality data for the lake; if the implementation of management practices for the lake were to move forward, in-lake data and bathymetric data would be needed and should be considered a high priority.

- Bathymetric data collection
- TP and chlorophyll data: Grab water quality samples should be collected if there is cause to believe that the water body is enriched with nutrients (as evidenced by mid-summer algae blooms) AND the waterbody is contributing flow to adjacent lakes.
- Macrophyte and/or aquatic invertebrate data should be collected in cooperation with the MPCA to determine if the waterbody is meeting the “healthy aquatic community standards.”

Zimmerman Lake Field Reconnaissance Supplement

Local Management BMPs



Zimmerman #1

Location: South side of Ryan Avenue W and west of Hamline Avenue N

Description: Example of large open areas in front yards

Potential Improvements: Install raingardens along road corridors; many opportunities in this area will exist when streets are reconstructed. (Note: there are also large boulevard trees limiting some areas.)



Zimmerman #2

Location: North of Eldridge Avenue W and west of Hamline Avenue N

Description: Large open lot

Potential Improvements: Room for good-sized infiltration or water quality feature (might not be able to get enough drainage area to the location to necessitate using the entire lot).



Zimmerman #3

Location: North of County Road B2 W and east of Snelling Avenue

Description: Southeast exit ramp loop

Potential Improvements: It appears that the loop areas adjacent to Snelling Ave. could be better used for treatment. These areas should be assessed for opportunities during road improvement projects.



Zimmerman #4

Location: South of County Road B and west of Midlothian Road

Description: Large open area at school

Potential Improvements: Incorporate feature for school and or adjacent roads. Note there are lots of opportunities on the school site to provide treatment (as needed). It appears that a raingarden was recently incorporated for a small paving project on site.

Site Specific Management BMPs



Zimmerman #5

Location: North of Commerce Street and west of Albert Street (or commerce Street to EB Hwy 36)

Description: Swale and dry pond picking up large parking area

Potential Improvements: Improve feature to include infiltration and/or water quality improvement.



Zimmerman #6

Location: West of Snelling Avenue and South of Hwy 36

Description: Swale picking up parking via curb cuts. No storage currently provided and curb cuts not draining properly.

Potential Improvements: Enhance area to provide depressional storage / create raingardens or bio-filtration areas.



Zimmerman #7

Location: West of Snelling Avenue and south of Hwy 36

Description: Green space area in apartment complex

Potential Improvements: Green space areas in apartment ground could be better used to provide treatment.



Zimmerman #8

Location: South of County Road B and east of Midlothian Road

Description: Swale flowing to storm sewer at St. Michael Church

Potential Improvements: Convert to raingarden/biofiltration area.