2009 Lake Water Quality Study

Sweeney Lake, Twin Lake, Northwood Lake, North Rice Pond, and South Rice Pond

Prepared by
Bassett Creek Watershed Management Commission

January 2010

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Executive Summary

Since 1970, the Bassett Creek Watershed Management Commission (BCWMC) has monitored water quality in ten major lakes within the Bassett Creek watershed. This long-term monitoring program was developed to detect changes or trends in lake water quality over time that will help determine the effects of changing land use patterns within the watershed as well as the effectiveness of BCWMC's efforts to maintain and improve water quality. The BCWMC adopted its current watershed management plan in 2004. This second-generation plan complies with the provisions of the Minnesota Rules Chapter 8410, the Metropolitan Surface Water Management Act, the Water Resources Management Policy Plan, and other regional plans, and it sets the vision and guidelines for managing surface water within the boundaries of the BCWMC.

Three indicators that are commonly used to measure water quality include chlorophyll *a* (a measurement of algae or small plants), the amount of total phosphorus (the main nutrient required for algal growth), and Secchi depth (transparency of the water). This report summarizes the results of water quality monitoring during 2009 in Sweeney, Lake, Twin Lake, Northwood Lake, and North and South Rice Ponds. The lakes were monitored for both chemical and biological water quality parameters, the latter including phytoplankton and zooplankton. Monitoring results are summarized by lake and include a description of the results along with graphical representations of the data.

The conclusions and recommendations from 2009 water quality monitoring are as follows:

Sweeney Lake

During 2009, the water quality of Sweeney Lake did not meet the state water quality standard and Bassett Creek Water Management Commission's (BCWMCs) goals for the lake. The water quality status of Sweeney Lake was eutrophic (nutrient rich and poor quality), and the summer average phosphorus concentration was *hyper*eutrophic (very nutrient rich, very poor water quality).

The observed 2009 water quality degraded significantly from the observed 2008 water quality. All three indicators show that the water quality in Sweeney Lake has degraded when compared to 2005, 2007, and 2008 because chlorophyll *a* and total phosphorus have increased, while Secchi depth has decreased.

The cause of the lake's water quality degradation in 2009 appears to be internal loading. Phosphorus released from sediment in 2009 was continuously mixed into the lake's surface waters during the growing season, thus increasing algal growth and reducing water clarity; while phosphorus released from sediment in 2008 was trapped in the lake's bottom waters until the fall mixing event, thus minimizing algal growth and increasing water clarity.

Twin Lake

During 2009, Twin Lake's water quality did not meet the state water quality standard and Bassett Creek Water Management Commission's (BCWMCs) goals for the lake were not met. The water quality status of Twin Lake was eutrophic and the summer average phosphorus concentration was hypereutrophic.

The observed 2009 water quality degraded from the observed 2008 water quality. All three indicators show that the water quality in Twin Lake has degraded when compared to 2000, 2005, and 2008 because chlorophyll *a* and total phosphorus have increased, while Secchi depth has decreased. The lake is currently at the poorest water quality observed since monitoring began. In 2009, late summer phytoplankton included the blue-green toxin-producing species *Cylindrospermopsis raciborski*, which comprised 25 percent of the algal community on August 12 and more than half of the algal community on August 26. Large numbers of this species are indicative of degraded water quality.

The cause of the lake's water quality degradation in 2009 appears to be internal loading.

It is recommended that the Commissioners consider collecting sediment samples during 2010 to determine if internal loading is causing the recent decline in the water quality of Twin Lake. It is also recommended that the Commissioners consider collecting additional water quality samples in February and March 2010, prior to ice out.

Northwood Lake

During 2009, Northwood Lake's water quality met state water quality standards and the BCWMC's goals for chlorophyll *a* and Secchi depth, but the lake's summer average total phosphorus concentration was more than five times greater than the state water quality standard and more than four times greater than the BCWMC's goal. Because Northwood Lake is a shallow lake, the water quality standards for the lake are less stringent than those for deep lakes (e.g., Sweeney Lake and Twin Lake).

2009 water quality status for Northwood Lake was eutrophic and the summer average phosphorus concentration was hypereutrophic.

Overall, the lake's water quality has improved since 2000 because chlorophyll *a* concentrations have declined and Secchi depth has increased. Although total phosphorus concentrations have increased since 2000, the increase has not resulted in increased algal growth or declining water transparency. Because increasing total phosphorus concentrations coincided with declining chlorophyll concentrations and increasing Secchi transparency, it appears that phosphorus is not the variable that limits algal growth in Northwood Lake.

North Rice Pond

During 2009, North Rice Pond's water quality met BCMC's goals for total phosphorus, chlorophyll *a*, and Secchi depth. Because North Rice Pond is a wetland, there are no state water quality standards applicable to the pond. Water quality was eutrophic, although the summer average phosphorus concentration was hypereutrophic.

Historical water quality data for North Rice Pond from 1994 and 1998 as well as 2009 show a trend toward water quality improvement.

South Rice Pond

During 2009, South Rice Pond's water quality met BCWMC's goal for chlorophyll *a*, but did not meet BCWMC's goals for total phosphorus and Secchi depth. Water quality was hypereutrophic and the summer average chlorophyll *a* value was eutrophic.

Historical water quality data indicates that consistently poor water quality has been observed in South Rice Pond during the period of record. A comparison of water quality observed in 2008 and 2009 indicates that total phosphorus concentrations increased while chlorophyll concentrations declined and water transparency improved. Hence, the water quality of South Rice Pond improved in 2009 despite increased phosphorus concentrations.

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Sweeney Lake, Twin Lake, Northwood Lake, North Rice Pond, and South Rice Pond

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1.0 Introduction

Since 1970, when the Bassett Creek Water Management Commission (BCWMC) and its predecessor, the Bassett Creek Flood Control Commission, were formed, water quality conditions in the ten major lakes have been periodically monitored. The BCWMC's policy is to preserve water quality conditions, and to improve them where possible. Nonpoint source pollution (pollutants transported by stormwater runoff) is the predominant cause of lake water quality degradation. The objective of the lake monitoring program is to detect changes or trends in water quality over time, thereby determining the effect of changing land use patterns in the watershed and the effectiveness of the BCWMC's efforts to prevent water quality degradation in the lakes.

In 1991, the BCWMC established an annual lake water quality monitoring program that generally followed the recommendations of the Metropolitan Council (Osgood 1989a) for a "Level I, Survey and Surveillance" data collection effort. The lake sampling program generally involves monitoring of ten lakes on a 4-year rotating basis, three or four lakes per year. However, some of the lakes, including Lost Lake and Sunset Hill (Cavanaugh) Lake have been eliminated from the program. Major lakes include the following water bodies, with prior monitoring years indicated parenthetically:

Table 1 Lakes Monitored in the Basset Creek Watershed BCWMC Area (Years with sampling data are in parenthesis)

• Crane (1977, 1982, 1993, 1997, 2001, 2007[1])	• Sunset Hill (Cavanaugh) (1977, 1982, 1994, 1998)
• Lost (1977, 1982, 1993, 1997)	• Sweeney[2] (1977, 1982, 1985, 1992, 1996, 2000, 2001, 2002, 2003, 2004, 2005, 2006[1], 2007[1], 2008[1])
• Medicine (1977, 1982, 1983, 1984, 1988, 1994[1], 1999[1], 2006[1])	• Twin (1977, 1982, 1992, 1996, 2000, 2005, 2008[1])
• Northwood (1972, 1977, 1982, 1992, 1996, 2000, 2005)	• Westwood[2] (1977, 1982, 1993, 1997, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007[1])

[1] Monitoring performed jointly with Three Rivers (formerly Suburban Hennepin Regional Park District).

[2] Includes monitoring by citizens as a part of the Metropolitan Council's Citizen Assisted Monitoring Program (CAMP)

Wirth Lake is currently monitored annually by the Minneapolis Park and Recreation Board. Hence, Wirth Lake is not included in the BCWMC's lake monitoring program. Medicine Lake is currently monitored annually by the Three Rivers Park District (Three Rivers). The BCWMC periodically participates with Three Rivers to monitor a second site at Medicine Lake. Westwood Lake, Sweeney Lake, and Parkers Lake have been monitored annually since 2000 by citizen volunteers participating in the Metropolitan Council's Citizen Assisted Monitoring Program (CAMP). Crane Lake was monitored nearly annually by Ridgedale Center during 1975 through 1994.

The lake sampling program occasionally includes limited monitoring for other water bodies, which has included the following ponds and the year sampled in parenthesis:

- Cortlawn, East Ring, and West Ring Ponds (1993)
- Grimes Pond (1996)
- North Rice and South Rice Ponds (1994, 1998)

South Rice Pond also has been included in the CAMP since 2000.

This report presents the results of the water quality monitoring in 2009 of Sweeney Lake, Twin Lake, Northwood Lake, and North and South Rice Ponds (locations shown on Figure 1). The lakes were monitored for water quality and biota, specifically phytoplankton and zooplankton. Monitoring results are summarized in the following pages, including a narrative description of the results as well as a graphical summary. More detailed data can be found in the appendices of the report.

The discussion of water quality conditions focuses on the three principal nutrient-related water quality indicators: total phosphorus (TP) concentrations, chlorophyll *a* concentrations, and Secchi disc transparency. Phosphorus is a nutrient that usually limits the growth of algae. Chlorophyll *a* is the primary photosynthetic pigment in lake algae; therefore, its concentration in a lake water sample indicates the amount of algae present in the sampled area of the lake. Secchi disc transparency is a measure of water clarity, and is inversely related to algal abundance.

P:\Mpls\23 MN\2327051\WorkFiles\2008 Lake Monitoring Twin Sweeney\Sweeney and Twin Maps\Lakes included in 2009 WQ Study.CDR RLG 03-23-09

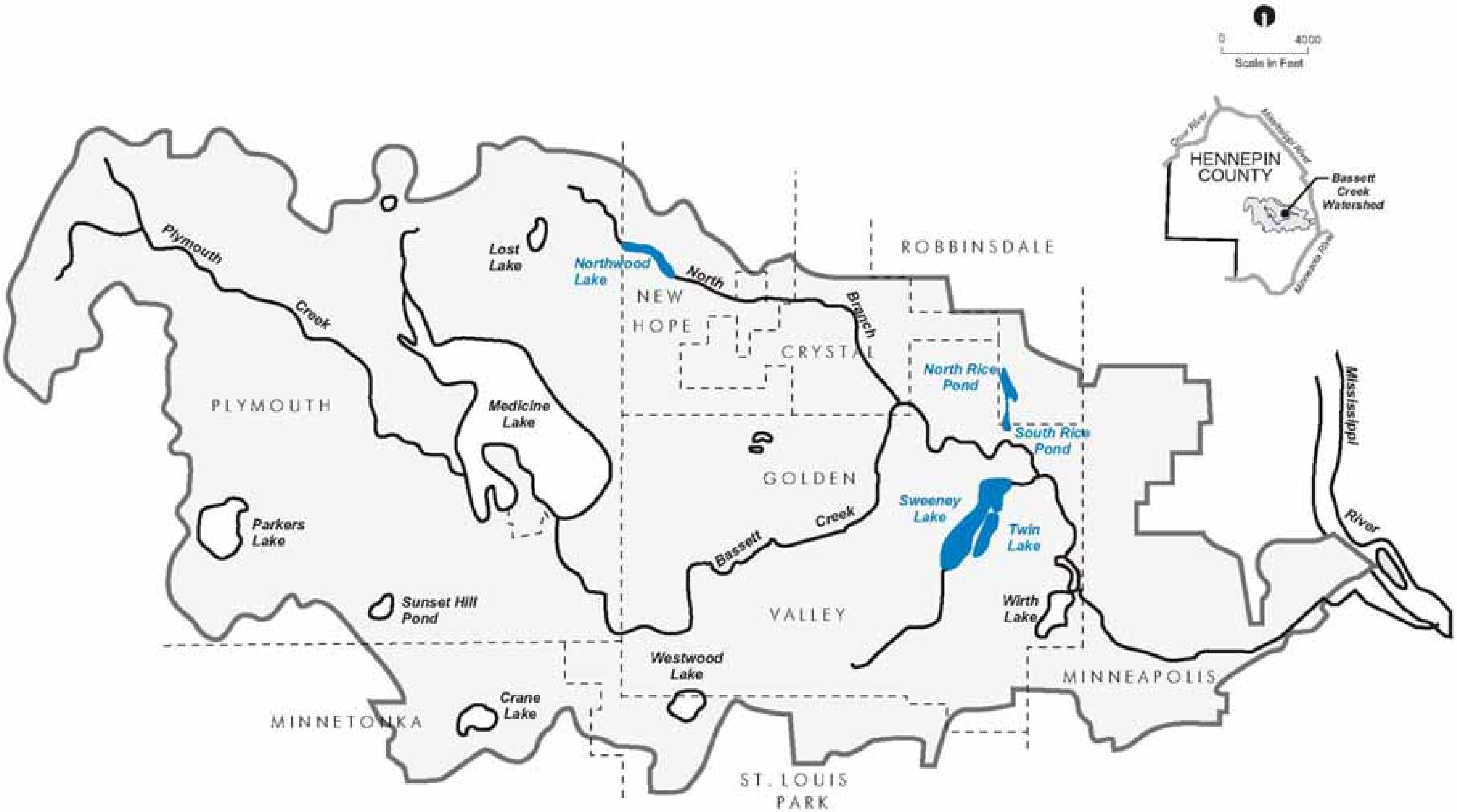

Figure 1

LOCATION OF LAKES INCLUDED IN
2009 WATER QUALITY STUDY
(Identified in Blue)

The water quality conditions were classified as to trophic state, based on the TP concentration, chlorophyll *a* concentration, and Secchi disc transparency (Table 2).

Table 2 Trophic State Classifications for Total Phosphorus, Chlorophyll *a*, and Secchi Disc Transparency

Trophic State	Total Phosphorus (TP)	Chlorophyll *a*	Secchi Disc Transparency
Oligotrophic (nutrient poor)	less than 10 µg/L	less than 2 µg/L	greater than 15 ft (4.6 m)
Mesotrophic (moderate nutrient levels)	10 µg/L – 24 µg/L	2 µg/L - 7.5 µg/L	15 ft - 6.6 ft (4.6 m - 2.0 m)
Eutrophic (nutrient rich)	24 µg/L – 57 µg/L	7.5 µg/L - 26 µg/L	6.6 ft – 2.8 ft (2.0 m - 0.85 m)
Hypereutrophic (extremely nutrient rich)	greater than 57 µg/L	greater than 26 µg/L	less than 2.8 ft (0.85 m)

In addition to chemically-based water quality parameters, biological data were compiled and evaluated in this study as well. Phytoplankton and zooplankton data can help determine the health of aquatic systems and can also indicate changes in nutrient status over time. Biological communities in lakes interact with each other and influence both short- and long-term variations in observed water quality.

Phytoplankton (algae) – form the base of the food web in lakes and directly influence fish production and recreational use. Chlorophyll *a*, the main pigment found in algae, is a general indicator of algal biomass in lake water. The identification of species and their abundance provides additional information about the health of a lake and can indicate changes in lake status as algal populations change over time. Different algal species provide varying levels of “food quality” and thus can affect the growth of zooplankton in a lake. Larger algal species that are difficult to consume or those of low food quality are less desirable for zooplankton and can limit overall productivity in a lake.

Zooplankton (microscopic crustaceans) – are vital to the health of a lake ecosystem because they feed upon the phytoplankton and are food themselves for many fish species. Protection of the lake’s zooplankton community through proper water quality management practices protects the lake’s fishery. Zooplankton are also important to lake water quality. The zooplankton community is comprised of three groups: Cladocera, Copepoda, and Rotifera. If present in abundance, large Cladocera can decrease the number of algae and improve water transparency within a lake.

2.0 Methods

2.1 Water Quality Sampling

Samples were collected from representative lake sampling stations (i.e., located at the deepest location(s) in each lake basin) on eight occasions in Sweeney Lake and Twin Lake and on six occasions in Northwood Lake and North and South Rice Pond. Sweeney Lake samples were collected from two basins (North and South). Table 3 lists sampling dates for each lake. Dates marked with an asterisk (*) are included in the summer average computations for comparison to applicable standards and historical records.

Table 3 Sample Collection Dates

Sweeney Lake	Twin Lake	Northwood Lake	North and South Rice Pond
February 26	February 26		
March 17	March 17		
April 21	April 21	April 22	April 22
May 4	May 4		
June 2*	June 2*		
June 16*	June 17*	June 17*	June 17*
July 14*	July 15*	July 15*	July 15*
August 11*	August 12*	August 12*	August 12*
August 24*	August 26*	August 26*	August 26*
September 21	September 23	September 23	September 23

Table 4 lists the water quality parameters and specifies at what depths the samples or measurements were collected. Dissolved oxygen, temperature, specific conductance, pH, and Secchi disc transparency (Secchi depth) were measured in the field, water samples were analyzed in the laboratory for total phosphorus, soluble reactive phosphorus, total nitrogen, and chlorophyll *a*. Sampling and analysis of water quality parameters were completed by Three Rivers. Phytoplankton and zooplankton samples were collected by Three Rivers (see Ecosystem Data) and were analyzed by Barr Engineering Company.

Table 4 Lake Water Quality Parameters

Parameters	Depth (Meters)	Sampled or Measured During Each Sample Event
Dissolved Oxygen	Surface to bottom profile at one meter intervals	X
Temperature	Surface to bottom profile at one meter intervals	X
Specific Conductance	Surface to bottom profile at one meter intervals	X
Secchi Disc	—	X
Total Phosphorus	0-2 Meter Composite Sample.	X
Total Phosphorus	One sample above the thermocline, one below the thermocline, and one near bottom sample from 0.5 meters above the bottom.	X
Soluble Reactive Phosphorus	0-2 Meter Composite.	X
Total Nitrogen (or Nitrogen Species Needed to Determine Total Nitrogen)	0-2 Meter Composite Sample.	X
pH	0-2 Meter Composite Sample.	X
pH	One sample above the thermocline, one below the thermocline, and one near bottom sample from 0.5 meters above the bottom.	X
Chlorophyll *a*	0-2 Meter Composite Sample.	X

2.2 Ecosystem Data

2009 phytoplankton and zooplankton data were collected in Sweeney Lake and Twin Lake during all April through September sample events and in Northwood Lake, North Rice Pond, and South Rice Pond during all June through August sample events. Phytoplankton and zooplankton samples were collected by Three Rivers and analyzed by Barr Engineering Company.

- **Phytoplankton—**Samples were surface water samples (composite 0-2 meter sample) and sample analysis included identification and enumeration of species.
- **Zooplankton—**Samples were bottom to surface tows and sample analysis included identification and enumeration of species.

3.0 Sweeney Lake

3.1 Site Description

Sweeney Lake, located in the City of Golden Valley (Hennepin County), has a water surface area of approximately 67 acres (27.1 hectares), a maximum depth of 27 feet (8.2 meters) and a mean depth of 12 feet (3.6 meters). It is surrounded by a 2,340 acre watershed. The littoral zone covers roughly 41 acres, which is 61 percent of the basin. The Sweeney Lake branch of Bassett Creek flows into the lake on the southern end and it exits at the northern end over a concrete dam. Surface inflow to the Lake comes from three general areas: direct drainage from the surrounding residential and commercial areas; inflow from Schaper Pond outlet; and limited inflow from Twin Lake. A peninsula separates Sweeney Lake from Twin Lake with a small connection between the two lakes allowing flow from Twin into Sweeney Lake. During some storm event conditions, Sweeney Lake may flow into Twin Lake. Privately-owned, single family homes line the entire western and southern shorelines of Sweeney Lake. The Hidden Lakes residential development and park land borders the eastern shore and the northern shore is bordered by the Golden Valley Health Center. The lake is primarily used by area residents for canoeing, boating, fishing, and aesthetic viewing purposes.

3.2 Goal

The BCWMC's goal for Sweeney Lake is a management classification of Level I, meaning its water quality should support all water-based recreational activities including swimming. Level I goals are (1) average summer total phosphorus concentration not to exceed 30 µg/L, (2) average summer chlorophyll *a* concentration not to exceed 10 µg/L, and (3) average summer Secchi disc transparency at least 2.2 meters (about 7 feet) (*BCWMC Watershed Management Plan* 2004).

3.3 State Standards

The federal Clean Water Act (CWA) requires states to adopt water-quality standards to protect waters from pollution. These standards define how much of a pollutant can be in the water and still allow it to meet designated uses, such as drinking water, fishing and swimming. The standards are set for a wide range of pollutants, including bacteria, nutrients, turbidity and mercury. A water body is "impaired" if it fails to meet one or more water quality standards. The state water quality standards applicable to Sweeney Lake are (1) maximum total phosphorus concentration of 40 µg/L, (2) maximum chlorophyll *a* concentration of 14 µg/L, and (3) minimum Secchi disc transparency of 1.4 meters (Minn. R. Ch. 7050.0222 Subp. 3).

3.4 BCWMC Watershed Management Plan, Sweeney Lake Watershed and Lake Management Plan, and Sweeney Lake TMDL Study

The *BCWMC Watershed Management Plan* (2004) incorporated the study results of the *Sweeney Lake Watershed and Lake Management Plan* (1994). A pond constructed as a part of the Schaper Park project during 1998 implemented a recommended management practice from the *Sweeney Lake Watershed and Lake Management Plan* (1994) and effectively reduced the amount of sediment and other pollutants that enter Sweeney Lake. The *BCWMC Watershed Management Plan* (2004) includes one of the other recommendations, an alum treatment facility, as a potential future water quality Capital Improvements Program (CIP) (not included in the 10-Year CIP).

In 2004, Sweeney Lake was included as a new listing in the MPCA's impaired waters list. Sweeney Lake was listed for excess nutrients (total phosphorus). The BCWMC received funding from the MPCA to conduct a total maximum daily load (TMDL) study for Sweeney Lake. The TMDL study began in 2007 and will be completed by mid-2010. The *BCWMC Watershed Management Plan* (2004) also includes the implementation of water quality improvement projects specified in the Sweeney Lake TMDL. An implementation plan was developed as a part of the draft *Sweeney Lake Total Phosphorus TMDL* (2009). Best Management Practices (BMPs) from the plan are shown in Table 5.

Table 5. Sweeney Lake Management Plan

Management Practice	Potential Phosphorus Removal (Pounds)
Best Management Practices (BMPs) that achieve a level of removal of phosphorus and total suspended solids equal to or greater than the level that would be achieved by a permanent pool that provides for storage of 2.5 inches of runoff volume from the entire development site will be required for all new development and redevelopment. This policy of the Bassett Creek Watershed Management Commission (BCWMD) and the City of Golden Valley has been required of all new development and redevelopment in the watershed since 1994.	30[1]
Best Management Practices that infiltrate the first one inch of rainfall from all impervious surfaces will be required for all new development and redevelopment where feasible. This policy is being considered by the City of Golden Valley and the BCWMD for future adoption.	Not estimated
Opportunities to implement extended detention basins, infiltration, biofiltration, grit chambers, and other BMPs will continue to be identified as part of new development, redevelopment, and maintenance projects where they will provide a water quality benefit to the Lake.	Not Estimated
As new BMPs and water quality improvement technologies are developed they will be evaluated to determine if they can provide a water quality benefit to the Lake and they will be implemented if they are determined to be reasonable and practicable.	Not Estimated
The program to promote the development of shoreline buffers will be continued.	15[2]
The feasibility of modifying the pond in Schaper Park to improve its ability to remove phosphorus will be evaluated and implemented if it is found to be reasonable and practicable. **Alternative**: Filtration barrier to improve Schaper Park pond performance.	40 20
The feasibility of dredging Spring Pond and diverting low flows from the Sweeney Lake branch of Bassett Creek to the pond will be evaluated and implemented if it is found to be reasonable and practicable. **Alternative**: Filtration barrier to improve pond performance.	20 20
The feasibility of chemically treating storm water from the Sweeney Lake branch of Bassett Creek will be investigated and implemented if it is found to be reasonable and practicable.	200
The feasibility of in-lake treatment to limit the internal phosphorus load from bottom sediments will be evaluated and implemented if it is found to be reasonable and practicable. Also consider inflow system. (175 lbs is based on a 55 percent Internal Load Reduction)	175
Existing BMPs will be monitored and maintained to insure that they continue to provide the water quality benefits that they were intended to provide.	Not Estimated

Table 5. Sweeney Lake Management Plan

Management Practice	Potential Phosphorus Removal (Pounds)
The city street sweeping program will continue and as new technology and new techniques are developed they will be evaluated to determine if they would provide a water quality benefit to the Lake and implemented if found to be reasonable and practicable.	18
A County and State Highway load reduction program	50[3]
The water quality education program will continue to work with residents to increase their understanding of practices that would reduce the amount of pollutants entering the Lake	10

[1]Based on an estimated 300 acres of redevelopment over the next 20-year period.
[2]Assumes 5,000 feet of shoreline buffer restoration.
[3]Assumes 50% load reduction of load from untreated highway areas and sweeping program.

3.5 Water Quality Data

Sweeney Lake was sampled ten times in both the northern basin and the southern basin during 2009. Samples from both stations were averaged for each sampling date to allow comparisons to data collected in previous years. During the 2000 sampling period, samples were collected only from the southern basin, although samples were collected from both basins during 1996, 2005, 2007, and 2008. Water quality data (Appendix A) for Sweeney Lake include:

- Vertical profiles of temperature, dissolved oxygen concentration, specific conductivity, and pH
- 0-2 m composite samples analyzed for chlorophyll *a*, total phosphorus, soluble reactive phosphorus, and total nitrogen
- Total phosphorus above and below the thermocline and near bottom
- Secchi disc transparency
- Phytoplankton
- Zooplankton

3.5.1 Temperature

Vertical profiles of temperature collected during 2009 show that the lake was generally either completely mixed or weakly stratified (Appendix A). The 2009 data were similar to 2005 data (Barr 2009), but differed from 2007 and 2008 data because the lake was stratified throughout the summer in 2007 and 2008 (Barr 2009). The data indicate the lake remains stratified throughout the growing season when the aeration system is turned off and remains mixed or weakly stratified when the aeration system is in operation.

3.5.2 Dissolved Oxygen

Vertical profiles of dissolved oxygen collected during 2009 indicate near bottom waters contained low oxygen concentrations (i.e., less than 2 mg/L) during February through March in both basins, June through August in the South Basin, and April through August in the North Basin. Dissolved oxygen concentrations in both basins were generally less than 5 mg/L at depths greater than 7 meters during June, 6 meters during July, and 5 meters during August. Panfish and gamefish species within the lake require dissolved oxygen concentrations of 5 mg/L or greater. Therefore they would have been unable to live in the lake's deeper waters for most of the growing season. High total phosphorus concentrations near the sediment surface were also detected during this period indicating internal loading of phosphorus due to oxygen depletion. The cause of the oxygen depletion below the thermocline is due to microbial degradation of organic material from settled algal material and stormwater inputs.

2005 and 2009 data indicate operation of the aeration system generally resulted in higher oxygen concentrations near the lake's bottom than occurred during 2007 and 2008. Despite these higher concentrations during 2005 and 2009, near bottom dissolved oxygen concentrations remained low throughout the summer and were not sufficient to prevent phosphorus release from sediments.

3.5.3 Total Phosphorus, Chlorophyll *a,* and Secchi Depth

Surface total phosphorus data are graphically summarized in Figure 2. The 2009 surface total phosphorus concentrations ranged from a high of 101 µg/L in mid-July to a low of 63 µg/L in early May and averaged 86 µg/L during the summer months (June through August). The 2009 average (86 µg/L) was higher than the 2005, 2007, and 2008 summer averages (53 µg/L, 48 µg/L, and 32 µg/L respectively).

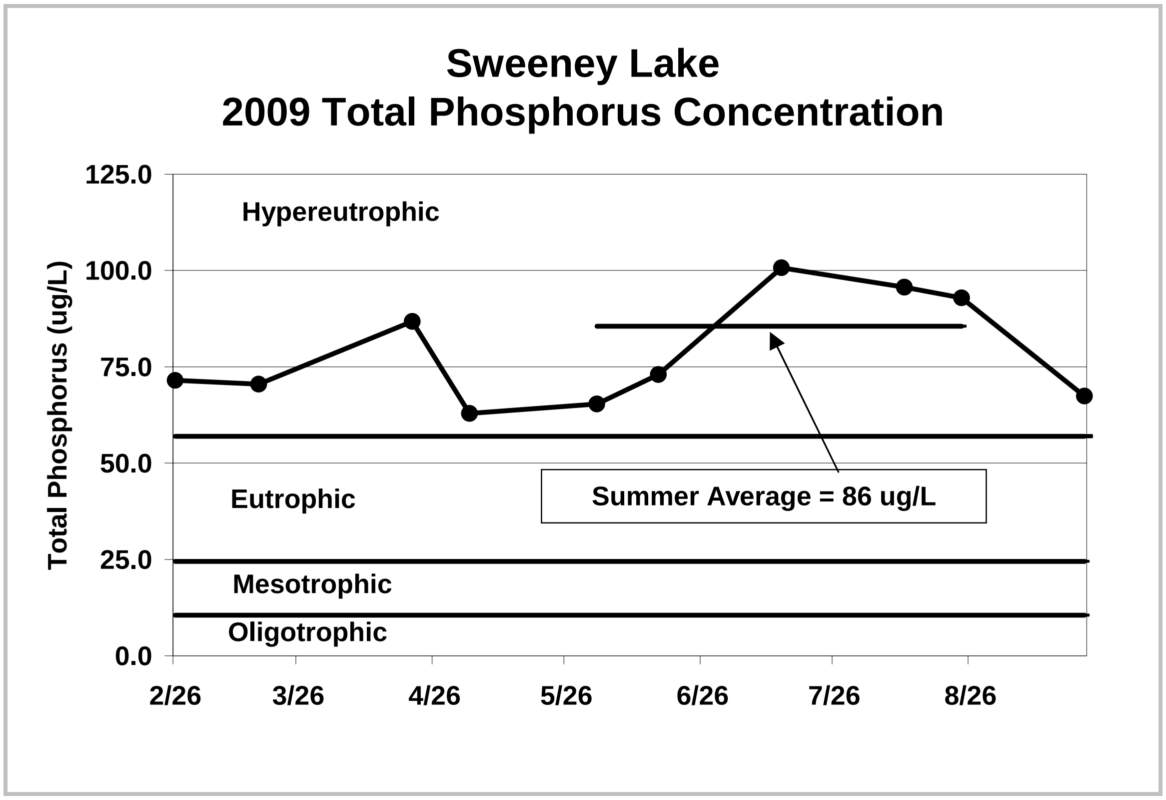

Figure 2   2009 Sweeney Lake Total Phosphorus Concentration

During February and March 2009, surface total phosphorus concentrations were three to five times lower than bottom total phosphorus concentrations (Figure 3). Low oxygen concentrations near the lake's sediment created optimum conditions for sediment phosphorus release during this period. Phosphorus buildup in the lake's bottom waters increased concentrations and caused the observed difference between surface and bottom water phosphorus concentrations. Although surface total phosphorus concentrations were generally lower than bottom total phosphorus concentrations throughout the growing season, the growing season difference was lower than the winter difference. Mixing by the aeration system minimized buildup of phosphorus in the lake's bottom waters during the growing season and, hence, minimized the difference between surface and bottom phosphorus concentrations.

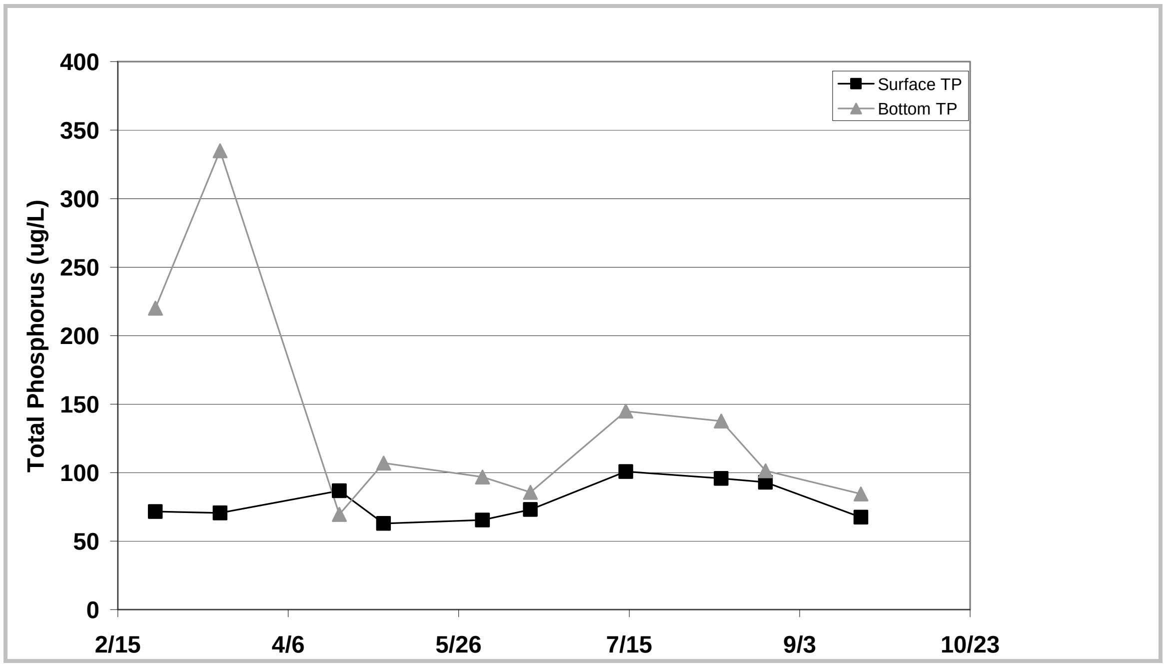

Figure 3 2009 Sweeney Lake Surface and Bottom Total Phosphorus Concentration

Surface chlorophyll *a* data are graphically summarized in Figure 4. 2009 surface chlorophyll *a* concentrations ranged from a high of 38 µg/L in April to a low of 3 µg/L in early May. The average summer concentration was 25 µg/L, which was higher than recent average summer concentrations in 2005 (19), 2007 (14) and 2008 (6). The 2008 summer average was the lowest summer average since monitoring began in 1972 and was approximately 25 percent of the 2009 summer average.

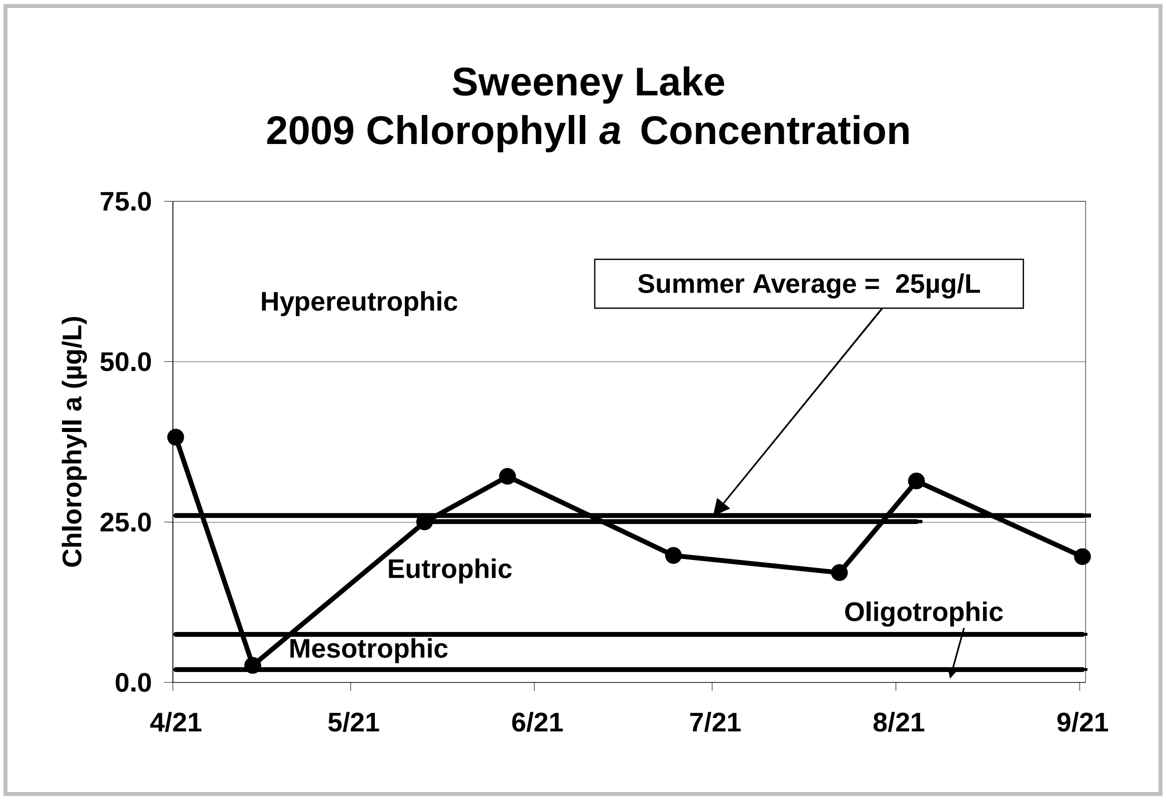

Figure 4 2009 Sweeney Lake Chlorophyll *a* Concentration

Secchi disc data are graphically summarized in Figure 5. 2009 Secchi disc transparency ranged from a low of 0.9 meters in late August to a high of 2.4 meters in early May and averaged 1.2 meters during the summer months. The 2009 average summer Secchi disc transparency was lower than recent summer averages in 2005 (1.8), 2007 (1.5) and 2008 (2.7). The 2008 summer average was the best average transparency (i.e. highest Secchi disc reading) recorded since 1972 and was more than double the 2009 summer average.

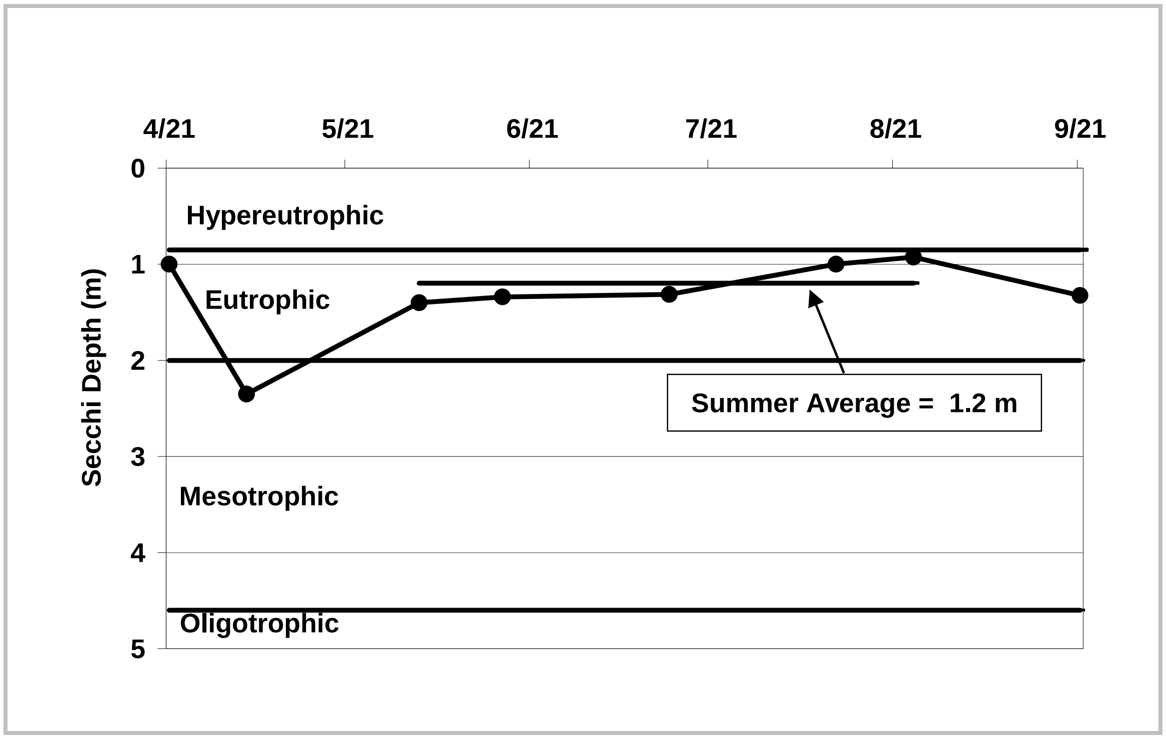

Figure 5 2009 Sweeney Lake Secchi Depth

The observed 2009 water quality degraded significantly from the observed 2008 water quality. All of the three indicators show that the water quality in Sweeney Lake has degraded when compared to 2005, 2007, and 2008 because chlorophyll *a* and total phosphorus have increased, while Secchi depth has decreased. 2008 water quality data showed improvement when compared to 2007 and 2005 because chlorophyll *a* and total phosphorus declined, while Secchi depth increased. 2008 water quality was the best since monitoring began in 1972. 2008 average summer phosphorous concentration was in the lower end of the eutrophic range, while 2008 average summer chlorophyll *a* and Secchi depth were within the mesotrophic range. 2009 water quality was substantially poorer than 2008 water quality, but within the range of historical data (Section 3.6). 2009 average summer phosphorus concentration was in the hypereutrophic range, while average summer chlorophyll *a* and Secchi depth were within the eutrophic range.

During 2009, Sweeney Lake's water quality did not meet the state water quality standard. The lake's summer average total phosphorus concentration (86 µg/L) was more than double the state standard (maximum of 40 µg/L); the lake's average summer chlorophyll a concentration (25 µg/L) was nearly double the state standard (maximum of 14 µg/L); and the lake's average summer Secchi disc transparency (1.2 meters) was 20 percent less than the state standard (minimum of 1.4 meters). Although the lake's water quality did not meet the state water quality standard in 2009, the lake's 2008 water quality met the state water quality standard.

BCWMC's goals for chlorophyll and Secchi disc were not met in 2009. The lake's average summer phosphorus concentration (86 µg/L) was nearly three times greater than BCWMC's goal (average summer concentration not to exceed 30 µg/L); the lake's average chlorophyll *a* concentration (25 µg/L) was two and a half times greater than BCWMC's goal (average summer concentration not to exceed 10 µg/L); and the lake's average summer Secchi disc transparency (1.2 meters) was approximately half of BCWMC's goal (summer average of at least 2.2 meters).

Water quality degradation in 2009 changed the lake's water quality from meeting BCWMC's goals for chlorophyll and Secchi disc in 2008 and nearly meeting BCMWC's phosphorus goal to not meeting BCWMC's goals. Furthermore, water quality degradation in 2009 changed the lake's water quality from meeting state standards to not meeting state standards.

As shown in Figure 6, the cumulative total precipitation for 2008 and 2009 were nearly the same during January through July; much lower precipitation occurred in 2009 beginning in August. The data suggest that watershed runoff in 2008 and 2009 was relatively similar through July and lower in 2009 beginning in August. Hence, the cause of the lake's water quality degradation in 2009 appears to be internal loading rather than watershed loading. As indicated in Figures 7 and 8, phosphorus released from sediment during the summer of 2009 was continuously mixed into the lake's surface waters during the growing season while phosphorus released from the sediment in the summer of 2008 was trapped in the lake's bottom waters until the fall mixing event. Hence, bottom phosphorus concentrations were high during the summer of 2008 while surface phosphorus concentrations were low. 2009 summer surface and bottom phosphorus concentrations were relatively similar.

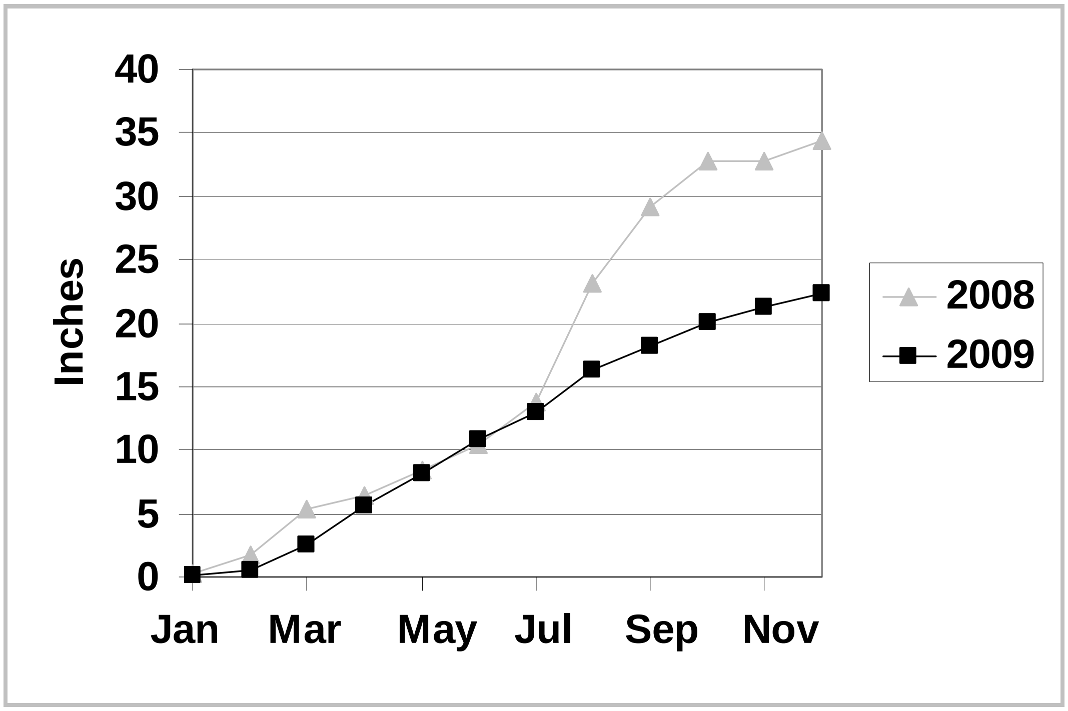

Figure 6. 2008 and 2009 Cumulative Precipitation

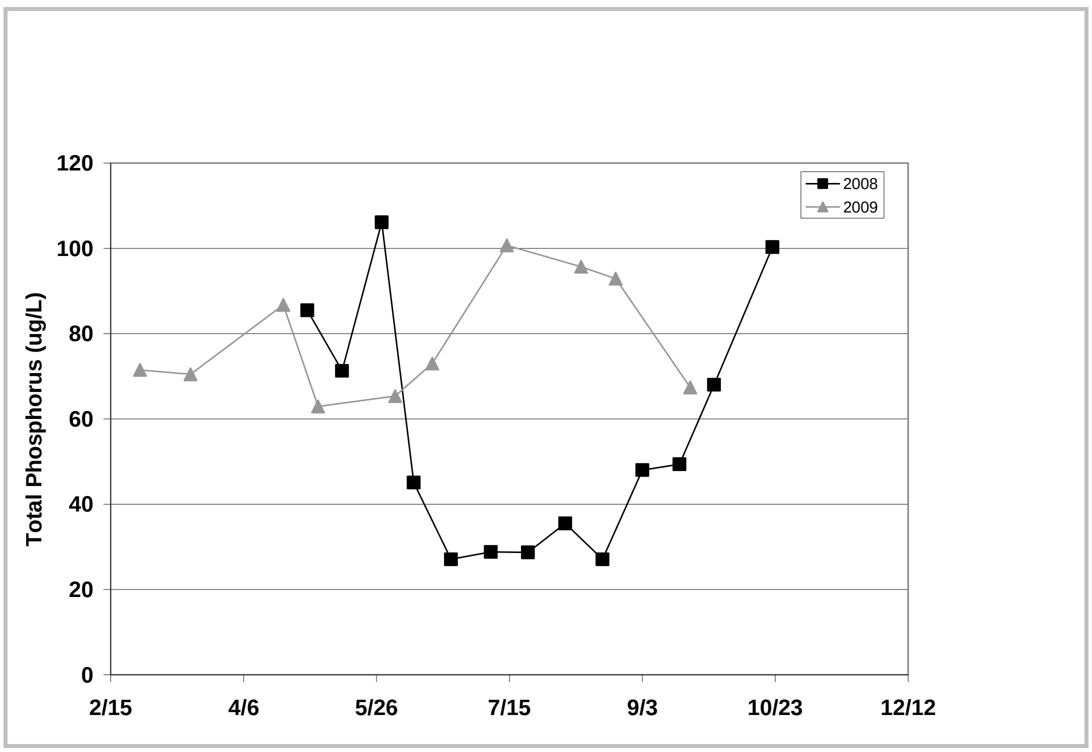

Figure 7. 2008-2009 Sweeney Lake Surface Total Phosphorus Concentration

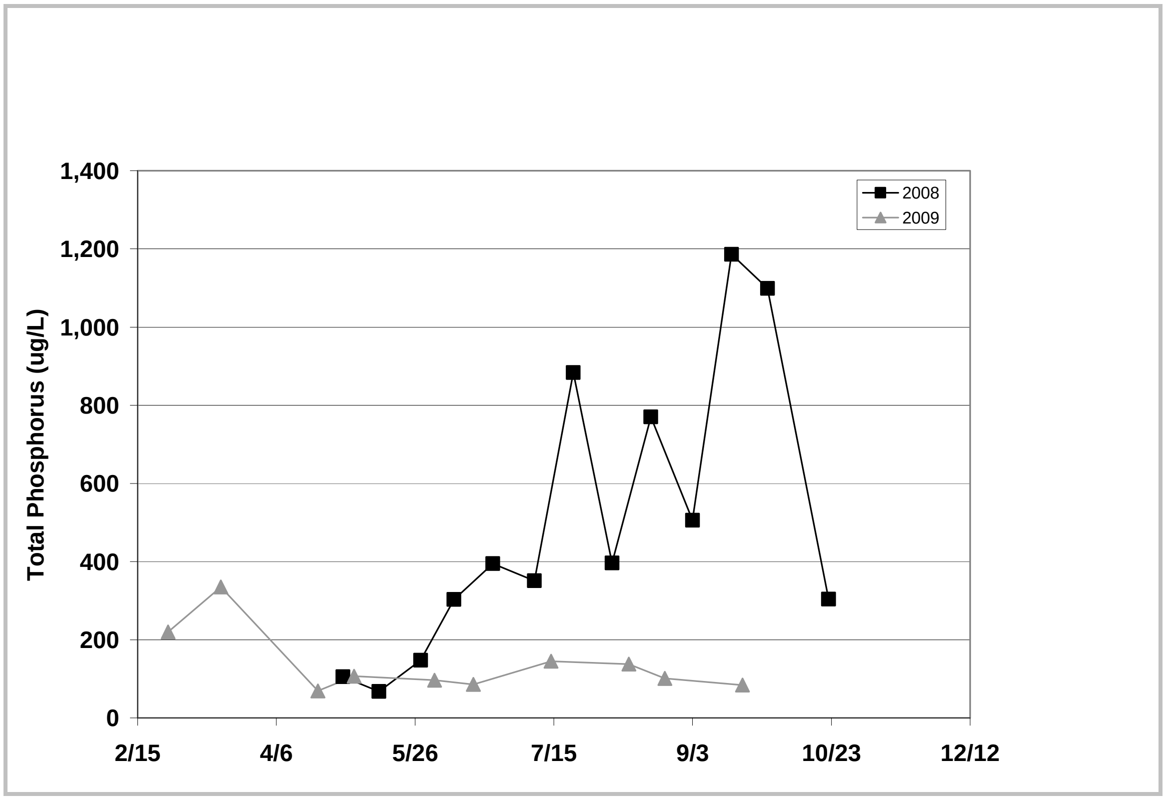

Figure 8. 2008-2009 Sweeney Lake Bottom Total Phosphorus Concentration

3.6 Historical Trends

Historical water quality trends are shown on Figure 9. Current data from all three measured parameters indicate poorer water quality in 2009 than recent years (i.e., since 2000). Despite degradation in 2009, the lake's water quality was within the range of values observed during the period of record.

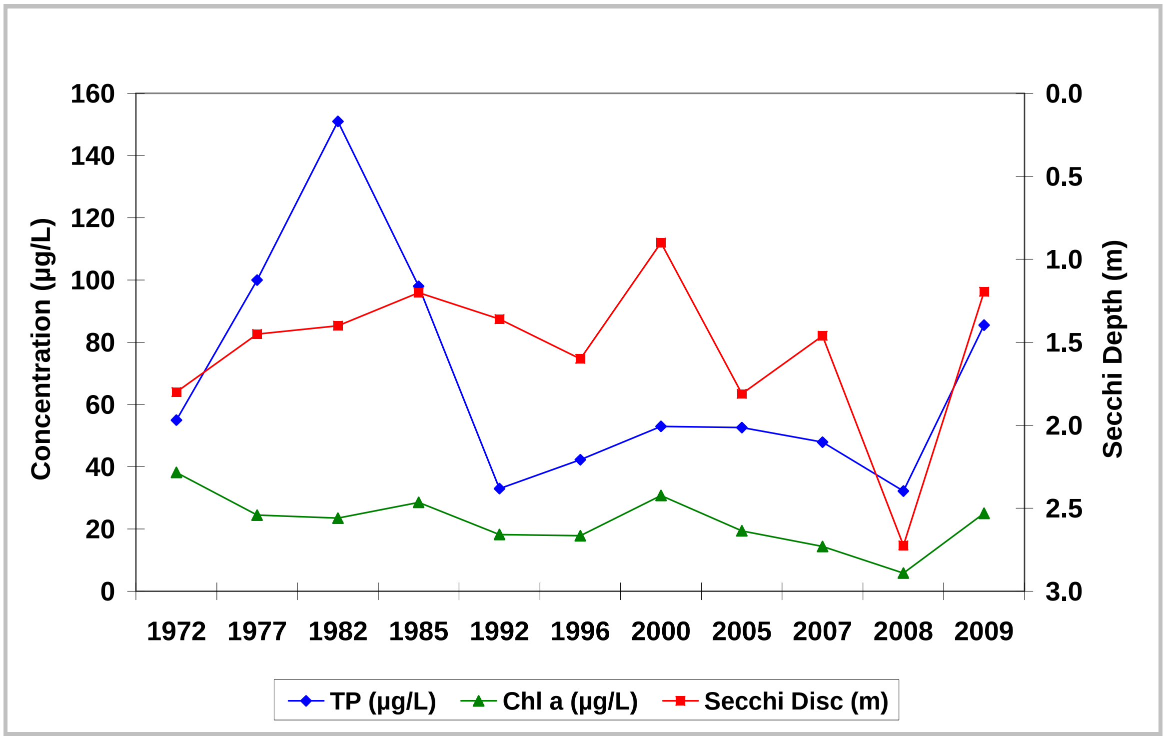

Figure 9 Historical Water Quality in Sweeney Lake.

3.7 Biota

Two components of lake biota are presented herein: phytoplankton and zooplankton. Fisheries status is managed by the Department of Natural Resources and is not covered in this report.

3.7.1 Phytoplankton

Phytoplankton, also called algae, are single-celled aquatic plants naturally present in lakes. They derive energy from sunlight (through photosynthesis) and from dissolved nutrients found in lake water. They provide food for several types of animals, including zooplankton, which are eaten by fish. A phytoplankton population in balance with the lake's zooplankton is ideal for fish production. An inadequate phytoplankton population reduces the lake's zooplankton population and adversely impacts the lake's fishery. Excess phytoplankton, however, reduce the lake's water clarity.

The lake's diverse algal community was comprised of six major algal groups:

- Chlorophyta or green algae,

- Cyanophyta or blue-green algae,
- Bacillariophyta or diatoms,
- Pyrrophyta or dinoflagellates,
- Chrysophyta or yellow-brown algae, and
- Cryptophyta or cryptomonads.

Green algae and cryptomonads dominated the spring community while blue green algae were predominant during the late summer. The number of phytoplankton increased nearly five-fold during June through August (Figure 10).

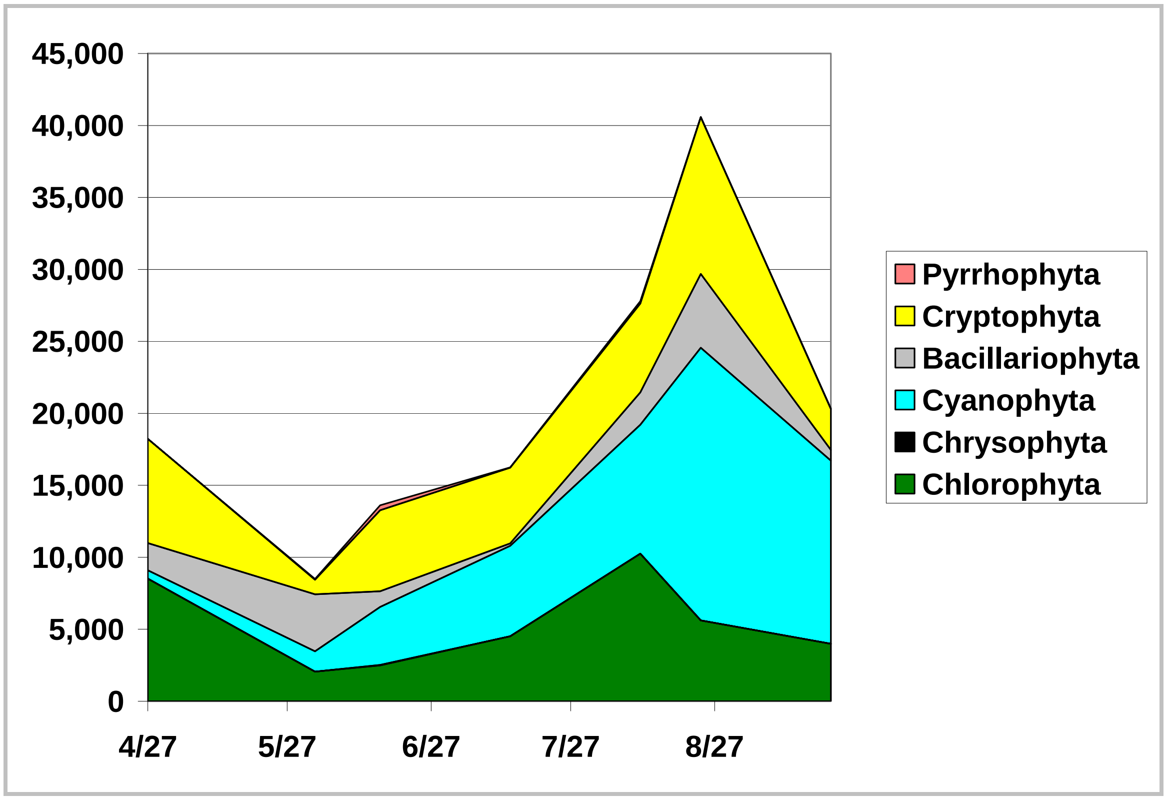

Figure 10 2009 Sweeney Lake Phytoplankton Data Summary by Division

A comparison of 2005, 2008, and 2009 data indicates 2005 and 2009 phytoplankton numbers were relatively similar and approximately double the 2008 phytoplankton numbers (Figure 11). Although 2005 and 2009 numbers were similar relative to 2008 numbers, 2009 generally had higher numbers than 2005.

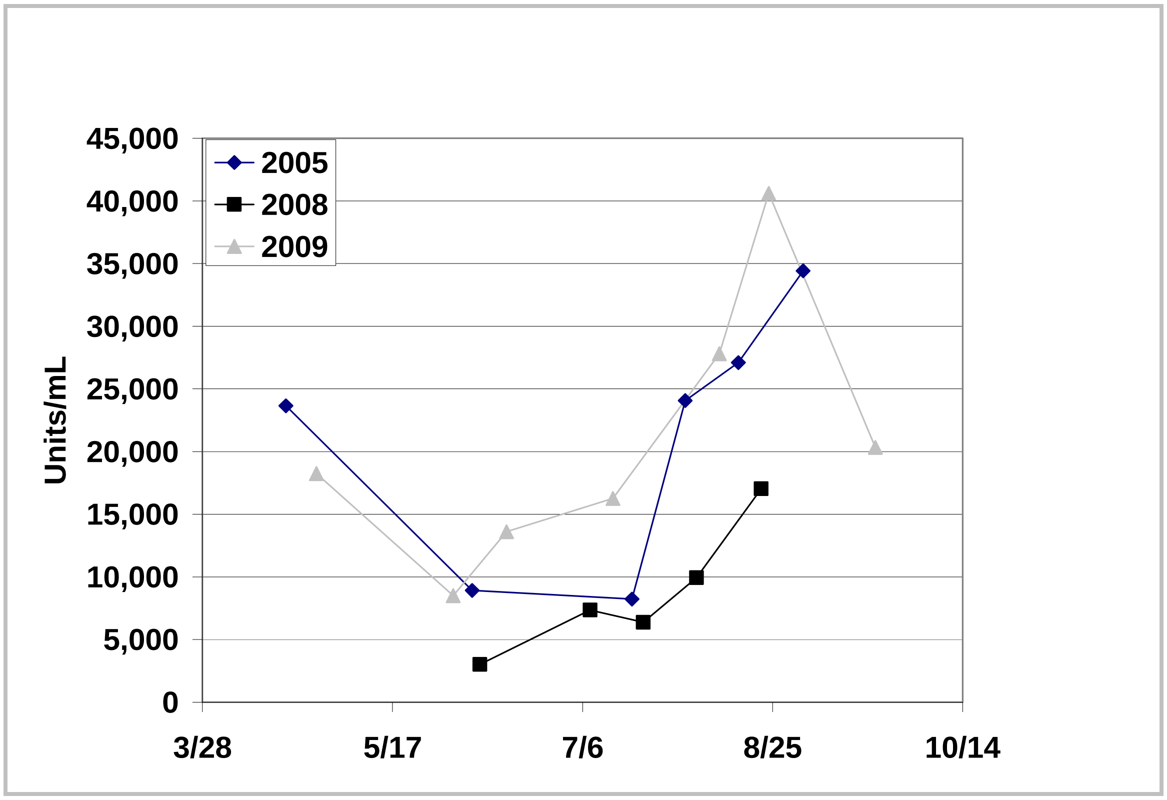

Figure 11 Comparison of 2005, 2008, and 2009 Sweeney Lake Phytoplankton

3.7.2 Zooplankton

Zooplankton are microscopic animals that feed on particulate matter, including algae, and are, in turn eaten by fish. Healthy zooplankton communities are characterized by balanced densities (number per meter squared) of the three major groups of zooplankton:

- Cladocera,
- Copepods, and
- Rotifers.

Fish predation, however, may alter community structure and reduce the numbers of larger bodied zooplankters (i.e., larger bodied Cladocera such as *Daphnia*).

All three groups of zooplankton were represented in Sweeney Lake during 2009 (see Figures 12 and 13). Large-bodied cladocerans were observed throughout the growing season at both the north and south sampling locations. Grazing by large-bodied cladocerans reduces the numbers of algae in the water and improves water transparency. The data indicate the lake has a healthy zooplankton community which supports the lake's fishery and exerts some control over the lake's algal community.

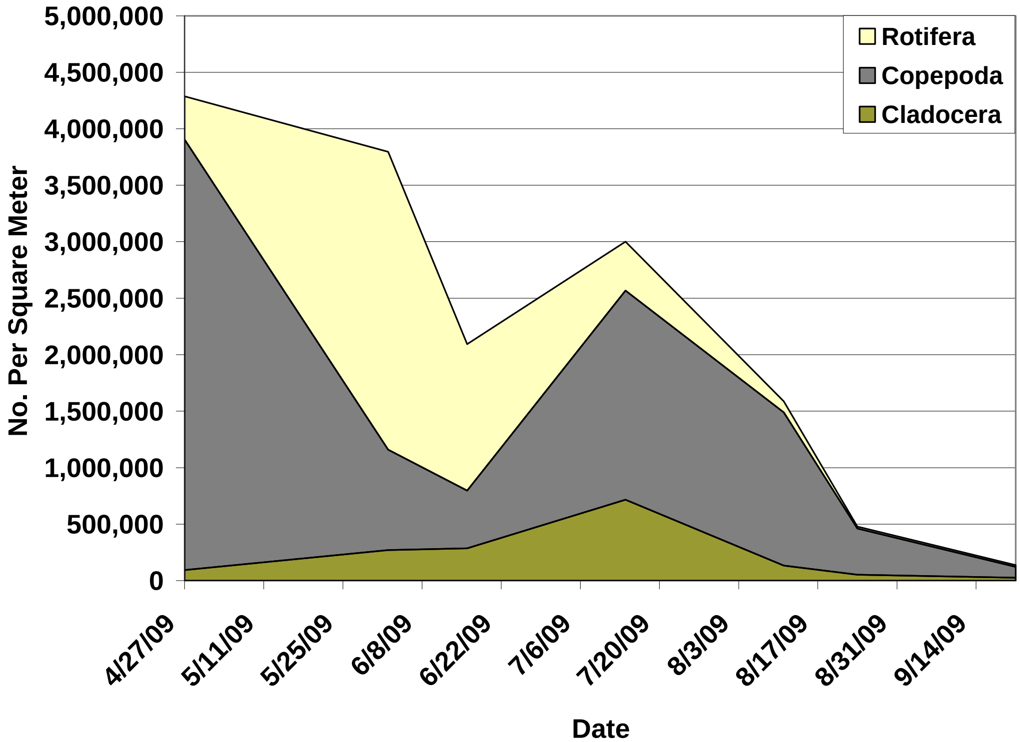

Figure 12 2009 Sweeney Lake (North Basin) Zooplankton Data Summary by Division

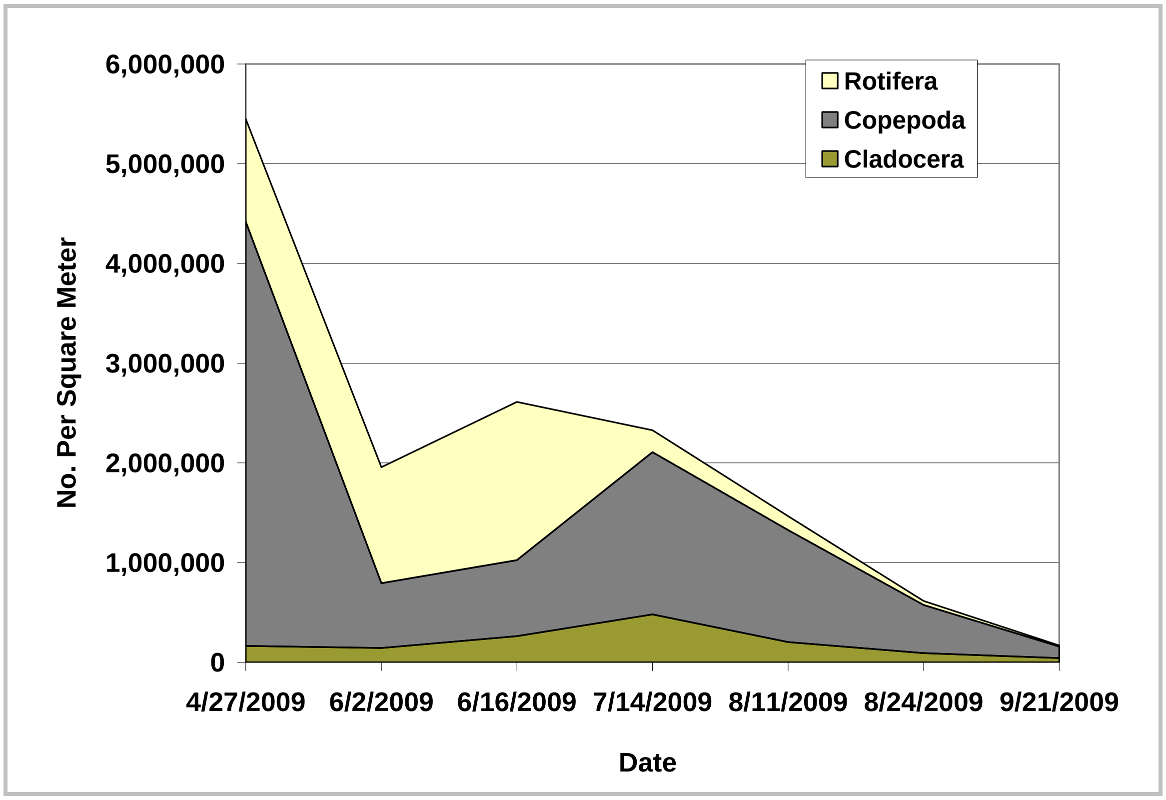

Figure 13 2009 Sweeney Lake (South Basin) Zooplankton Data Summary by Division

A comparison of 2005, 2008, and 2009 zooplankton in the North and South Basins indicate zooplankton numbers increased between 2005 and 2008 as well as between 2008 and 2009 (Figures 14 and 15).

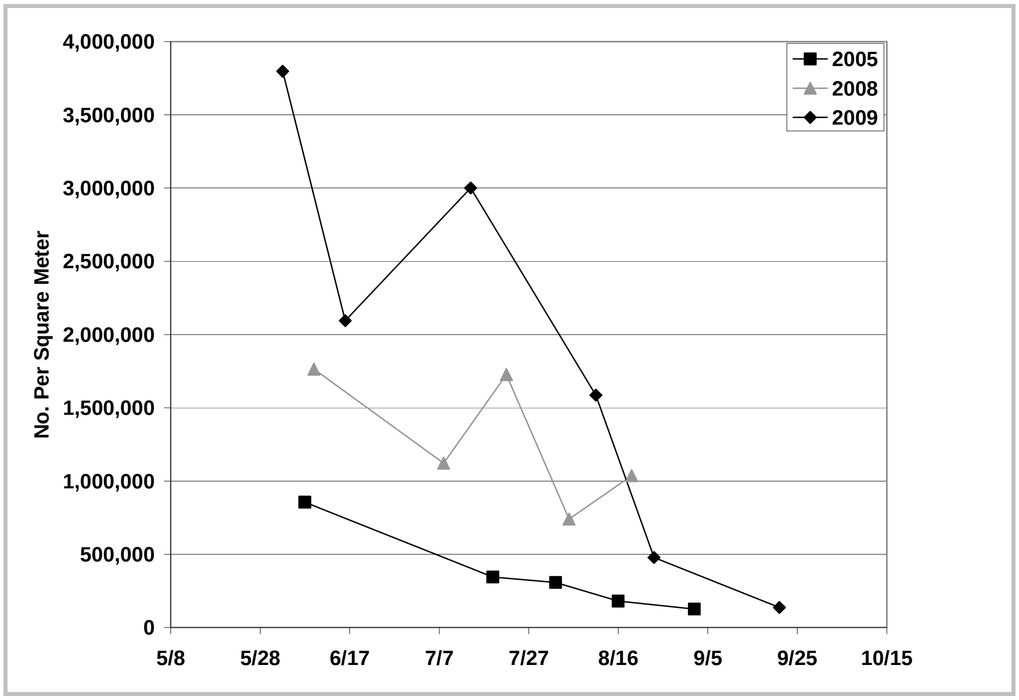

Figure 14 Comparison of 2005, 2008, and 2009 Zooplankton in Sweeney Lake (North Basin)

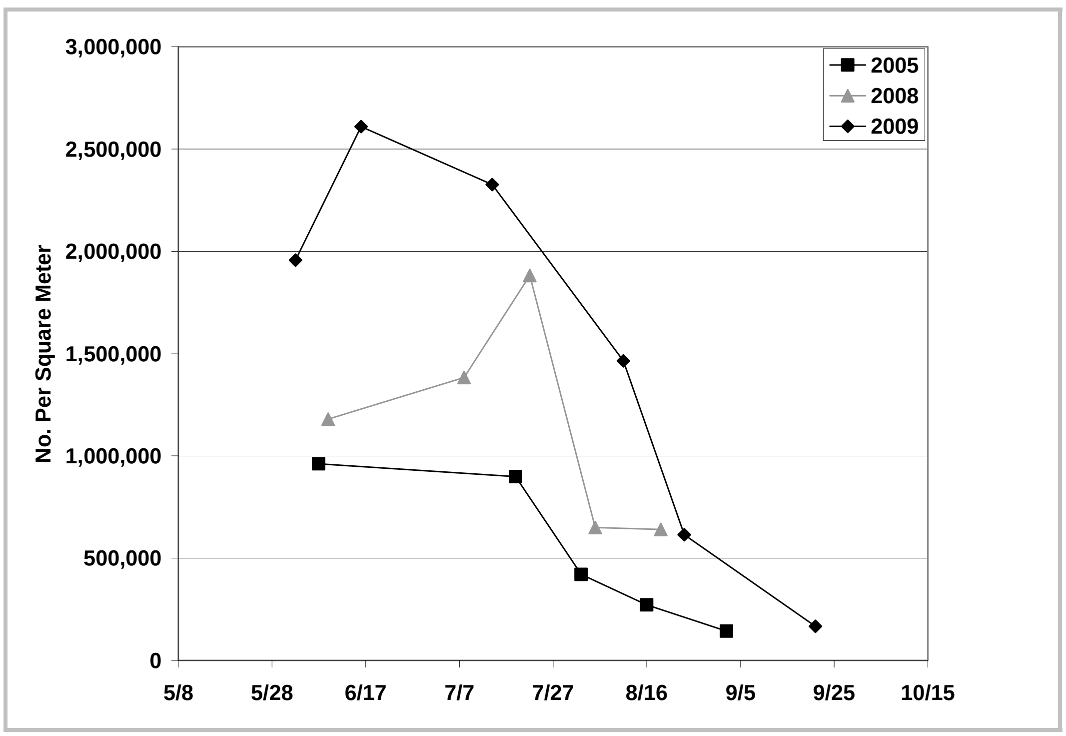

Figure 15 Comparison of 2005, 2008, and 2009 Zooplankton in Sweeney Lake (South Basin)

3.8 Conclusions

- The overall water quality status of Sweeney Lake was eutrophic (nutrient rich and poor quality), although the summer average phosphorus concentration was hypereutrophic (very nutrient rich, very poor water quality).

- 2009 phytoplankton numbers were slightly higher than 2005 numbers and approximately double the 2008 phytoplankton numbers.

- Zooplankton numbers increased between 2005 and 2008 as well as between 2008 and 2009.

- Sweeney Lake water quality has degraded when compared to 2005, 2007, and 2008, as evidenced by increased chlorophyll *a* and total phosphorus concentrations and decreased Secchi depth.

- Sweeney Lake did not meet the BCWMC Level I water quality goal for total phosphorus (average summer concentration not to exceed 30 µg/L), chlorophyll *a* (average summer concentration not to exceed 10 µg/L), and Secchi disc transparency (average summer depth of at least 2.2 meters). In 2009, average summer total phosphorus and chlorophyll concentrations were 86 and 25 µg/L, respectively, while summer average Secchi disc transparency was 1.2 meters.

- Sweeney Lake did not meet State water quality standards for total phosphorus (maximum of 40 µg/L), chlorophyll *a* (maximum of 14 µg/L), and Secchi disc (maximum of 1.4 meters).

- The cause of the lake's water quality degradation in 2009 appears to be internal loading rather than watershed loading. Phosphorus released from sediment in 2009 was continuously mixed into the lake's surface waters during the growing season while phosphorus released from sediment in 2008 was trapped in the lake's bottom waters until the fall mixing event.

3.9 Recommendations

Recommendations include:

- Continue implementation of management strategies in BCWMC Watershed Management Plan (2004)
- Evaluate management strategies recommended in TMDL, and
- Begin implementation of BMPs recommended in TMDL.

4.0 Twin Lake

4.1 Site Description

Twin Lake (Golden Valley, Hennepin County) has a water surface area of approximately 21 acres (8.5 hectares), a maximum depth of 54.5 feet (16.6 meters), and a mean depth of 25.7 feet (7.8 meters). The lake has a small watershed and during periods of high water it connects to Sweeney Lake via a meandering channel that runs through a wetland. The northern half of the lake is surrounded by the wooded Hidden Lakes residential development. The southern half of the lake is surrounded by Minneapolis Park and Recreation Board property and consists of wooded brush areas including a marsh at the southern end of the lake. The lake is used for all recreational activities, including swimming.

4.2 Goal

The BCWMC's goal for Twin Lake is a management classification of Level I, meaning its water quality should support all water-based recreational activities including swimming, scuba diving, and snorkeling. Level I goals are (1) average summer total phosphorus concentration not to exceed 30 µg/L, (2) average summer chlorophyll *a* concentration not to exceed 10 µg/L, and (3) average summer Secchi disc transparency of at least 2.2 meters (about 7 feet) (*Bassett Creek Watershed Management Plan* 2004).

4.3 State Standards

The federal Clean Water Act (CWA) requires states to adopt water-quality standards to protect waters from pollution. These standards define how much of a pollutant can be in the water and still allow it to meet designated uses, such as drinking water, fishing and swimming. The standards are set for a wide range of pollutants, including bacteria, nutrients, turbidity and mercury. A water body is "impaired" if it fails to meet one or more water quality standards. The state water quality standards applicable to Twin Lake are (1) maximum total phosphorus concentration of 40 µg/L, (2) maximum chlorophyll *a* concentration of 14 µg/L, and (3) minimum Secchi disc transparency of 1.4 meters (Minn. R. Ch. 7050.0222 Subp. 3).

4.4 BCWMC Watershed Management Plan and Twin Lake Watershed and Lake Management Plan

The *BCWMC Watershed Management Plan* (2004) incorporated the study results of the *Twin Lake Watershed and Lake Management Plan* (2000). Because Twin Lake had previously met Level I water quality goals and watershed modeling indicated only modest improvements could be made with structural BMPs, emphasis for management was placed on using general watershed BMPs. One site-specific structural best management practice was recommended: the expansion of a pond in a low area on the south of the railroad. The pond expansion would provide additional storage for water quality treatment. The BCWMC authorized Golden Valley to construct the pond, but the City has been unable to obtain the required right of way from the property owner.

4.5 Water Quality Data

Twin Lake was sampled at the deepest point eight times during the 2009 growing season. Water quality data collected for Twin Lake are summarized in Appendix B, and include:

- Vertical profiles of temperature, dissolved oxygen concentration, specific conductivity, and pH
- 0-2 m composite samples analyzed for chlorophyll *a*, total phosphorus, soluble reactive phosphorus, and total nitrogen
- Total phosphorus at mid depth and near bottom
- Secchi disc transparency

4.5.1 Temperature

Vertical profiles of temperature collected during 2009 show that the lake was strongly stratified throughout the 2009 growing season (Appendix B).

4.5.2 Dissolved Oxygen

Vertical profiles of dissolved oxygen collected during 2009 show that lake stratification impacted the lake’s oxygen concentrations. Waters above the lake’s thermocline (warmer surface waters) were well oxygenated throughout the growing season. Waters below the lake’s thermocline (cooler bottom waters) contained low oxygen concentrations. Dissolved oxygen concentrations were generally less than 2 mg/L at depths greater than 6 meters throughout the growing season (Appendix B). Panfish and gamefish species within the lake require dissolved oxygen concentrations of 5 mg/L or greater. Therefore they would have been unable to live in the lake's deeper waters for most of the growing season. High total phosphorus concentrations near the sediment surface were also detected during this period indicating internal loading of phosphorus due to oxygen depletion. The cause of the oxygen depletion below the thermocline is due to microbial degradation of organic material from settled algal material and stormwater inputs.

Oxygen depletion during February was more severe than during the summer. During February, the lake's maximum oxygen concentration at the surface was 2.1 mg/L and concentrations from 2 meters to the bottom were less than 1 mg/L. During July and August, surface water concentrations of oxygen ranged from 7.8 to 11.4 mg/L and concentrations were less than 1 mg/L beginning at 4 to 6 meters. The data indicate wind mixing during the ice-free months replenishes the lake's surface water oxygen supply and prevents the severe depletion observed under the ice during the winter period.

4.5.3 Total Phosphorus, Chlorophyll *a,* and Secchi Depth

Surface total phosphorus concentrations are graphically summarized in Figure 16. Twin Lake exhibited poor water quality in 2009. The 2009 Twin Lake surface total phosphorus concentration ranged from a high of 229 µg/L (April) to a low of 38 µg/L (September) and averaged 69 µg/L during the summer.

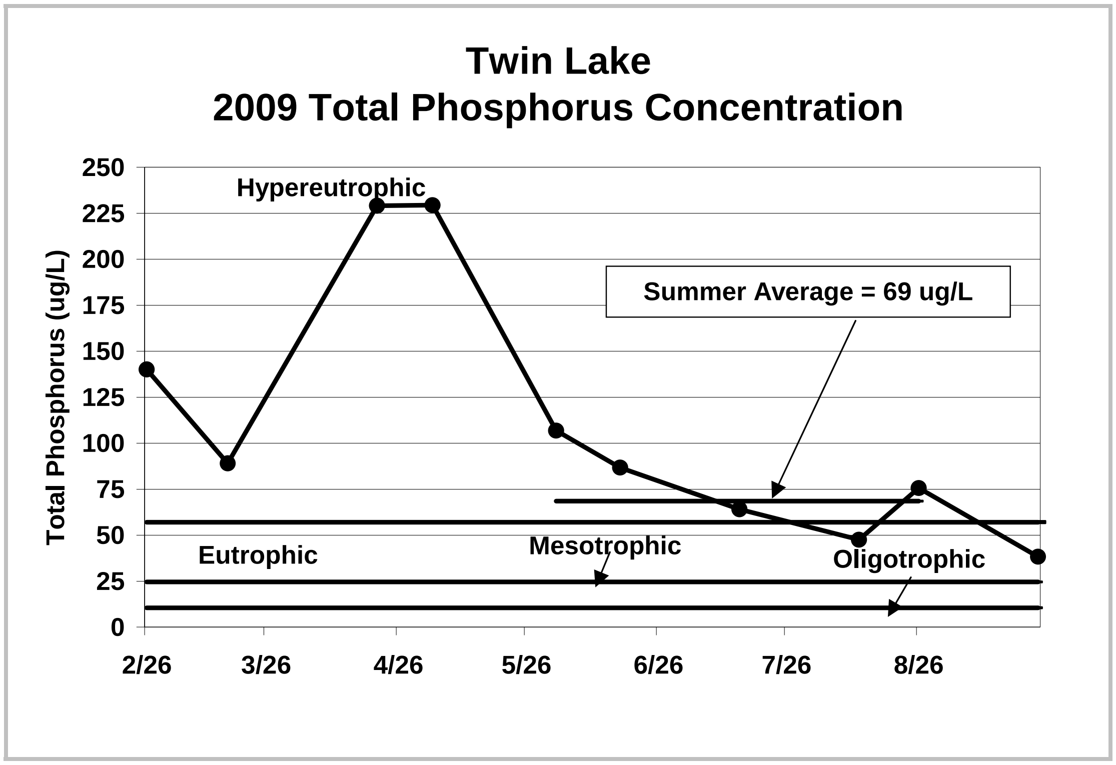

Figure 16 2009 Twin Lake Total Phosphorus Concentration

An extremely high total phosphorus concentration (229 µg/L) following ice-out and lake mixing in spring destined Twin Lake for poor water quality throughout the growing season despite steady declines in phosphorus. Phosphorus concentrations declined more than five-fold from April through September:

- 229 µg/L in April and May
- 87 to 107 µg/L during June,
- 64 µg/L during July,
- 48 to 76 µg/L during August, and
- 38 µg/L during September.

Despite the five-fold decline in phosphorus during the growing season, the average summer concentration of 69 µg/L was more than double the BCWMC's goal for the lake (maximum of 30 µg/L) and substantially greater than the state water quality standard (maximum of 40 µg/L).

Surface total phosphorus concentrations in 2009 were higher than concentrations observed in 2000, 2005, and 2008 (Figure 17). Concentrations in 2000 and 2005 were similar and indicated good water quality. It appears that internal loading from bottom sediments caused poor water quality in 2008 and even poorer water quality in 2009.

Maximum total phosphorus concentration in the lake's bottom waters during 2009 (1,358 µg/L) was nearly double the 2008 (713µg/L) maximum (Figure 18). Low oxygen concentrations near the lake's sediment created optimum conditions for sediment phosphorus release during the summer of 2008 as well as the winter and summer of 2009. Stratification caused a phosphorus buildup in the lake's bottom waters during the summer of 2008 and winter and summer of 2009. The fall 2009 and spring 2010 mixing events homogenized the lake's phosphorus concentrations, increasing the lake's surface water concentrations and decreasing the lake's bottom water concentrations. However, phosphorus buildup occurred following each mixing event.

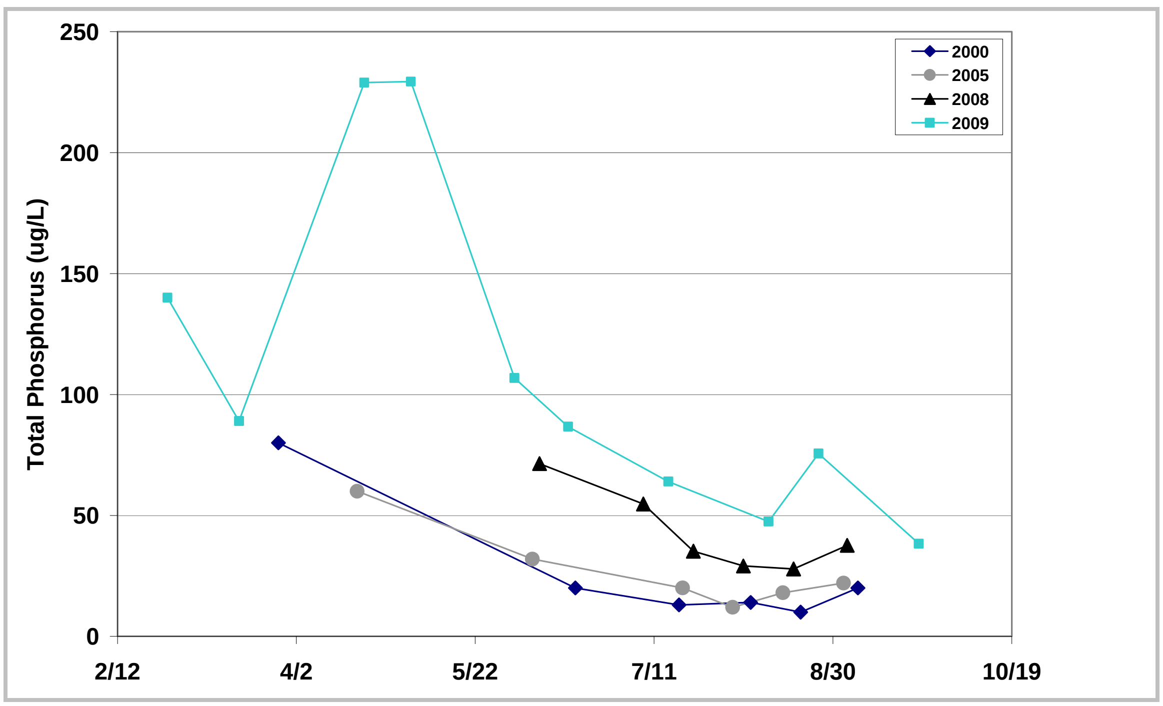

Figure 17 Comparison of 2000, 2005, 2008, and 2009 Twin Lake Surface Total Phosphorus Concentrations

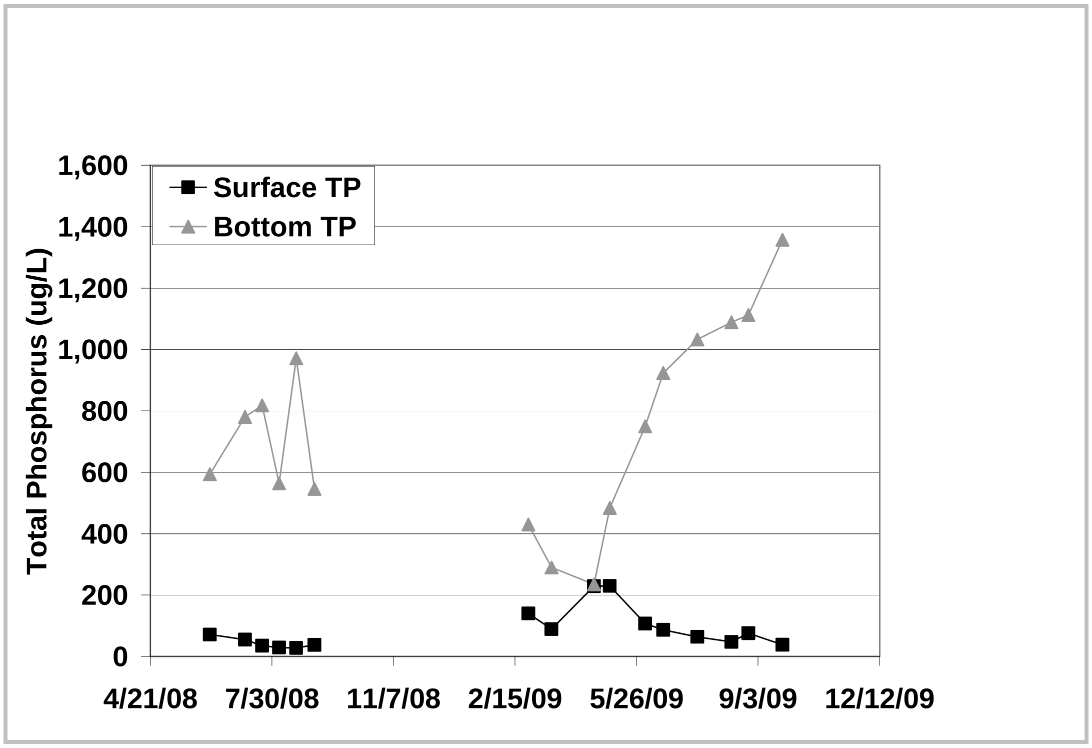

Figure 18   Twin Lake 2009 Surface and Bottom Total Phosphorus Concentration

As shown in Figure 6, the cumulative total precipitation for 2008 and 2009 were nearly the same during January through July; much lower precipitation occurred in 2009 beginning in August. The data suggest that watershed runoff in 2008 and 2009 was relatively similar through July and lower during August. Hence, the cause of the lake's water quality degradation in 2009 appears to be internal loading rather than watershed loading.

In 2009, Twin Lake chlorophyll *a* concentrations ranged from a high of 88 µg/L in April to a low of 13 µg/L in mid-June (Figure 19). The 2009 average summer concentration (22 µg/L) is more than triple the 2008 average summer concentration (7 µg/L). The 2008 and 2009 summer average chlorophyll *a* concentrations are the highest and second highest summer average concentration of chlorophyll *a* yet recorded in Twin Lake.

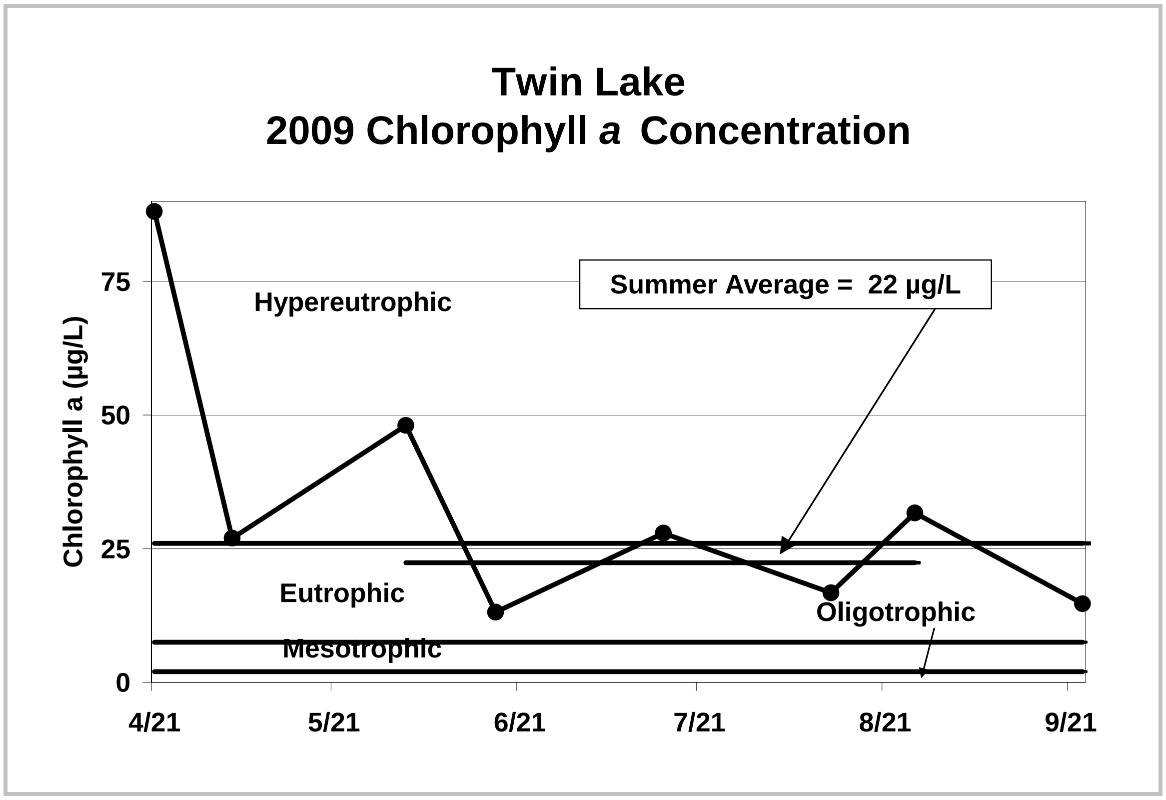

Figure 19 2009 Twin Lake Chlorophyll *a* Concentration

In 2008, Twin Lake Secchi disc transparency ranged from a high of 2.1 meters in June to a low of 0.7 meters in August (Figure20). The lake's 2009 average summer Secchi disc transparency was 1.2 meters, which is 40 percent lower than the 2008 summer average (2.0 meters) and the lowest summer average yet recorded in Twin Lake.

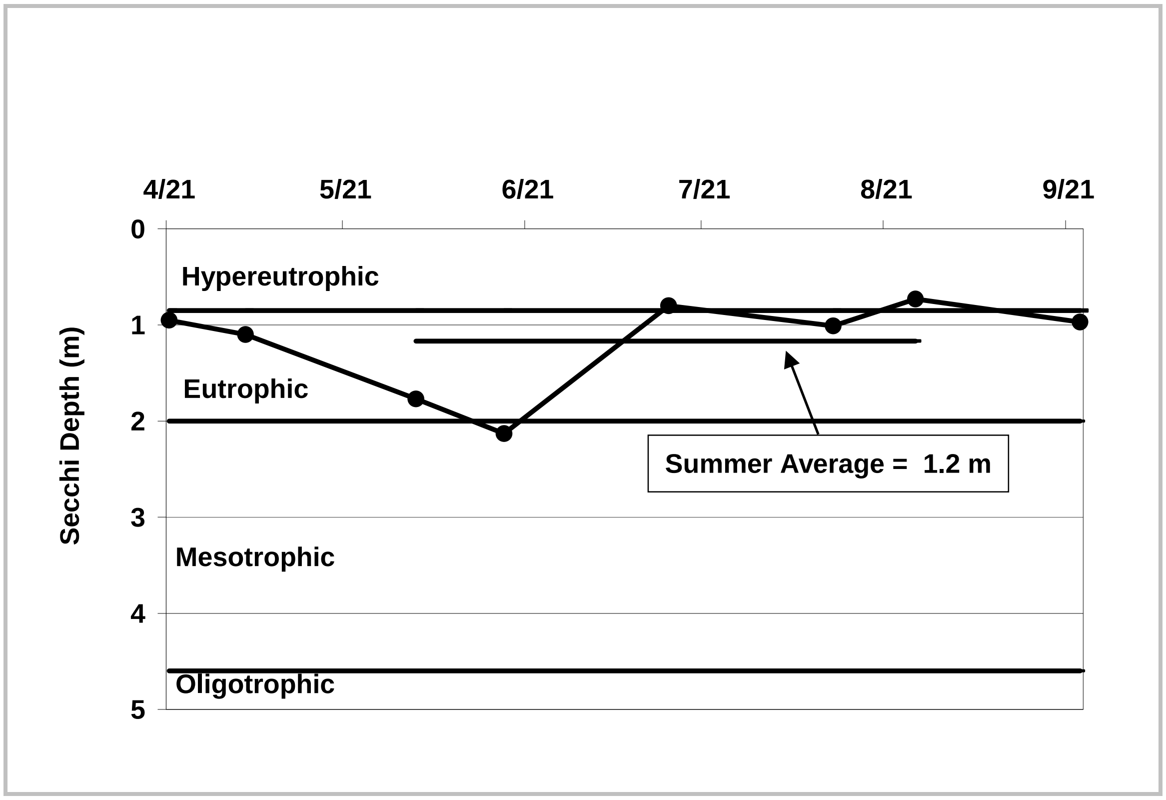

Figure 20 2009 Twin Lake Secchi Depth

The summer average total phosphorus concentration indicates that Twin Lake is in the hypereutrophic category, while the summer average chlorophyll *a* concentration and Secchi disc transparency are within the upper limits of the eutrophic classification.

In 2009, Twin Lake did not meet the BCWMC Level I water quality goal for total phosphorus (average summer concentration not to exceed 30 µg/L), chlorophyll *a* (average summer concentration not to exceed 10 µg/L); or Secchi disc transparency (average summer depth of at least 2.2 meters). The lake's average summer total phosphorus and chlorophyll *a* concentrations were 69 µg/L and 22 µg/L, respectively, and summer average Secchi disc transparency was 1.2 meters.

In 2009, Twin Lake did not meet the state standards for water quality. The lake's average summer total phosphorus concentration (69 µg/L) exceeded the state maximum of 40 µg/L; the lake's average summer chlorophyll *a* concentration (22 µg/L) exceeded the state maximum of 14 µg/L; and the lake's summer average Secchi disc transparency (1.2 meters) was less than the state minimum of 1.4 meters.

4.6 Historical Trends

Historical data indicate an improvement in water quality between 1982 and 1992 after which it remained relatively constant from 1992 to 2005. However all three nutrient-related parameters indicate that water quality decreased between 2005 and 2008 and decreased again between 2008 and 2009. The lake is currently at the poorest water quality observed since monitoring began (Figure 21).

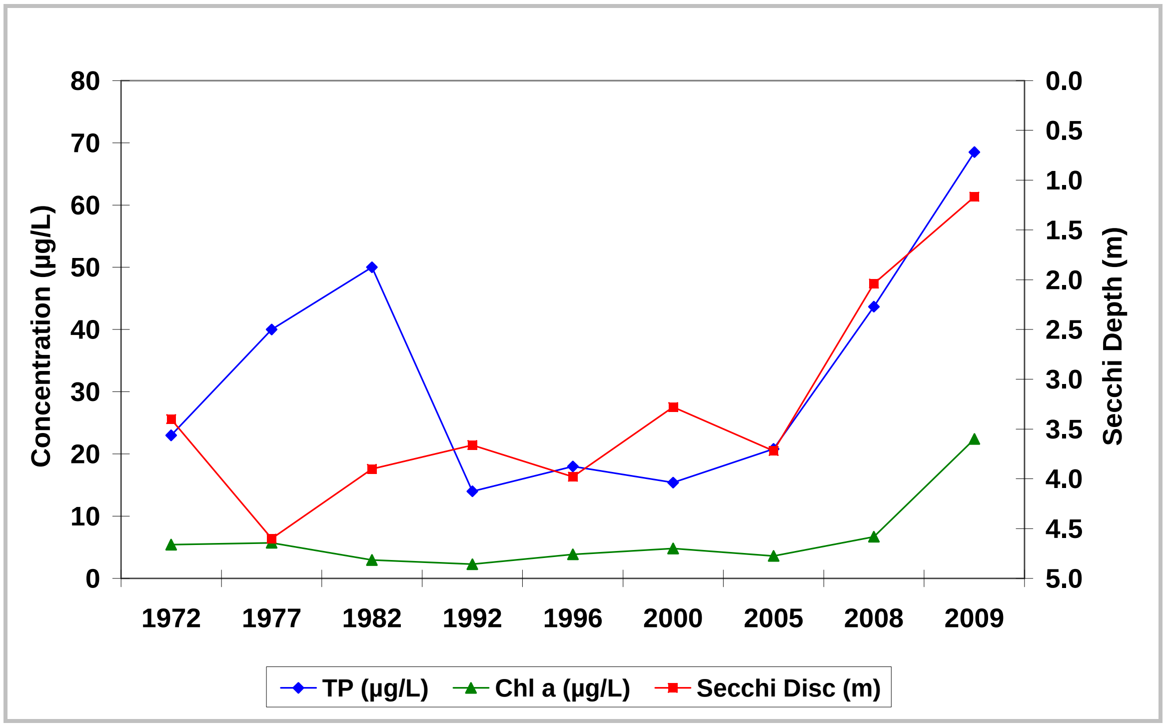

Figure 21 Historical Water Quality Data in Twin Lake

4.7 Biota

Two components of lake biota are presented herein: phytoplankton and zooplankton. Fisheries status is managed by the Department of Natural Resources and is not covered in this report.

4.7.1 Phytoplankton

Phytoplankton, also called algae, are single-celled aquatic plants naturally present in lakes. They derive energy from sunlight (through photosynthesis) and from dissolved nutrients found in lake water. They provide food for several types of animals, including zooplankton, which are eaten by fish. A phytoplankton population in balance with the lake's zooplankton is ideal for fish production. An inadequate phytoplankton population reduces the lake's zooplankton population and adversely impacts the lake's fishery. Excess phytoplankton, however, reduce the lake's water clarity.

The lake's diverse algal community was comprised of six major algal groups:

- Chlorophyta or green algae,
- Cyanophyta or blue-green algae,
- Bacillariophyta or diatoms,
- Pyrrophyta or dinoflagellates,
- Chrysophyta or yellow-brown algae, and
- Cryptophyta or cryptomonads.

Cryptomonads dominated the spring community while blue green algae were predominant during the late summer. The number of phytoplankton increased by nearly an order of magnitude from mid-June to mid-July and then tripled from mid July to late August (Figure22). Late summer phytoplankton included the blue-green toxin producing species *Cylindrospermopsis raciborski*, comprising 25 percent of the community on August 12 and more than half of the community on August 26. This species was previously observed on only one occasion (September 6, 2000) and then at a very low density (105 per milliliter). Large numbers of this species are indicative of degraded water quality.

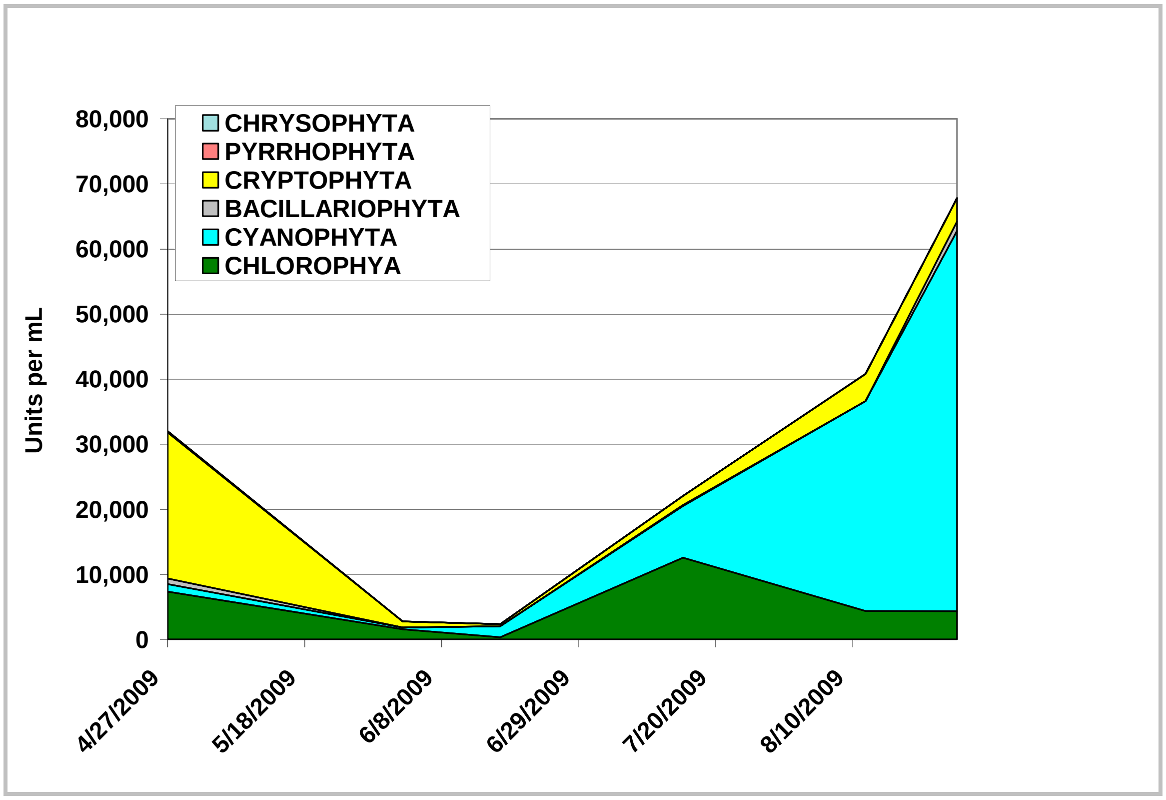

Figure 22   2009 Twin Lake Phytoplankton Data Summary by Division

Substantially higher numbers of phytoplankton were observed during the late summer of 2009 (67,381) as compared with 2000 (1,171), 2005 (5,024), and 2008 (19,184) (Figure 23). The data substantiate the water quality degradation indicated by increases in phosphorus and chlorophyll *a* concentrations and reduced Secchi disc transparency.

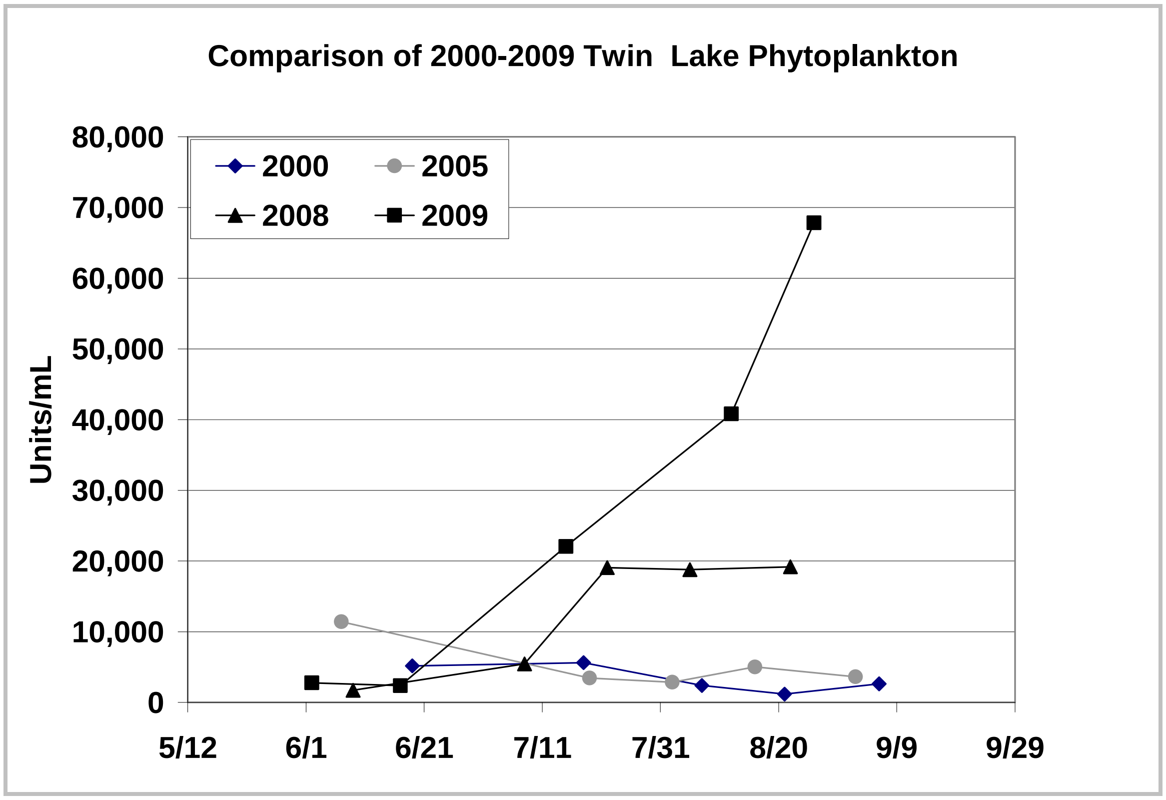

Figure 23 Comparison of 2000, 2005, 2008, and 2009 Twin Lake Phytoplankton

4.7.2 Zooplankton

Zooplankton are microscopic animals that feed on particulate matter, including algae, and are, in turn eaten by fish. Healthy zooplankton communities are characterized by balanced densities (number per meter squared) of the three major groups of zooplankton:

- Cladocera,
- Copepods, and
- Rotifers.

Fish predation, however, may alter community structure and reduce the numbers of larger bodied zooplankters (i.e., larger bodied Cladocera).

All three groups of zooplankton were represented in Twin Lake during 2009 (Figure 24). Large numbers of *Daphnia*, a large-bodied zooplankton, were observed during June (Figure

25). Grazing by large-bodied cladocerans reduces the numbers of algae in the water and improves water transparency. An order of magnitude decline in *Daphnia* from mid-June to mid-July corresponded with an order of magnitude increase in phytoplankton numbers, despite a 26 percent decline in surface water total phosphorus concentration during this period (Figure 25). The data indicate grazing by *Daphnia* improved the lake's water quality in June. Fish predation is the most likely cause of *Daphnia* reductions in July that corresponded with increased numbers of phytoplankton.

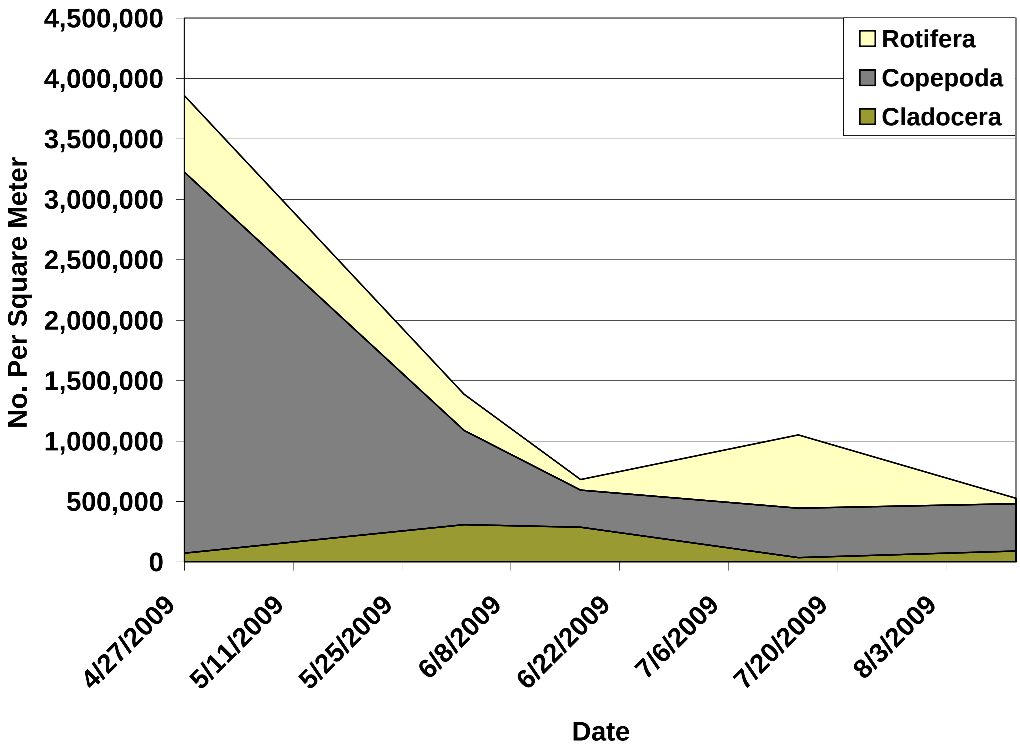

Figure 24 2009 Twin Lake Zooplankton Data Summary by Division

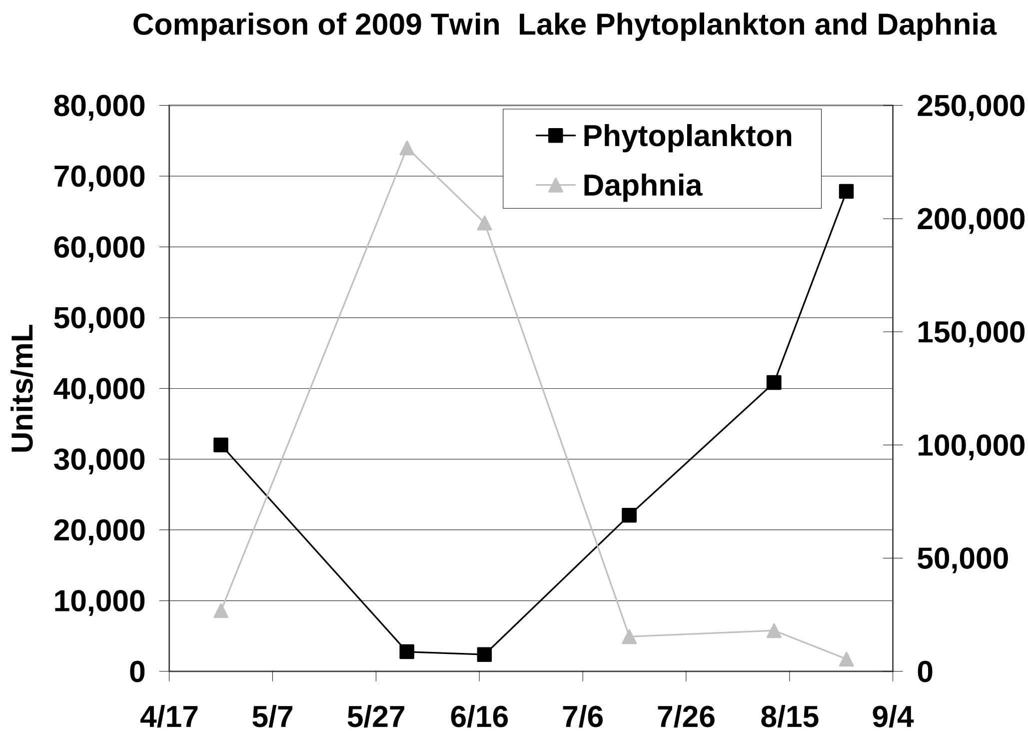

Figure 25 Comparison of 2009 Twin Lake Phytoplankton and *Daphnia*

A similar pattern of *Daphnia* decline and a corresponding increase in phytoplankton numbers occurred during the June through July period of 2008 (Figure 26). The reduced control by zooplankton during this period corresponded with a tripling of the number of phytoplankton in the lake despite declining phosphorus concentrations. Chlorophyll *a* concentrations also increased and Secchi disc transparency decreased during this period.

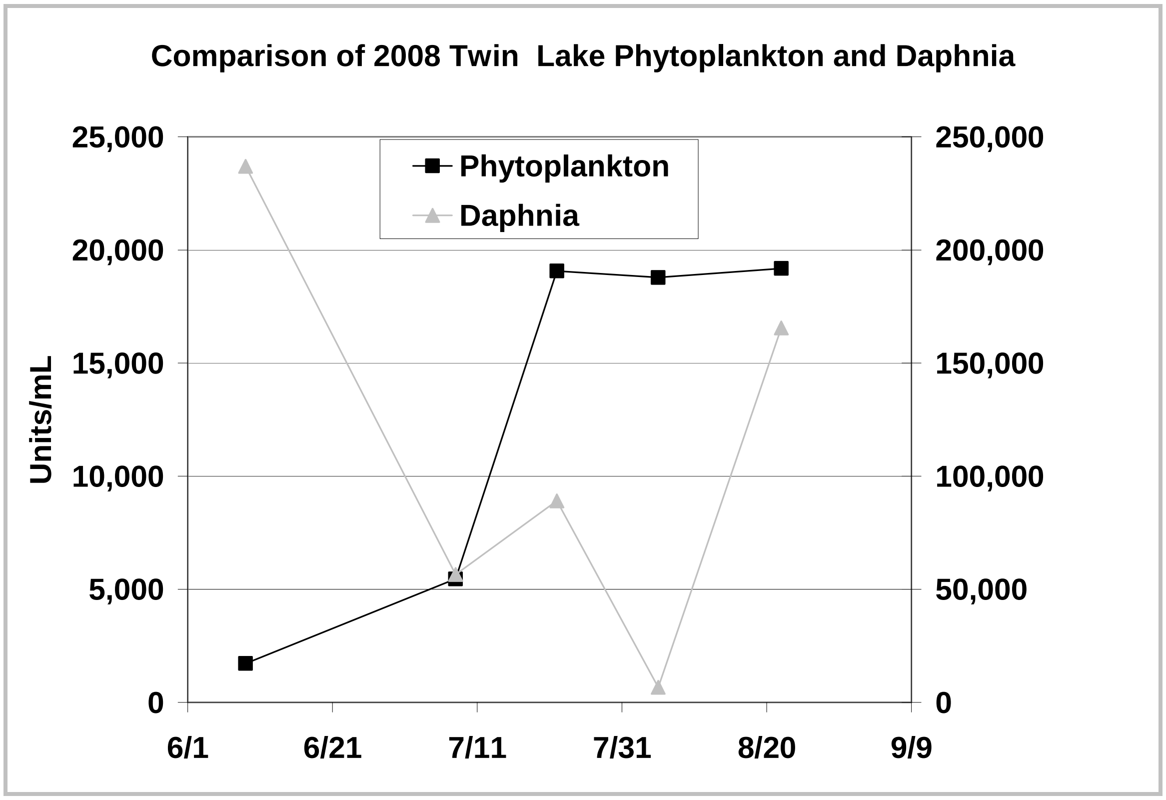

Figure 26 Comparison of 2008 Twin Lake Phytoplankton and *Daphnia*

Although increased lake fertility resulted in increased zooplankton during the early summer of 2008 and 2009 as compared with 2000 and 2005, fish predation reduced late summer zooplankton numbers to similar levels during the four years of measurement. A comparison of 2000 through 2009 zooplankton indicates higher numbers of zooplankton were generally found in June and July of 2008 and 2009 than were observed during June and July of 2000 and 2005 (Figure 27). However, declines in zooplankton during June and July of 2008 and 2009, resulted in similar numbers of zooplankton during August as were observed during August of 2000 and 2005 (Figure 27).

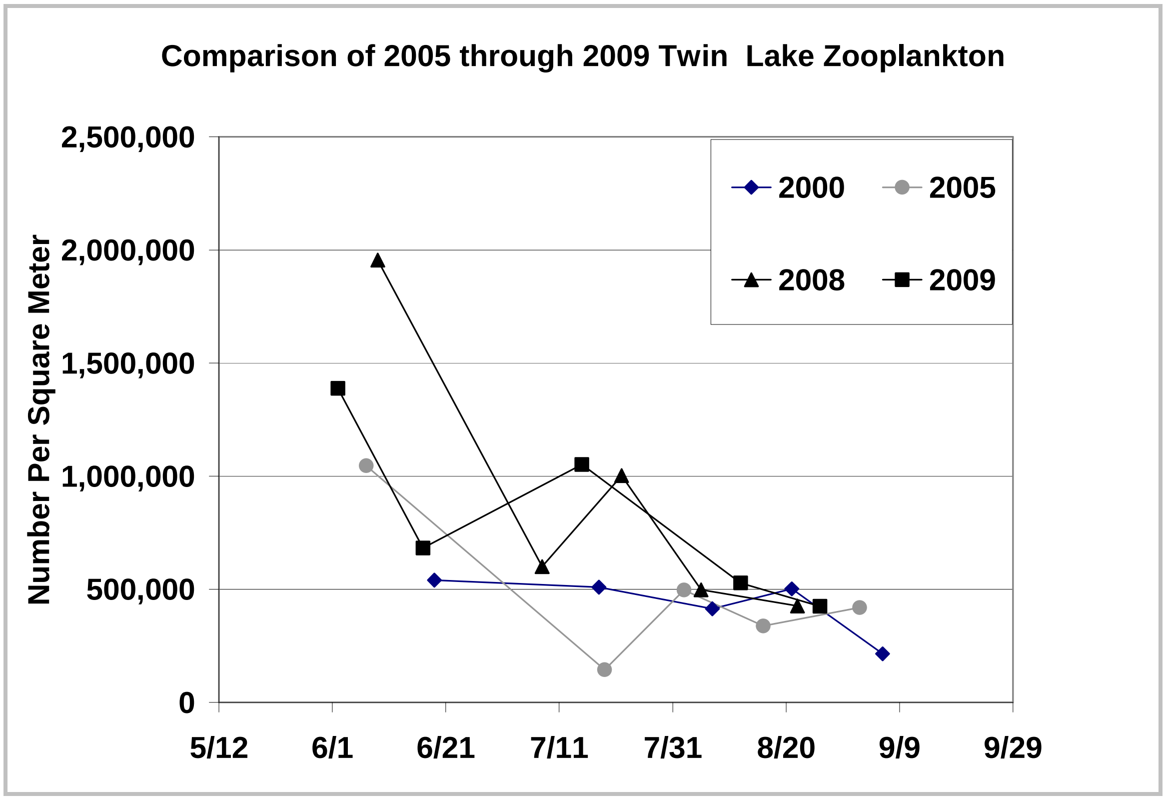

Figure 27 Comparison of 2000, 2005, 2008, and 2009 Twin Lake Zooplankton

4.8 Conclusions

- The summer average total phosphorus concentration indicates that Twin Lake is currently in the hypereutrophic category, while the summer average chlorophyll *a* concentration and Secchi disc transparency are within the eutrophic classification.

- In 2009, Twin Lake did not meet the BCWMC Level I water quality goal for total phosphorus (average summer concentration not to exceed 30 µg/L), chlorophyll *a* (average summer concentration not to exceed 10 µg/L), or Secchi disc transparency (average summer depth of at least 2.2 meters). The lake's average summer total phosphorus and chlorophyll *a* concentrations were 69 µg/L and 22 µg/L, respectively, and summer average Secchi disc transparency was 1.2 meters.

- In 2009, Twin Lake did not meet the state standards for water quality. The lake's average summer total phosphorus concentration (69 µg/L) exceeded the state maximum of 40 µg/L; the lake's average summer chlorophyll *a* concentration (22 µg/L) exceeded the state maximum of 14 µg/L; and the lake's summer average Secchi disc transparency (1.2 meters) was less than the state minimum of 1.4 meters.

- Historical data indicate an improvement in water quality between 1982 and 1992 after which it remained relatively constant from 1992 to 2005. However all three nutrient-related parameters indicate that water quality decreased between 2005 and 2008 and decreased again between 2008 and 2009. The lake is currently at the poorest water quality observed since monitoring began.

- 2009 noted substantially higher numbers of phytoplankton during the late summer as compared with 2000, 2005, and 2008.

- Substantial declines in large-bodied zooplankters occurred from early June to early July of both 2008 and 2009. The reduced control by zooplankton during this period corresponded with substantial increases in the number of phytoplankton in the lake despite declining phosphorus concentrations.

- Although increased lake fertility resulted in increased zooplankton during the early summer of 2008 and 2009 as compared with 2000 and 2005, fish predation reduced late summer zooplankton numbers to similar levels during the four years of measurement.

- The cause of the lake's water quality degradation in 2009 appears to be internal loading rather than watershed loading.

4.9 Recommendations

It is recommended that the Commissioners consider collecting sediment samples during 2010 to determine if internal loading is causing the recent decline in the water quality of Twin Lake. It is also recommended that the Commissioners consider collecting additional water quality samples in February and March 2010, before ice-out.

5.0 Northwood Lake

5.1 Site Description

Northwood Lake is located along the North Branch of Bassett Creek, south of Rockford Road and immediately east of Highway 169 in the city of New Hope (Figure 1). It has a water surface area of 15 acres (6.1 hectares), a maximum depth of 5 feet (1.5 meters), and a mean depth of 2.7 feet (0.8 meters). Because of the shallow nature of the lake, the entire area is considered to be littoral (shallow). The Northwood Lake watershed area is approximately 1,341 acres (543 hectares), excluding the Northwood Lake water surface area. The watershed lies within the Cities of Plymouth and New Hope, the latter being fully developed. The lake formerly consisted of the North Branch of Bassett Creek and surrounding wetland area. During the early 1960s the basin was dredged and the water leveled raised creating Northwood Lake.

Northwood Lake has been designated by the DNR as a Type V wetland (DNR designation #627P). Type V wetlands typically have a water depth of less than 10 feet, may contain submergent vegetation species and may be fringed by emergent vegetation. The Northwood Lake shoreline is developed with single family homes, except for a short stretch that abuts Highway 169 and a section within Northwood Park on the northeastern shore. Most of the residential lawns extend to the water’s edge and approximately 15 to 30 percent of lakeshore property owners have installed riprap. The Northwood Lake outlet consists of a two-stage weir and a 48-inch reinforced concrete pipe that discharges from the southeast side of the lake under Boone Avenue.

Most of the lakeshore residents use Northwood Lake for aesthetics and wildlife viewing, however, the lake is also used for fishing and boating. Geese and duck populations have summered on Northwood Lake in the past and appear to graze heavily on Northwood Park lawns.

5.2 Goal

The BCWMC’s goal for Northwood Lake is a management classification of Level III, meaning its water quality should support aesthetic viewing. Level III goals are (1) average summer total phosphorus concentration not to exceed 75 µg/L, (2) average summer chlorophyll *a* concentration not to exceed 40 µg/L, and average summer Secchi disc transparency of at least 1.0 meters (about 3 feet) (*Bassett Creek Watershed Management Plan*, 2004).

5.3 State Standards

The federal Clean Water Act (CWA) requires states to adopt water-quality standards to protect waters from pollution. These standards define how much of a pollutant can be in the water and still allow it to meet designated uses, such as drinking water, fishing and swimming. The standards are set for a wide range of pollutants, including bacteria, nutrients, turbidity and mercury. A water body is "impaired" if it fails to meet one or more water quality standards. The state water quality standards applicable to Northwood Lake are (1) maximum total phosphorus concentration of 60 µg/L, (2) maximum chlorophyll *a* concentration of 20 µg/L, and (3) minimum Secchi disc transparency of 1.0 meters (Minn. R. Ch. 7050.0222 Subp. 4). Because Northwood Lake is a shallow lake, the water quality standards for the lake are less stringent than those for deep lakes (e.g., Sweeney Lake and Twin Lake).

5.4 BCWMC Watershed Management Plan and Northwood Lake Watershed and Lake Management Plan

The *BCWMC Watershed Management Plan* (2004) incorporated the study results of the *Northwood Lake Watershed and Lake Management Plan* (1996). The *Northwood Lake Watershed and Lake Management Plan* (1996) divided the watershed of the lake into four drainage districts to help evaluate nutrient loading to the lake and to determine recommendations of appropriate best management practices. Recommendations included (1) construction or improvement of wet detention basins within each drainage district to increase the removal of phosphorus from stormwater, (2) a study of the lake's fishery to estimate phosphorus loading by benthivorous fish, (3) a study of waterfowl which reside in Northwood Lake to calculate the dissolved phosphorus load entering the lake from waterfowl, and (4) monitoring to estimate the internal phosphorus load released from the lake's sediments. The *Northwood Lake Watershed and Lake Management P*lan (1996) indicated water quality goal attainment may not be possible for Northwood Lake.

In 2000, the City of New Hope implemented a new management technique for clearing lake waters to improve the water clarity of Northwood Lake. Barley straw was carefully placed at pre-determined locations throughout the lake. The theory for the barley straw's ability to improve water clarity is as follows. As barley straw decays, it apparently adds a substance to the lake's water, which inhibits algal growth, despite the presence of high concentrations of phosphorus. The use of barley straw during 2000 greatly improved the lake's water transparency and the lake was transparent to its bottom. Sunlight reaching the lake's bottom enabled macrophytes to grow and two species of plants were observed in 2000. It was noted that visual inspection during the 2000 growing season indicated a substantial decline in algal mats when compared to previous years. A similar treatment in Valley Lake, Lakeville had beneficial results in terms of lake water quality. Barley straw treatment of Northwood Lake continued annually during 2000 through 2003 and was discontinued after the 2003 growing season.

5.5 Water Quality Data

Northwood Lake was sampled six times during the 2009 growing season. Water quality data (Appendix C) for Northwood Lake include:

- Vertical profiles of temperature, dissolved oxygen concentration, specific conductivity, and pH
- 0-2 m composite samples analyzed for chlorophyll *a*, total phosphorus, soluble reactive phosphorus, and total nitrogen
- Total phosphorus above and below the thermocline and near bottom
- Secchi disc transparency

5.5.1 Temperature

Vertical profiles of temperature collected during 2009, similar to 2000 and 2005 temperature profiles, show that the lake was well-mixed throughout the growing season. In 1996, the lake differed from other years in that stratification occurred during the summer.

5.5.2 Dissolved Oxygen

Vertical profiles of dissolved oxygen collected during 2009 show that oxygen depletion occurred near the bottom and that oxygen concentrations were less than 2 mg/L from 1 meter to the bottom during late August and September. Dissolved oxygen concentrations were less than 5 mg/L from 1 meter to the bottom during June through September. During July and September, dissolved oxygen concentrations were less than 5 mg/L throughout the lake.

Panfish and gamefish species within the lake require dissolved oxygen concentrations of 5 mg/L.

5.5.3 Total Phosphorus, Chlorophyll *a,* and Secchi Depth

Surface total phosphorus data are graphically summarized in Figure 22. Northwood Lake exhibited poor water quality in 2009. The 2009 Northwood Lake surface total phosphorus concentration ranged from a high of 547 µg/L (September) to a low of 145 µg/L (April) and averaged 317 µg/L during the summer. Total phosphorus concentrations increased from spring through mid-July, declined during August, and again increased in September. All observed 2009 total phosphorus concentrations were within the hypereutrophic (very poor water quality) category.

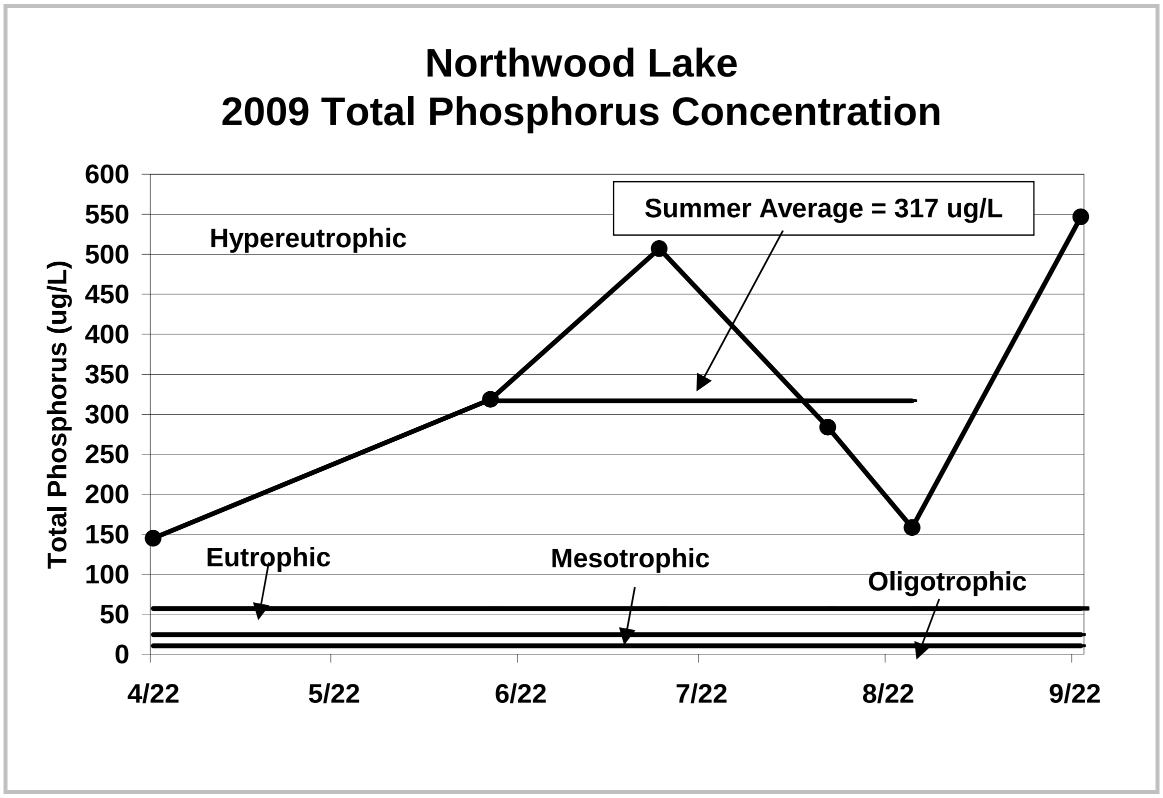

Figure 28 2009 Northwood Lake Total Phosphorus Concentration

Lake total phosphorus concentrations in 2009 were sometimes homogeneous, an indication the lake was well-mixed. However, the low oxygen concentrations near the bottom resulted in sediment phosphorus release and phosphorus buildup during periods when mixing did not occur. Mixing resulted in homogeneous total phosphorus concentrations during April, June, late-August, and September. However, a lack of mixing resulted in phosphorus build-up during July and mid-August, periods when bottom total phosphorus concentrations were higher than surface concentrations (Figure 29). In mid-August, the bottom phosphorus concentration was more than double the surface concentration indicating substantial buildup of phosphorus released from sediments.

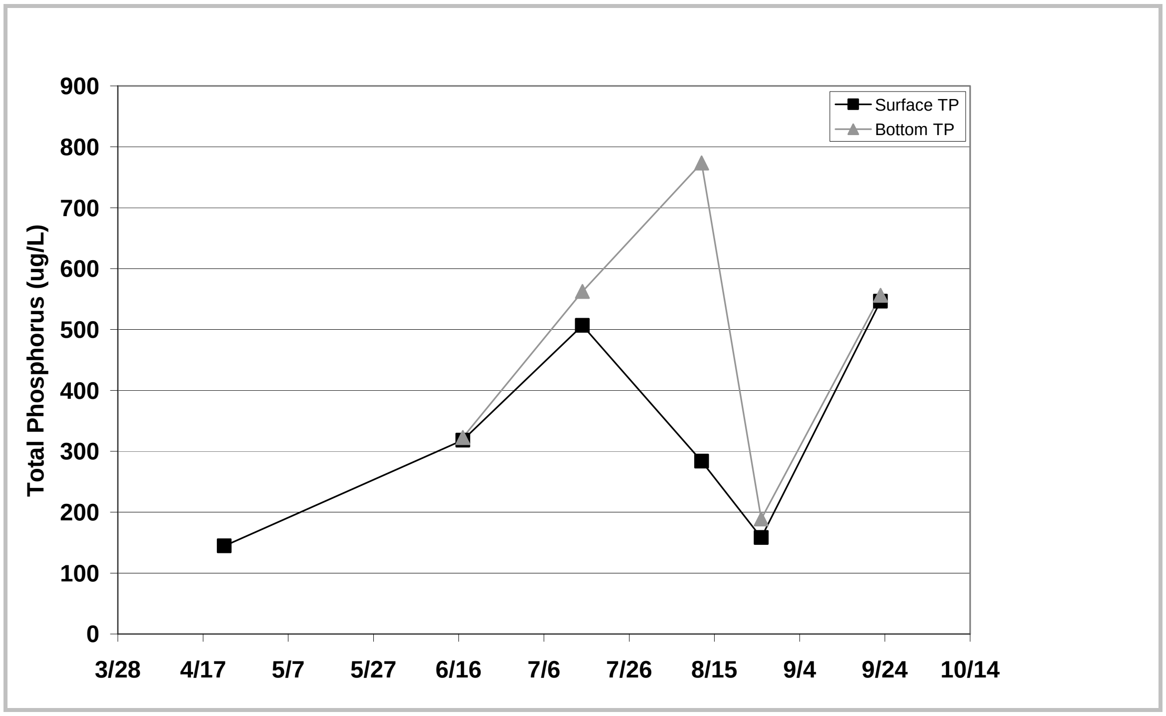

Figure 29 2009 Northwood Lake Surface and Bottom Total Phosphorus Concentration

Surface chlorophyll *a* data are graphically summarized in Figure 24. 2009 surface chlorophyll *a* concentrations ranged from a high of 33 µg/L during late-September to a low of 7 µg/L in mid-August. The average summer concentration was 8 µg/L. Chlorophyll a concentrations declined from spring through mid-August and increased from mid-August through September. Concentrations were in the hypereutrophic (very poor water quality) category in spring, declined to the mesotrophic (good water quality category) in mid-August, and increased to the hypereutrophic category in September. The summer average was within the eutrophic (poor water quality) category, but was only slightly higher than the upper limit for the mesotrophic (good water quality) category. Summer chlorophyll concentrations were much lower than expected since the phosphorus concentrations were consistently in the hypereutrophic category.

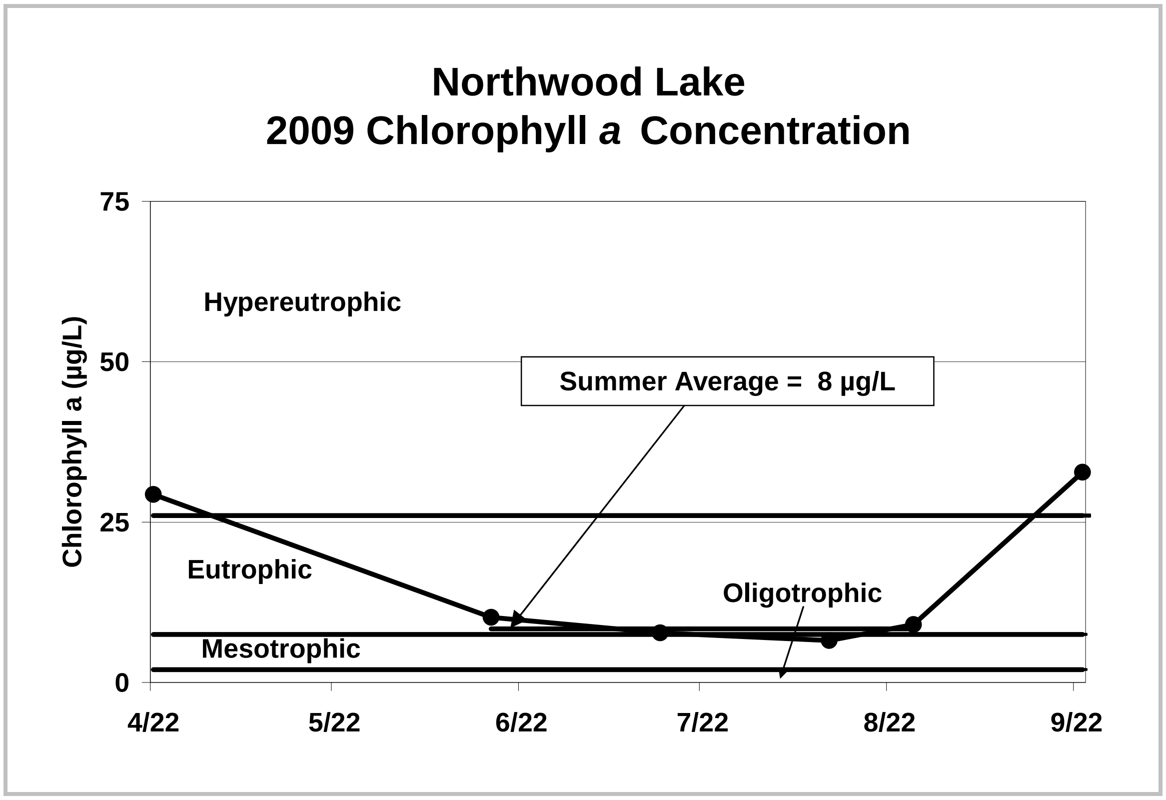

Figure 30 2009 Northwood Lake Chlorophyll *a* Concentration

Secchi disc data are graphically summarized in Figure 25. Secchi disc transparency ranged from a low of 0.7 meters in September to a high of 1.4 meters in June and averaged 1.2 meters during the summer months. Secchi disc transparency improved from April through June, declined slightly during the summer, and declined from late-August through September.

The lake's average summer chlorophyll a concentration (8 µg/L) and Secchi disc transparency (1.2 meters) met BCWMC's goals for chlorophyll (average summer chlorophyll *a* concentration not to exceed 40 µg/L) and Secchi disc (average summer Secchi disc transparency of at least 1.0 meters) in 2009. However, the lake's average summer total phosphorus concentration (317 µg/L) was more than four times greater than BCWMC's goal (average summer concentration not to exceed 75 µg/L).

Similarly, the lake's average summer chlorophyll a concentration (8 µg/L) and Secchi disc transparency (1.2 meters) met the state water quality standards for chlorophyll (average summer chlorophyll *a* concentration not to exceed 20 µg/L) and Secchi disc (average summer Secchi disc transparency of at least 1.0 meters) in 2009. However, the lake's average summer total phosphorus concentration (317 µg/L) was more than five times greater than the state water quality standard for phosphorus (average summer concentration not to exceed 60 µg/L).

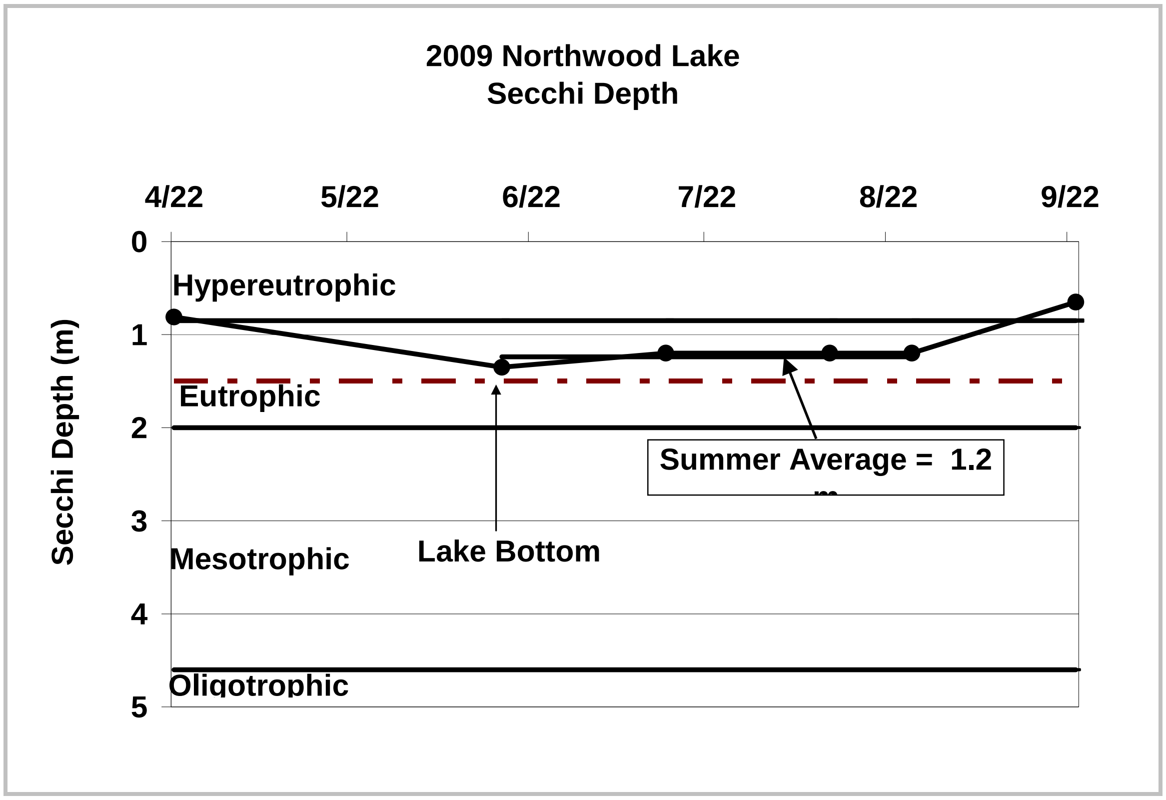

Figure 31 2009 Northwood Lake Secchi Depth

5.6 Historical Trends

Historical water quality trends are shown on Figure 26. Chlorophyll concentrations have consistently declined since 1977 and the 2009 summer average was the lowest concentration observed since chlorophyll monitoring began in 1977. Secchi disc transparency was very poor from 1977 through 1996, improved four-fold in 2000 when the City of New Hope used barley straw to improve the lake's water transparency, and has continued at levels similar to 2000 levels through the present. The 2009 average summer Secchi disc value was the second best (highest) value since monitoring began in 1977. Total phosphorus concentrations increased from 1972 through 1982, declined from 1982 through 2000, and increased from 2000 through 2009. The 2009 total phosphorus concentration was within the range of historical values. Because increasing total phosphorus concentrations coincided with declining chlorophyll concentrations and increasing Secchi disc transparency, it appears that phosphorus is not the variable currently limiting algal growth in Northwood Lake.

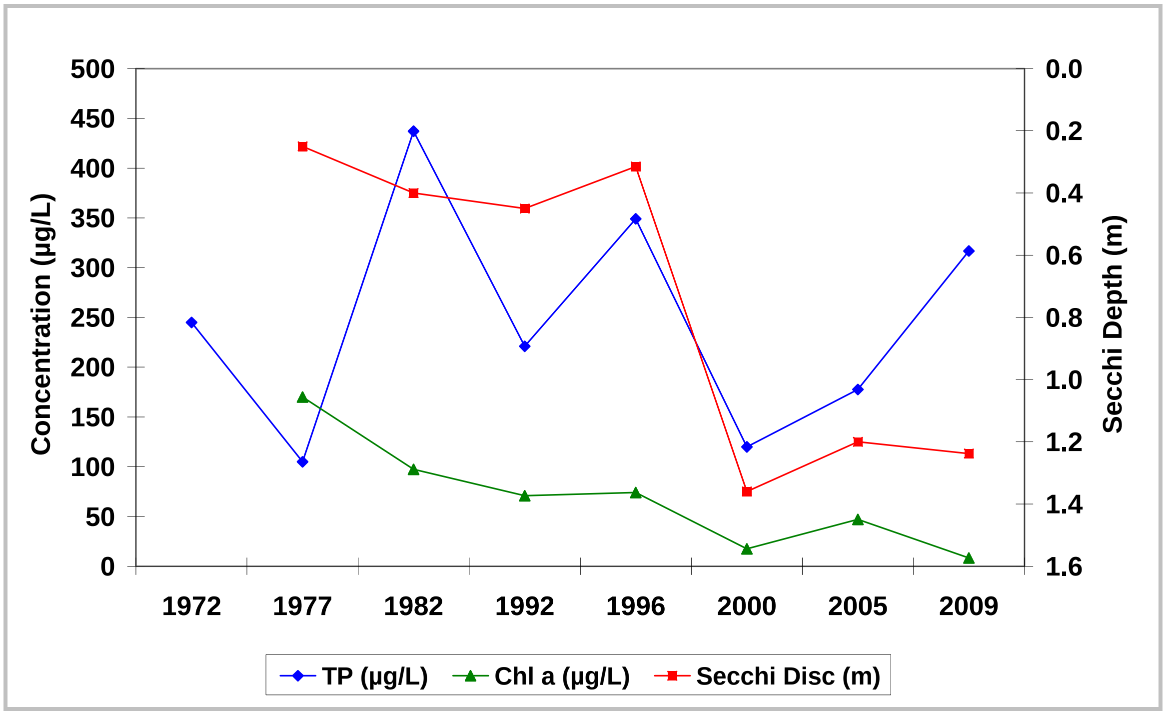

Figure 32 Historical Water Quality in Northwood Lake.

5.7 Biota

Two components of lake biota are presented herein: phytoplankton and zooplankton. Fisheries status is managed by the Department of Natural Resources and is not covered in this report.

5.7.1 Phytoplankton

Phytoplankton, also called algae, are single celled aquatic plants naturally present in lakes. They derive energy from sunlight (through photosynthesis) and from dissolved nutrients found in lake water. They provide food for several types of animals, including zooplankton, which are eaten by fish. A phytoplankton population in balance with the lake's zooplankton is ideal for fish production. An inadequate phytoplankton population reduces the lake's zooplankton population and adversely impacts the lake's fishery. Excess phytoplankton, however, reduce the lake's water clarity.

The lake's diverse algal community was comprised of six major algal groups:

- Chlorophyta or green algae,
- Cyanophyta or blue-green algae,
- Bacillariophyta or diatoms,
- Pyrrophyta or dinoflagellates,
- Chrysophyta or yellow-brown algae, and
- Cryptophyta or cryptomonads.

The spring and early summer algal community was primarily comprised of green algae, blue-green algae, and cryptomonads while blue-green algae dominated the late summer community (Figure 33). On August 12, *Merismopedia tenuissima* comprised 61 percent of the community. Because *Merismopedia tenuissima*, has an exceptionally small biomass, chlorophyll concentrations were low on August 12 despite high numbers of this taxon. Due to the small biomass of this taxon, little chlorophyll is present in each cell and high numbers of cells yield relatively low chlorophyll concentrations.

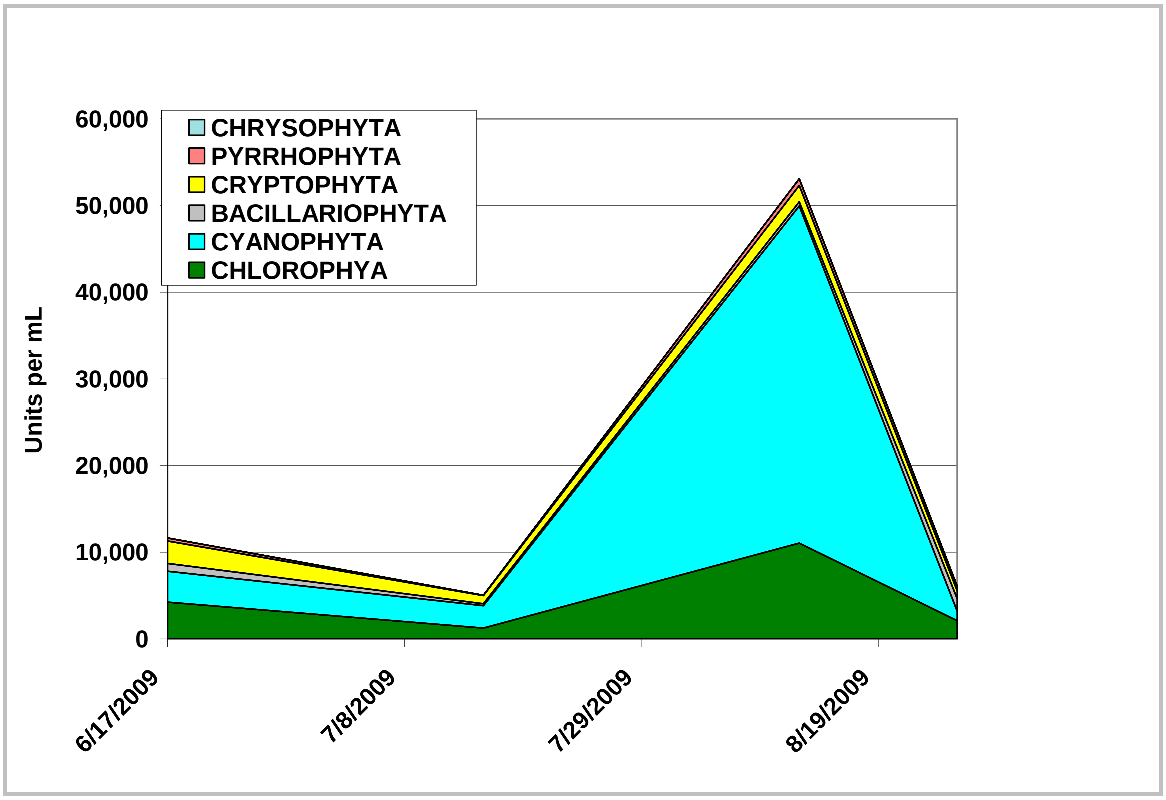

Figure 33 2009 Northwood Lake Phytoplankton Data Summary by Division

5.7.2 Zooplankton

Zooplankton are microscopic animals that feed on particulate matter, including algae, and are, in turn eaten by fish. Healthy zooplankton communities are characterized by balanced densities (number per meter squared) of the three major groups of zooplankton:

- Cladocera,
- Copepods, and
- Rotifers.

Fish predation, however, may alter community structure and reduce the numbers of larger bodied zooplankters (i.e., larger bodied Cladocera).

All three groups of zooplankton were represented in Northwood Lake during 2009 (Figure 34). Large-bodied cladocerans were observed through mid-August. Grazing by large-bodied cladocerans reduces the numbers of algae in the water and improves water transparency.

However, the relatively low numbers observed in Northwood Lake indicates little biological control occurred in 2009. It appears that fish predation reduced the numbers of zooplankton in late summer, including a reduction in cladocerans to non-detectable levels in late August.

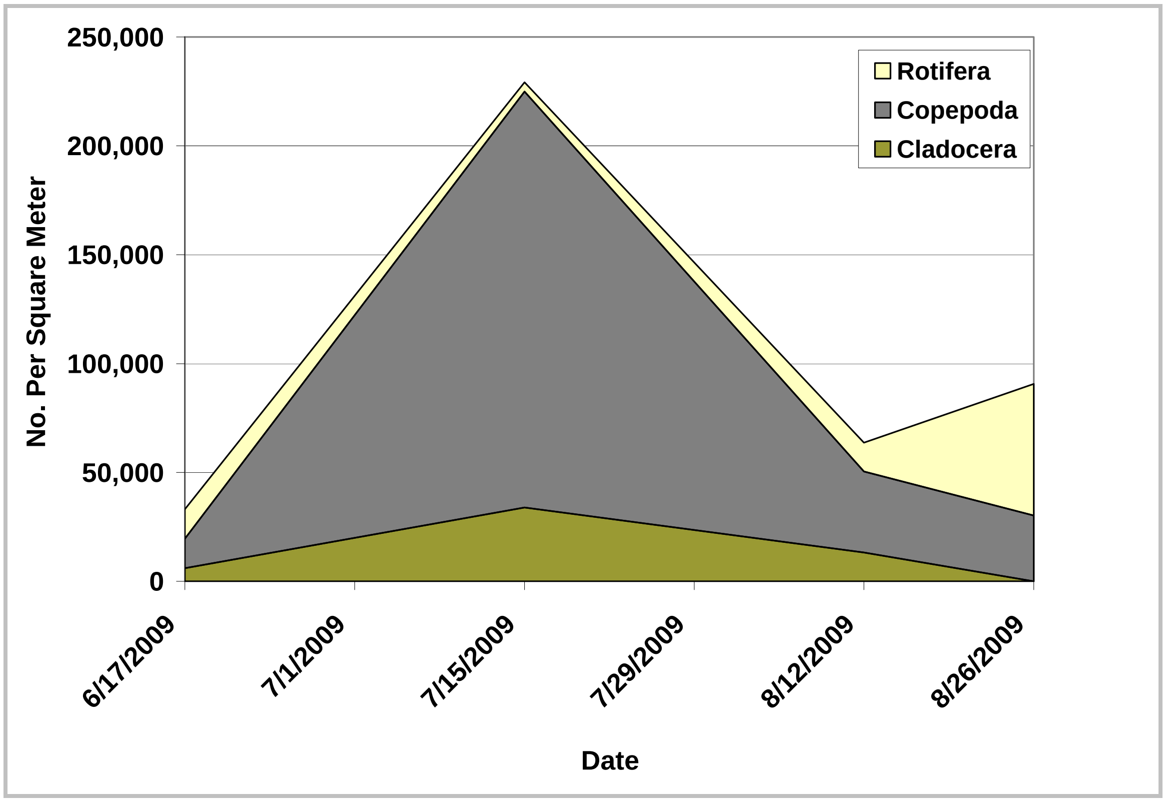

Figure 34 2009 Northwood Lake Zooplankton Data Summary by Division

5.8 Conclusions

- The summer average total phosphorus concentration indicates Northwood Lake is in the hypereutrophic category, while the summer average chlorophyll concentration and Secchi disc transparency are within the eutrophic category. The summer average chlorophyll concentration is only slightly higher than the upper limit for the mesotrophic (good water quality) category.

- In 2009, the lake's average summer chlorophyll a concentration (8 µg/L) and Secchi disc transparency (1.2 meters) met BCWMC's goals for chlorophyll (average summer chlorophyll *a* concentration not to exceed 40 µg/L) and Secchi disc (average summer Secchi disc transparency of at least 1.0 meters) in 2009. However, the lake's average summer total phosphorus concentration (317 µg/L) was more than four times greater than BCWMC's goal (average summer concentration not to exceed 75 µg/L).

- Similarly, in 2009, the lake's average summer chlorophyll a concentration (8 µg/L) and Secchi disc transparency (1.2 meters) met the state water quality standards for chlorophyll (average summer chlorophyll *a* concentration not to exceed 20 µg/L) and Secchi disc (average summer Secchi disc transparency of at least 1.0 meters). However, the lake's average summer total phosphorus concentration (317 µg/L) was more than five times greater than the state water quality standard for phosphorus (average summer concentration not to exceed 60 µg/L).

- Historical data indicate declining chlorophyll levels since 1977 and improved Secchi disc water transparency since 2000. Although total phosphorus concentrations have increased since 2000, chlorophyll levels have declined and Secchi disc transparency has remained relatively constant.

6.0 North and South Rice Pond

6.1 Site Description

North Rice Pond, located in the City of Robbinsdale (Figure 1), has a surface area of approximately 3.7 acres and a maximum depth of 5 feet (1.5 meters). South Rice Pond, located in the cities of Golden Valley and Robbinsdale (Figure 1), receives the overflow from North Rice Pond. It has a surface area of approximately 3.2 acres and a maximum depth of 3 feet (0.9 meters). North Rice Pond (27-644W) and South Rice Pond (27-645W) have been designated by the DNR as public waters. In addition, they both appear to be wetlands.

6.2 Goal

The BCWMC's goal for North Rice Pond and South Rice Pond is a management classification of Level III, meaning its water quality should support aesthetic viewing. Level III goals are (1) maximum total phosphorus concentration of 75 µg/L, (2) maximum chlorophyll *a* concentration of 40 µg/L, and minimum Secchi disc transparency of 1.0 meters (about 3 feet) (Barr 2004).

6.3 State Standards

Minnesota has established standards for lakes, but the standards are not applicable to wetlands. Because North Rice Pond (27-644W) and South Rice Pond (27-645W) appear to be wetlands, there are no state water quality standards applicable to the ponds.

6.4 BCWMC Watershed Management Plan and North and South Rice Pond Watershed and Lake Management Plan

The *BCWMC Watershed Management Plan* (2004) incorporated the study results of the *North Rice, South Rice, and Grimes Ponds Watershed and Lake Management Plan* (1997). The *North Rice, South Rice, and Grimes Ponds Watershed and Lake Management Plan* (1997) had several recommendations to consider that would improve the water quality of the ponds. Recommendations included:

1. Macrophyte Harvesting and Removal. North Rice and South Rice Ponds receive a portion of their annual phosphorus loads due to release of phosphorus from decaying aquatic plants. This option consists of removing the aquatic plants from the open water portions of each pond. Aquatic plant removal will also likely be necessary to ensure the effectiveness of the areal alum application for each pond.

2. In-Pond Alum Treatment. North Rice and South Rice Ponds receive a majority of their annual phosphorus loads due to release of phosphorus from bottom sediments. Areal application of aluminum sulfate (alum) to the pond water could be used as a long-term control of phosphorus release from the bottom sediments.

3. Wetland Inspection to Optimize Treatment Effectiveness. Inspection of a wetland (Basin K located in the Sunset Hill Drainage District) was recommended. The wetland has significant infiltration capacity and receives all of the stormwater runoff from this drainage district. Because of this infiltration capacity, Basin K currently removes about 86 percent of the total phosphorus. Inspection of this wetland on a regular basis, during both dry- and wet-weather periods, would ensure that it continues to function as an infiltration/wet detention basin.

6.5 Water Quality Data

North and South Rice Pond were sampled six times in both the northern basin and the southern basin during the 2009 growing season. Water quality data (Appendix) for Rice Pond include:

- Vertical profiles of temperature, dissolved oxygen concentration, specific conductivity, and pH
- 0-2 m composite samples analyzed for chlorophyll *a*, total phosphorus, soluble reactive phosphorus, and total nitrogen
- Total phosphorus above and below the thermocline and near bottom
- Secchi disc transparency

6.5.1 Temperature

Vertical profiles of temperature collected during 2009 show weak stratification was generally observed in North Rice Pond while South Rice Pond was generally well-mixed.

6.5.2 Dissolved Oxygen

Vertical profiles of dissolved oxygen collected during 2009 show that oxygen depletion occurred throughout the growing season in both ponds, but that South Rice Pond had more severe depletion than North Rice Pond. Oxygen concentrations were less than 5 mg/L throughout both ponds during July through September. Oxygen concentrations were less than 2 mg/L throughout North Rice Pond during mid-August and September as well as South Rice

Pond during July, mid-August, and September. Near-bottom oxygen levels were consistently less than 2 mg/L during July through September at both ponds.

6.5.3 Total Phosphorus, Chlorophyll *a,* and Secchi Depth

Surface total phosphorus data are graphically summarized in Figure 35 for North Rice Pond. The 2009 North Rice Pond surface total phosphorus concentration ranged from a high of 89 µg/L (April) to a low of 38 µg/L (August) and averaged 70 µg/L during the summer. Total phosphorus concentrations decreased from spring through late-August and then increased during September. All observed 2009 total phosphorus concentrations were within the hypereutrophic (very poor water quality) category except for a late August value in the eutrophic (poor water quality) category.

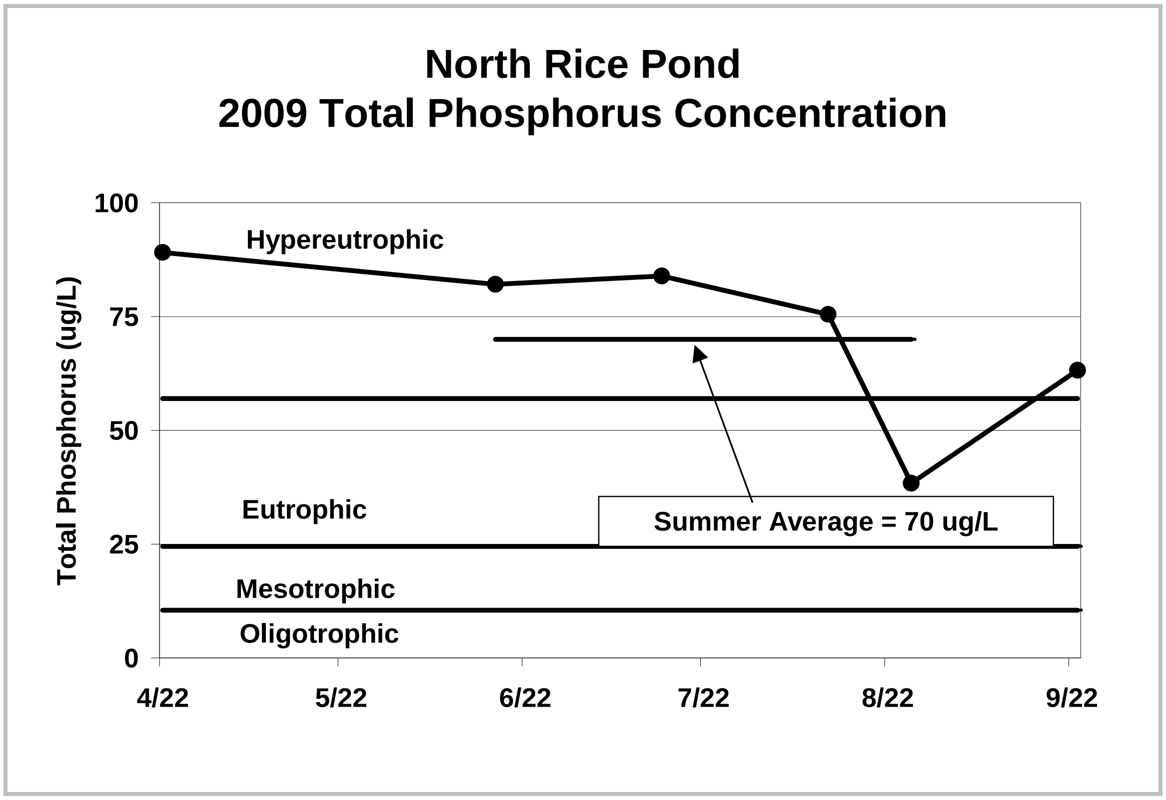

Figure 35 2009 North Rice Pond Total Phosphorus Concentration

Surface total phosphorus data are graphically summarized in Figure 36 for South Rice Pond. The 2009 South Rice Pond surface total phosphorus concentration ranged from a high of 382 µg/L (mid-August) to a low of 153 µg/L (April) and averaged 216 µg/L during the summer. Total phosphorus concentrations generally increased from spring through mid-August, then decreased in late-August, and increased again during September. All observed 2009 total phosphorus concentrations were within the hypereutrophic (very poor water quality) category.

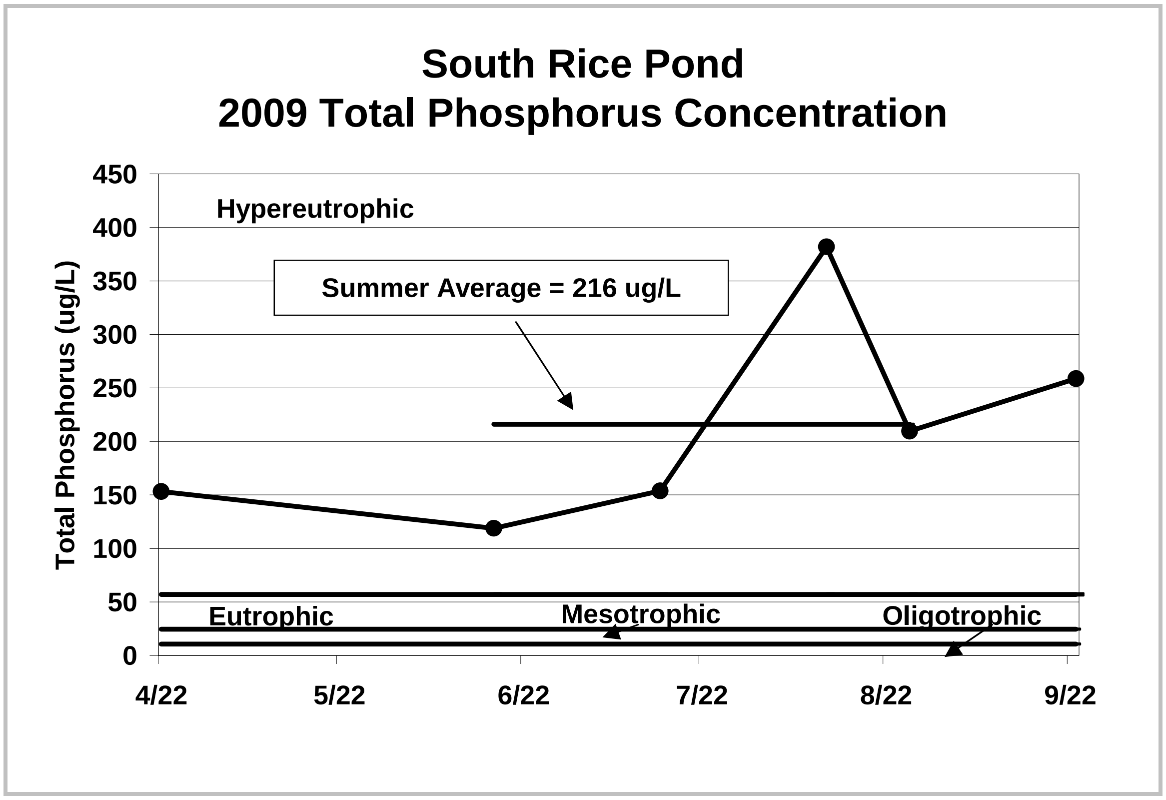

Figure 36 2009 South Rice Pond Total Phosphorus Concentration

In North Rice Pond and South Rice Pond, low oxygen concentrations near the bottom resulted in sediment phosphorus release and phosphorus buildup during the summer (Figures 37 and 38). However, the difference between surface and bottom phosphorus concentrations was generally greater at North Rice Pond than South Rice Pond due to the weak stratification consistently observed at North Rice Pond.

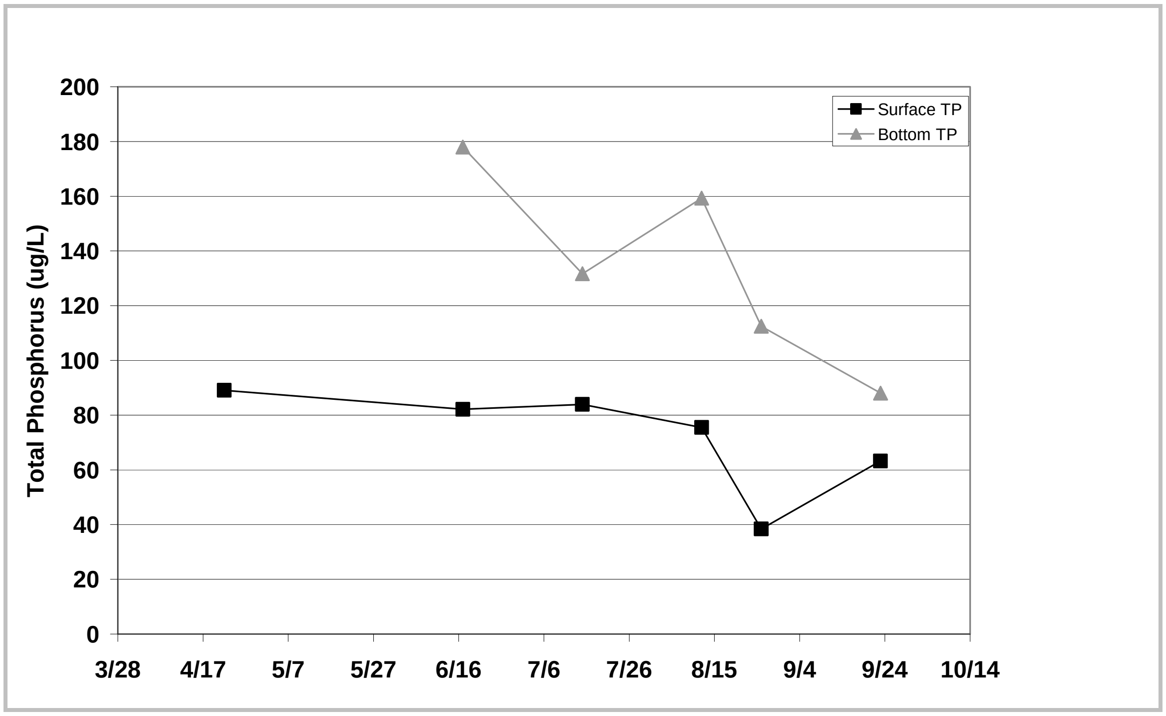

Figure 37 2009 North Rice Pond Surface and Bottom Total Phosphorus Concentration

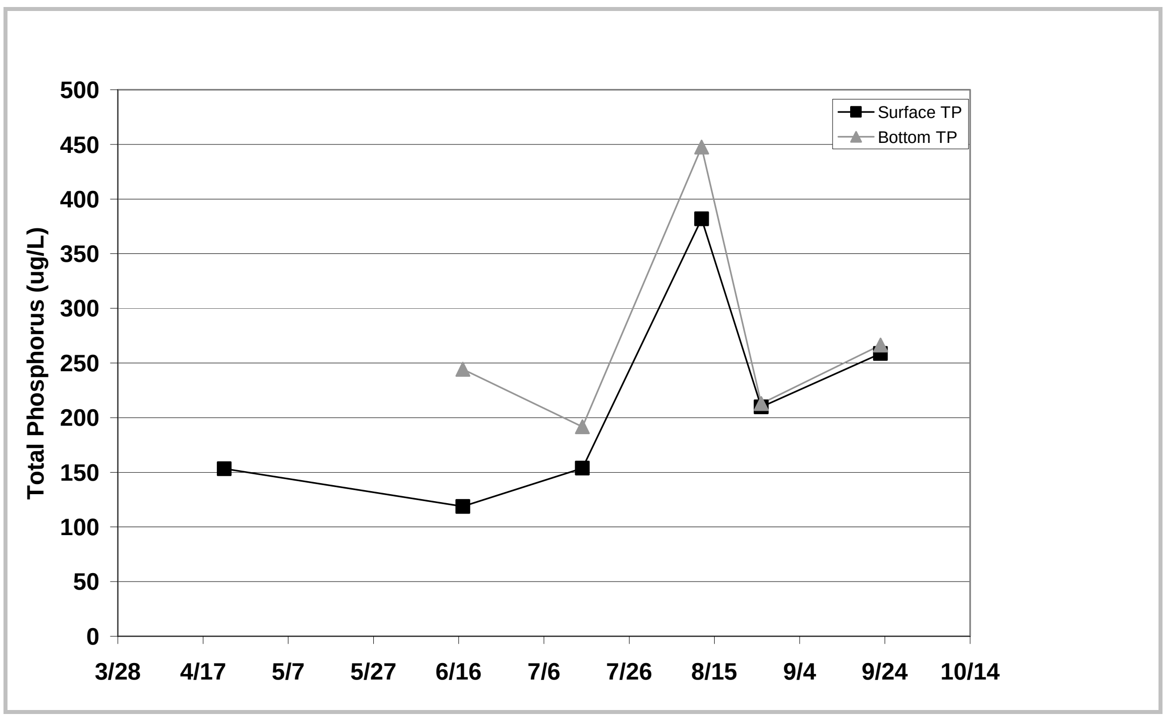

Figure 38 2009 South Rice Pond Surface and Bottom Total Phosphorus Concentration

Surface chlorophyll *a* data for North Rice Pond are graphically summarized in Figure 39. 2009 surface chlorophyll *a* concentrations ranged from a high of 16 µg/L during June to a low of 4 µg/L in late-August. The average summer concentration was 12 µg/L. Concentrations were generally in the eutrophic (poor water quality) category, although a the late August value was in the mesotrophic (good water quality) category. Summer chlorophyll concentrations were much lower than expected since the phosphorus concentrations were consistently in the hypereutrophic category.

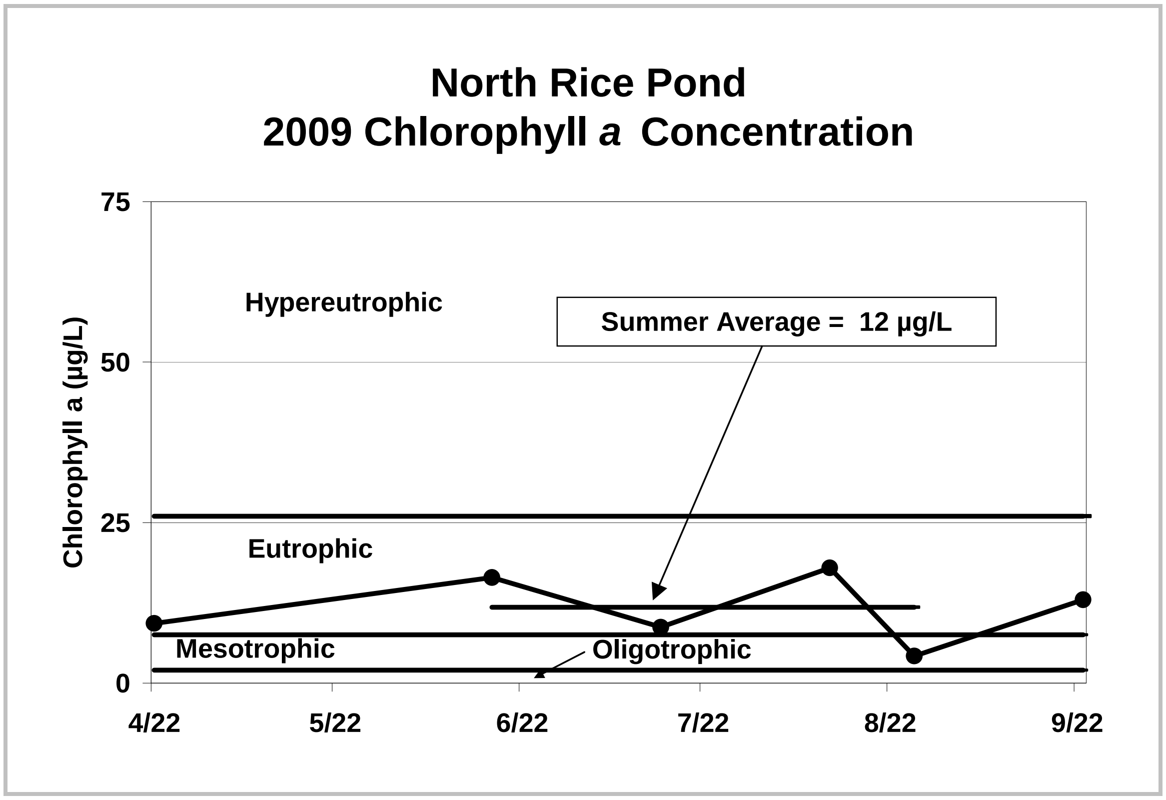

Figure 39 2009 North Rice Pond Chlorophyll *a* Concentration

Surface chlorophyll *a* data for South Rice Pond are graphically summarized in Figure 40. 2009 surface chlorophyll *a* concentrations ranged from a high of 48 µg/L during September to a low of 1 µg/L in June. The average summer concentration was 9 µg/L. Concentrations ranged from Oligotrophic (excellent water quality) to eutrophic (poor water quality). Summer chlorophyll concentrations were much lower than expected since the phosphorus concentrations were consistently in the hypereutrophic category.

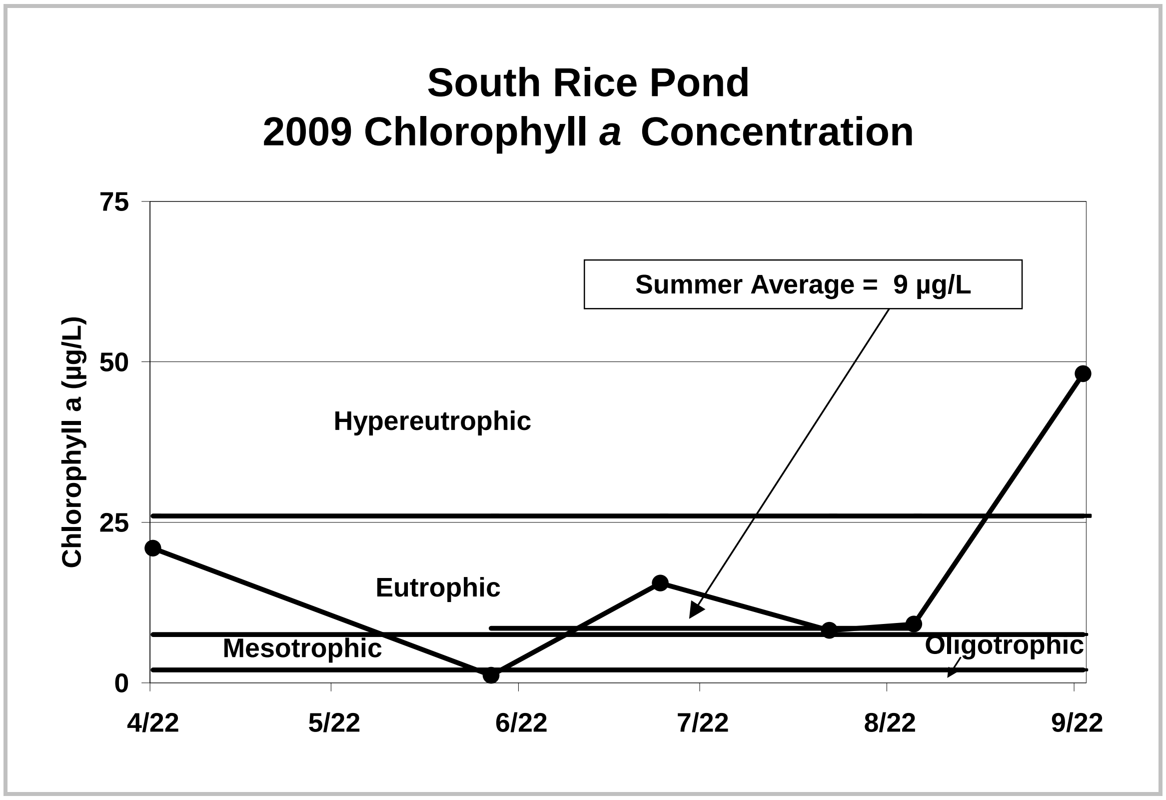

Figure 40 2009 South Rice Pond Chlorophyll *a* Concentration

Secchi disc data for North Rice Pond are graphically summarized in Figure 41. Secchi disc transparency ranged from a low of 0.8 meters in late August to a high of 1.4 meters in July and averaged 1.1 meters during the summer months.

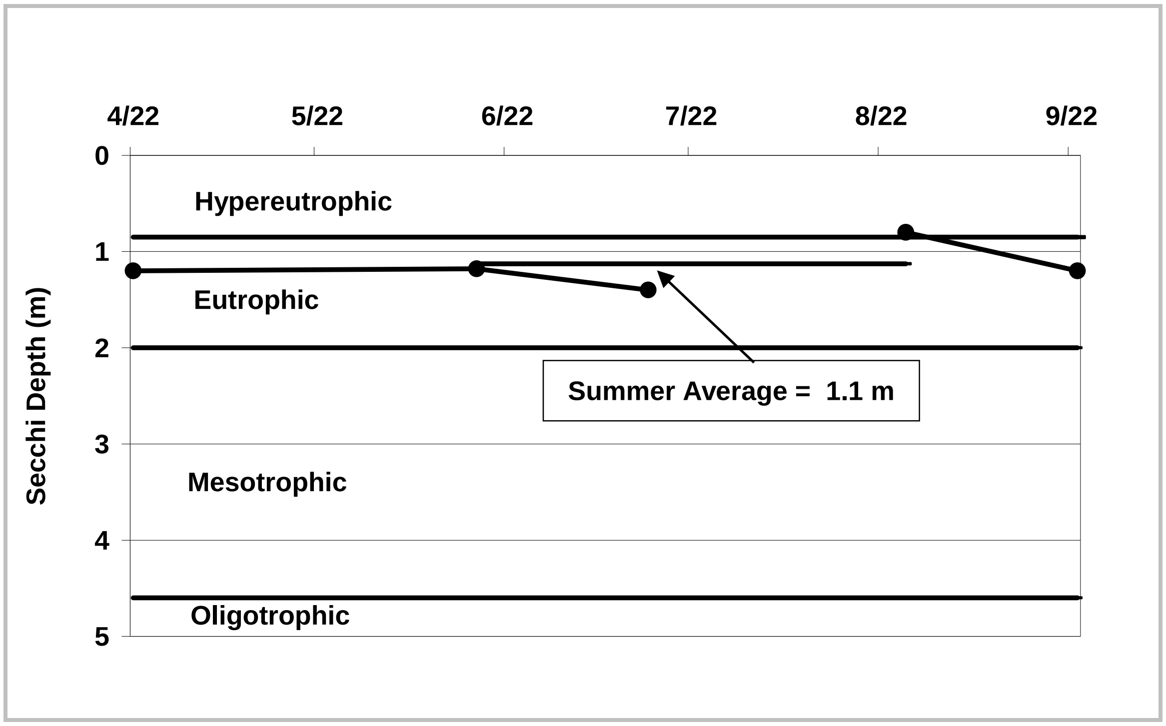

Figure 41 2009 North Rice Pond Secchi Depth

Secchi disc data for South Rice Pond are graphically summarized in Figure 42. Secchi disc transparency ranged from a low of 0.4 meters in April to a high of 1.1 meters in June and averaged 0.8 meters during the summer months.

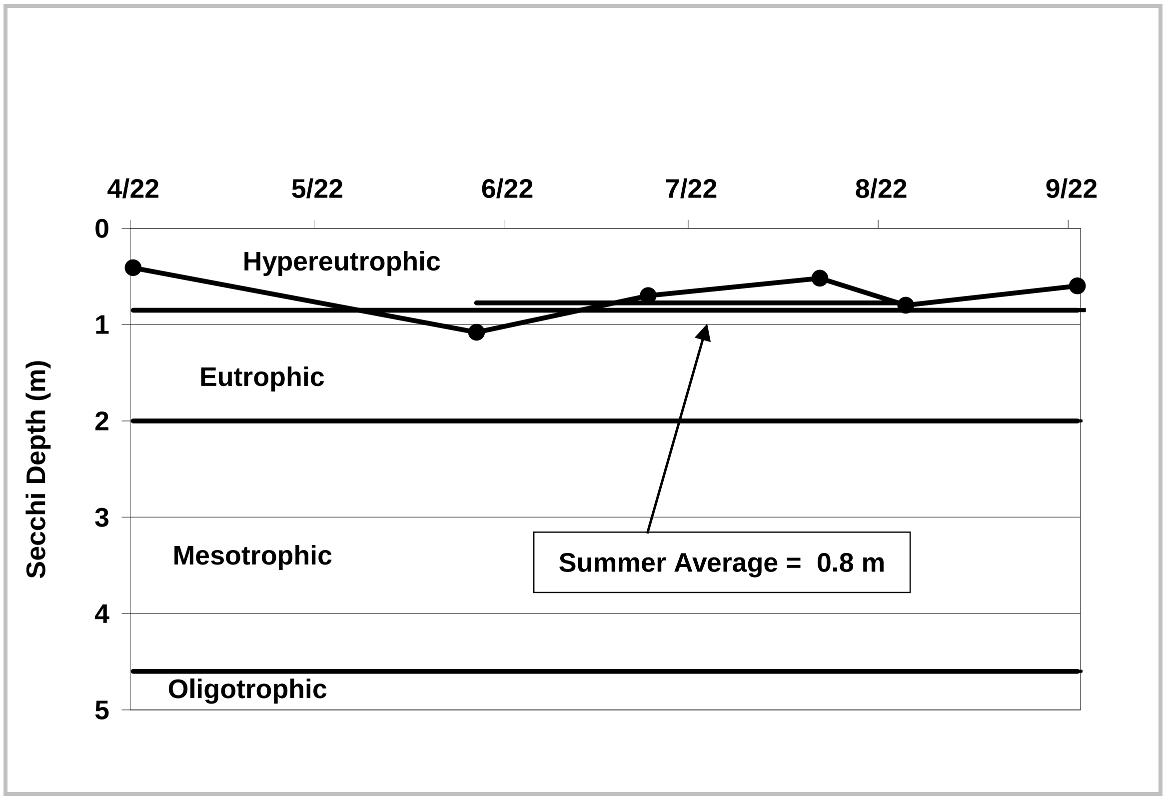

Figure 42 2009 South Rice Pond Secchi Depth

The 2009 average summer values for total phosphorus (70 µg/L), chlorophyll *a* (12 µg/L) and Secchi disc transparency (1.1 meters) at North Rice Pond met BCWMC's goals for total phosphorus (average summer concentration not to exceed 75 µg/L) and chlorophyll (average summer chlorophyll *a* concentration not to exceed 40 µg/L) concentrations as well as Secchi disc transparency (average summer Secchi disc transparency of at least 1.0 meters).

The 2009 average summer value for chlorophyll *a* at South Rice Pond (9 µg/L) met BCWMC's goal (average summer chlorophyll *a* concentration not to exceed 40 µg/L). However, the 2009 average summer values for total phosphorus (216 µg/L) and Secchi disc (0.8 meters) at South Rice Pond did not meet BCWMC's goals for total phosphorus (average summer concentration not to exceed 75 µg/L) or Secchi disc transparency (average summer Secchi disc transparency of at least 1.0 meters.

6.6 Historical Trends

Historical water quality trends are shown on Figure 43 for North Rice Pond. North Rice Pond shows a trend toward water quality improvement based upon data from 1994, 1998, and 2009.

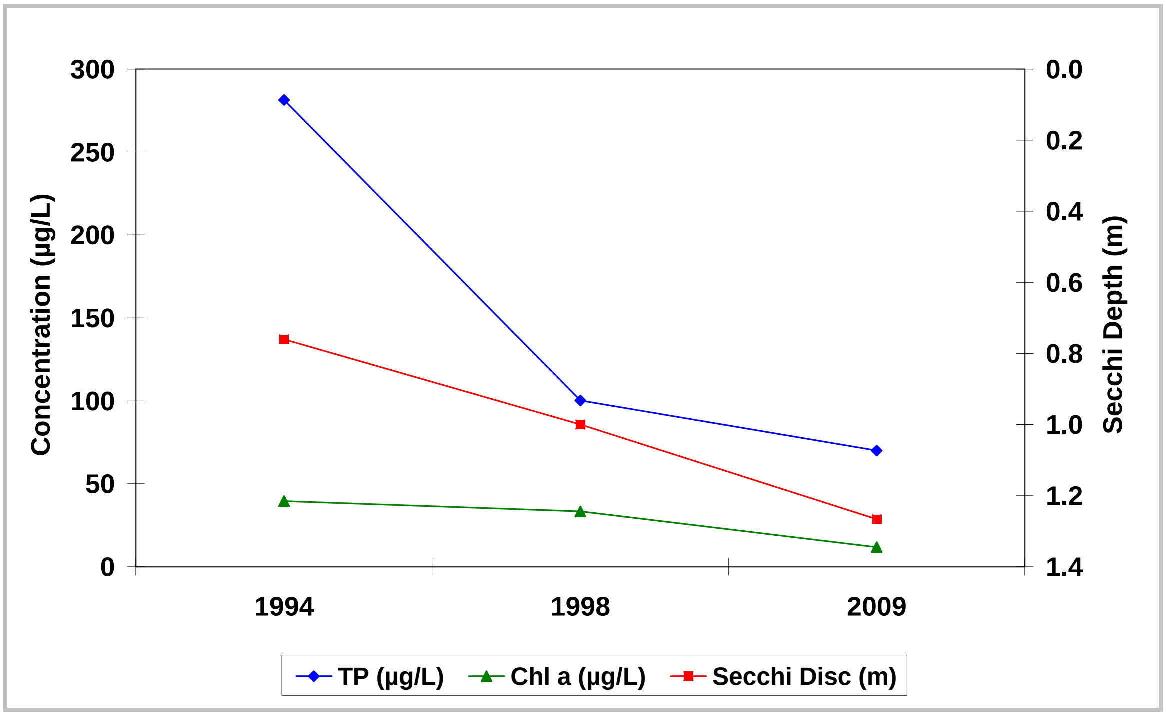

Figure 43 Historical Water Quality in North Rice Pond

Historical water quality trends shown on Figure 44 for South Rice Pond indicate consistently poor water quality has been observed during the period of record. A comparison of 2008 and 2009 water quality indicates total phosphorus concentrations increased while chlorophyll concentrations declined and water transparency improved.

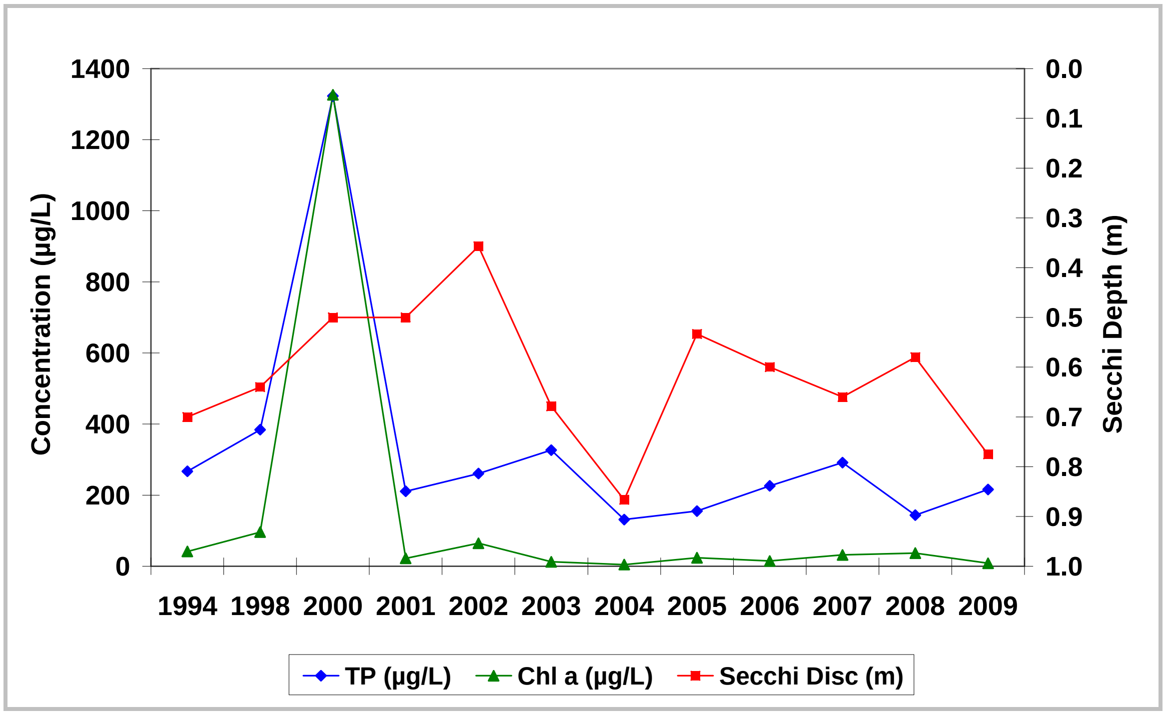

Figure 44 Historical Water Quality in South Rice Pond

6.7 Biota

Two components of lake biota are presented herein: phytoplankton and zooplankton. Fisheries status is managed by the Department of Natural Resources and is not covered in this report.

6.7.1 Phytoplankton

Phytoplankton, also called algae, are single celled aquatic plants naturally present in lakes. They derive energy from sunlight (through photosynthesis) and from dissolved nutrients found in lake water. They provide food for several types of animals, including zooplankton, which are eaten by fish. A phytoplankton population in balance with the lake's zooplankton is ideal for fish production. An inadequate phytoplankton population reduces the lake's zooplankton population and adversely impacts the lake's fishery. Excess phytoplankton, however, reduce the lake's water clarity.

The North and South Rice Ponds observed a diverse algal community. Both ponds observed five major algal groups:

- Chlorophyta or green algae,

- Cyanophyta or blue-green algae,
- Bacillariophyta or diatoms,
- Euglenophyta or euglenoids
- Cryptophyta or cryptomonads.

In addition, South Rice Pond observed Pyrrhophyta or dinoflagellates.

Green algae and cryptomonads dominated the June North Rice Pond community. Blue-green algae increased from June through mid-August and dominated August community (Figure 45).

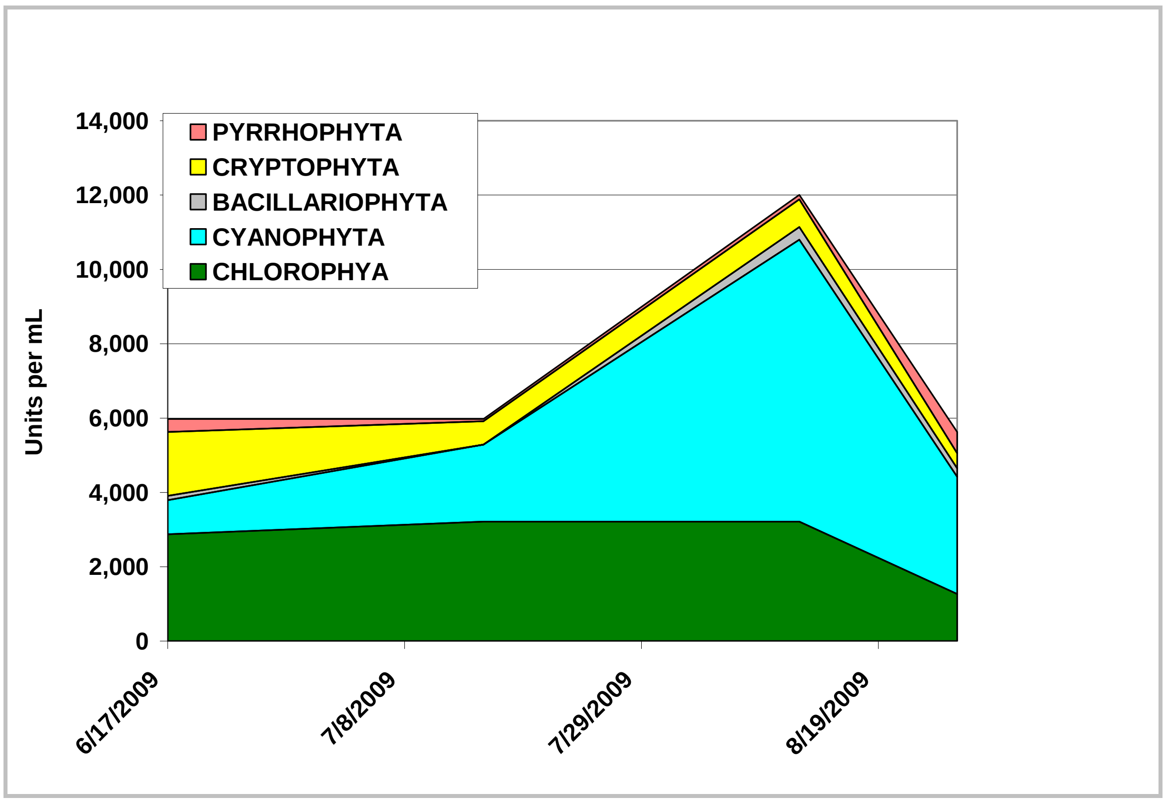

Figure 45 2009 North Rice Pond Phytoplankton Data Summary by Division

Green algae dominated the June South Rice Pond community. Blue-green algae increased more rapidly in South Rice Pond than North Rice pond and dominated the community during both July and August (Figure 46).

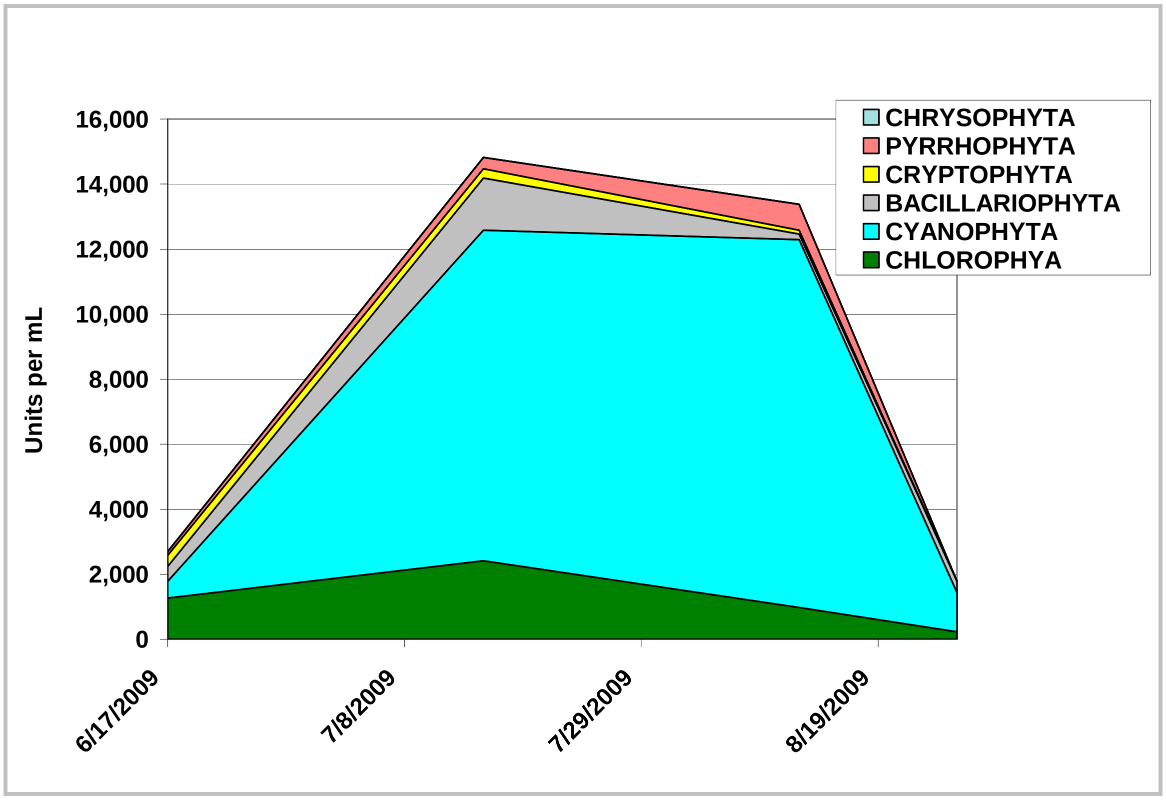

Figure 46 2009 South Rice Pond Phytoplankton Data Summary by Division

6.7.2 Zooplankton

Zooplankton are microscopic animals that feed on particulate matter, including algae, and are, in turn eaten by fish. Healthy zooplankton communities are characterized by balanced densities (number per meter squared) of the three major groups of zooplankton:

- Cladocera,
- Copepods, and
- Rotifers.

Fish predation, however, may alter community structure and reduce the numbers of larger bodied zooplankters (i.e., larger bodied cladocera).

All three groups of zooplankton were represented in North and South Rice Ponds during 2009 (Figures 47 and 48). It appears that zooplankton exerted little biological control over the ponds' phytoplankton communities due to the relatively low numbers of large-bodied cladocera observed in the ponds. It appears that fish predation reduced the numbers of zooplankton in late summer.

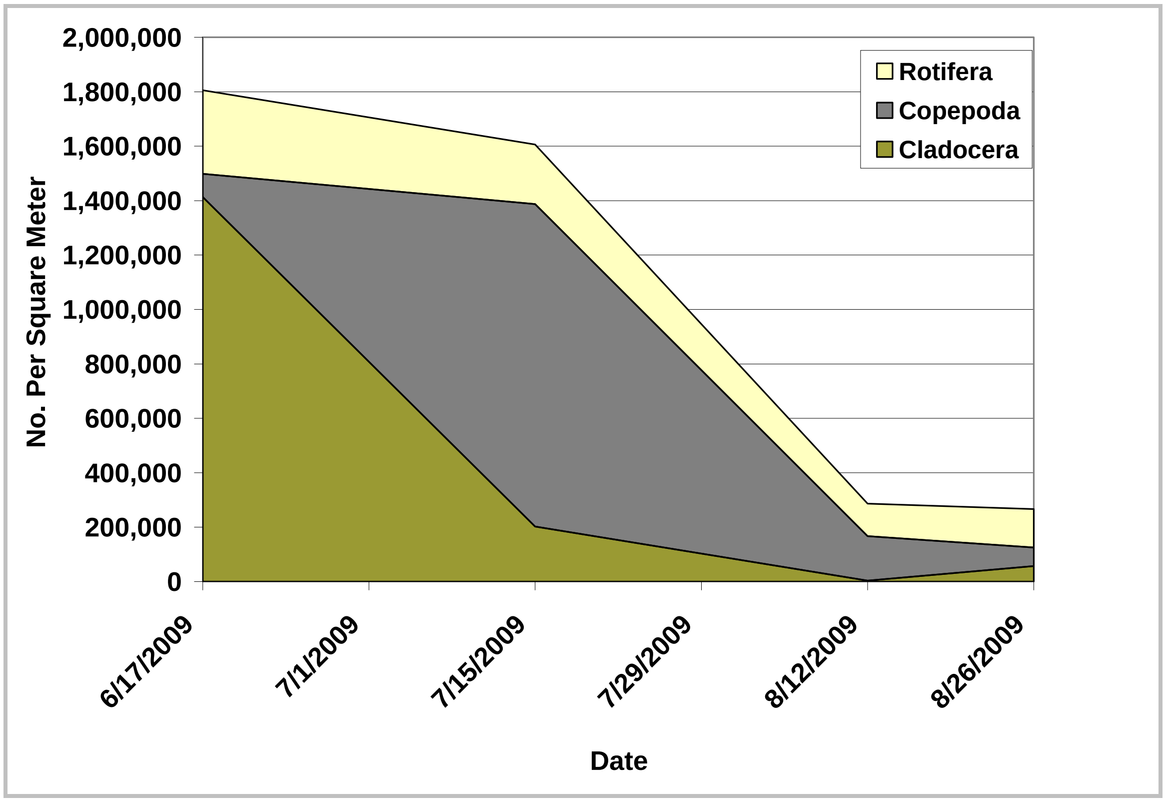

Figure 47 2009 North Rice Pond Zooplankton Data Summary by Division

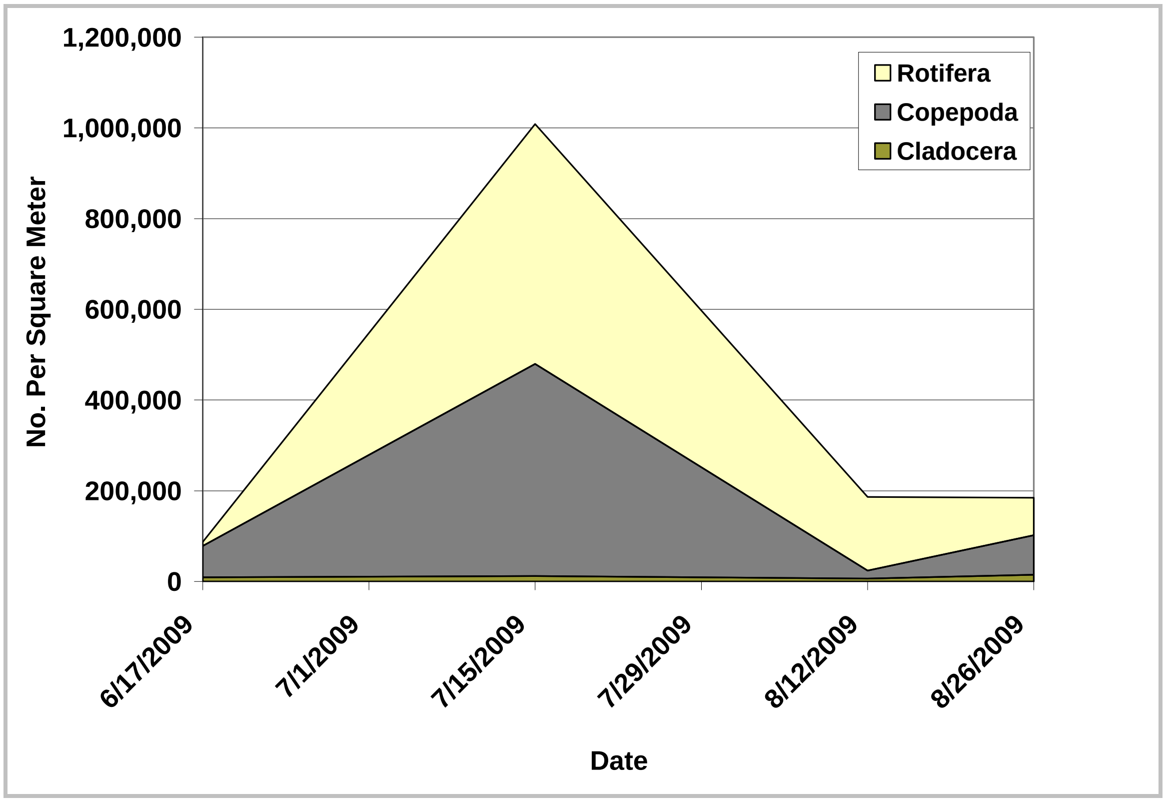

Figure 48 2009 South Rice Pond Zooplankton Data Summary by Division

6.8 Conclusions

- The 2009 summer average total phosphorus concentrations at North and South Rice Ponds were in the hypereutrophic (very poor water quality) category while summer average chlorophyll concentrations were in the eutrophic (poor water quality) category. Summer average Secchi disc transparency at North Rice Pond was in the eutrophic (poor water quality) category while summer average Secchi disc transparency at South Rice Pond was in the hypereutrophic category.

- The 2009 average summer values for total phosphorus (70 µg/L), chlorophyll *a* (12 µg/L) and Secchi disc transparency (1.1 meters) at North Rice Pond met BCWMC's goals for total phosphorus (average summer concentration not to exceed 75 µg/L) and chlorophyll (average summer chlorophyll *a* concentration not to exceed 40 µg/L) concentrations as well as Secchi disc transparency (average summer Secchi disc transparency of at least 1.0 meters).

- The 2009 average summer value for chlorophyll *a* at South Rice Pond met BCWMC's goal (average summer chlorophyll *a* concentration not to exceed 40 µg/L). However, the 2009 average summer values for total phosphorus (216 µg/L) and Secchi disc (0.8 meters) at South Rice Pond did not meet BCWMC's goals for total phosphorus (average summer concentration not to exceed 75 µg/L) or Secchi disc transparency (average summer Secchi disc transparency of at least 1.0 meters.

- Historical water quality for North Rice Pond shows a trend toward water quality improvement based upon data from 1994, 1998, and 2009.

- Historical water quality for South Rice Pond indicate consistently poor water quality has been observed during the period of record. A comparison of 2008 and 2009 water quality indicates total phosphorus concentrations increased while chlorophyll concentrations declined and water transparency improved.

7.0 References

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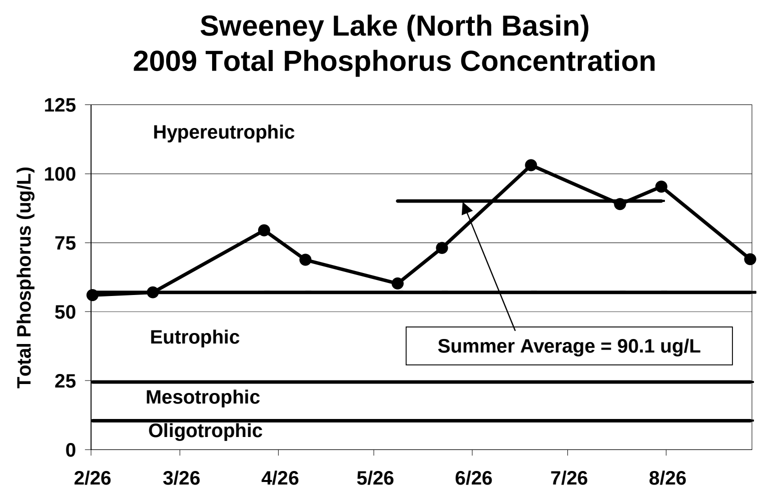
Barr Engineering Company. 2006. Lake Water Quality Study Northwood Lake, Sweeny Lake, and Twin Lake. Prepared for the Basset Creek Water Management BCWMC.

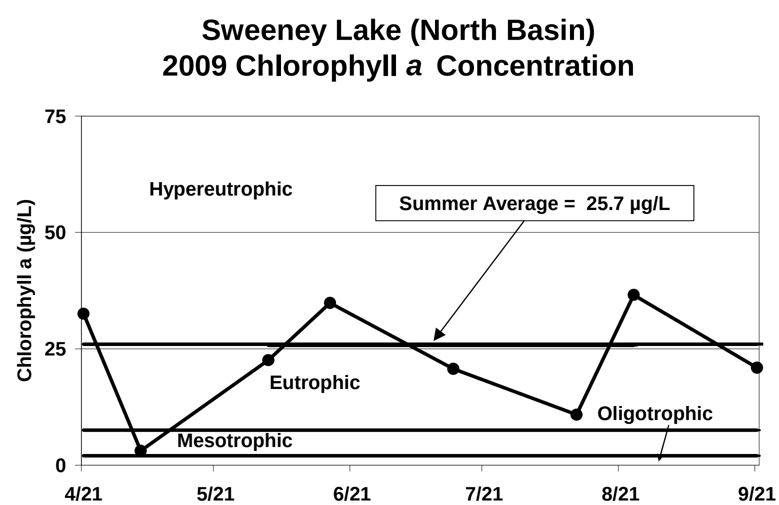
Osgood, R., A. 1989a. An evaluation of Lake and Stream Monitoring Programs in the Twin Cities Metropolitan Area. Metropolitan Council Publication No. 590-89-128.

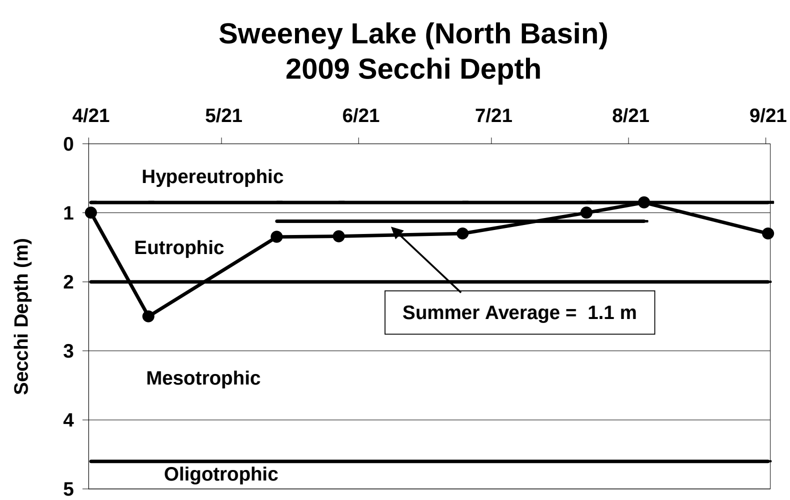
Osgood, R., A. 1989b. 1989 Study of the Water Quality of 20 Metropolitan Area Lakes. Metropolitan Council Publication No. 590-89-130.

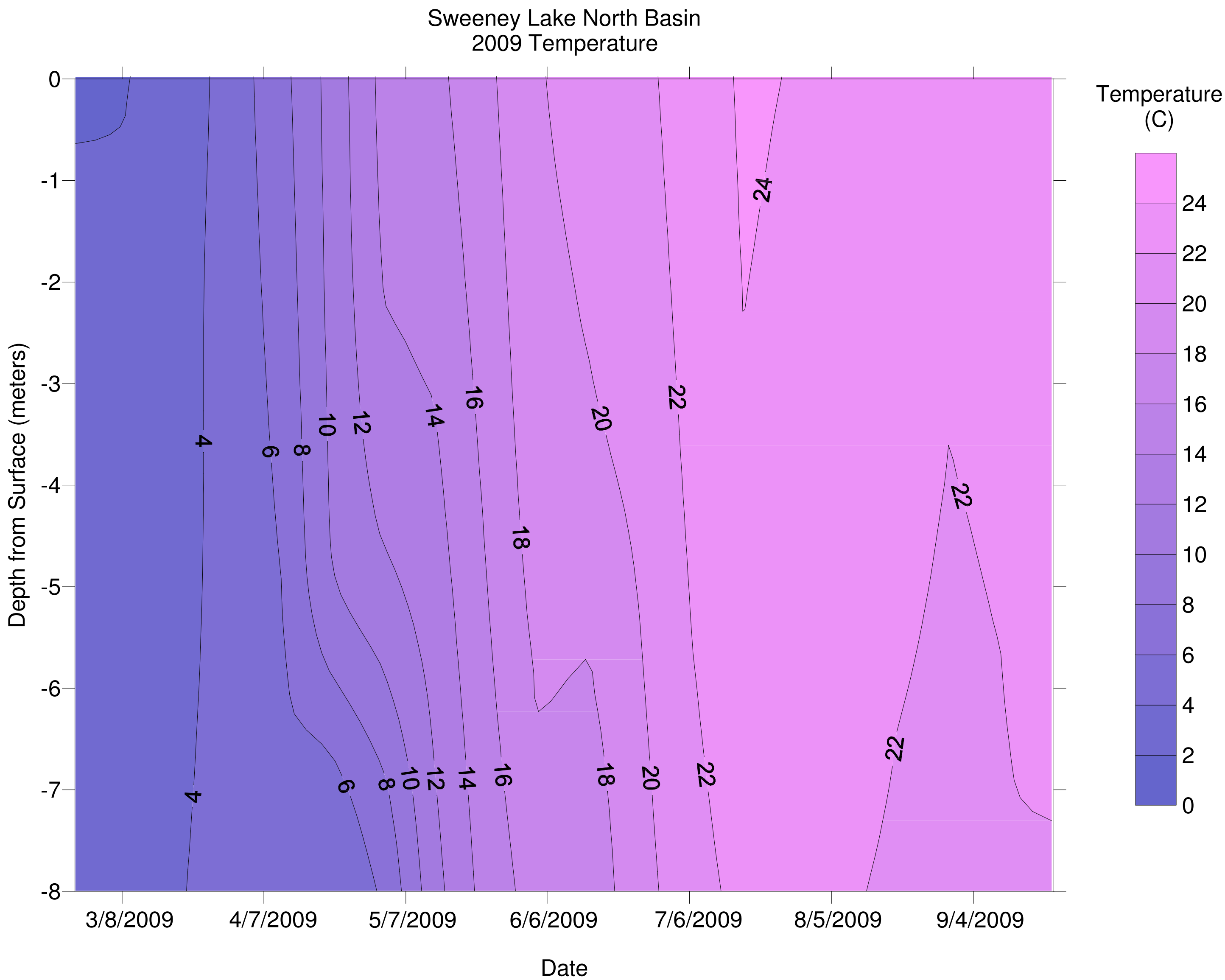
Appendix A

2009 Sweeney Lake Data

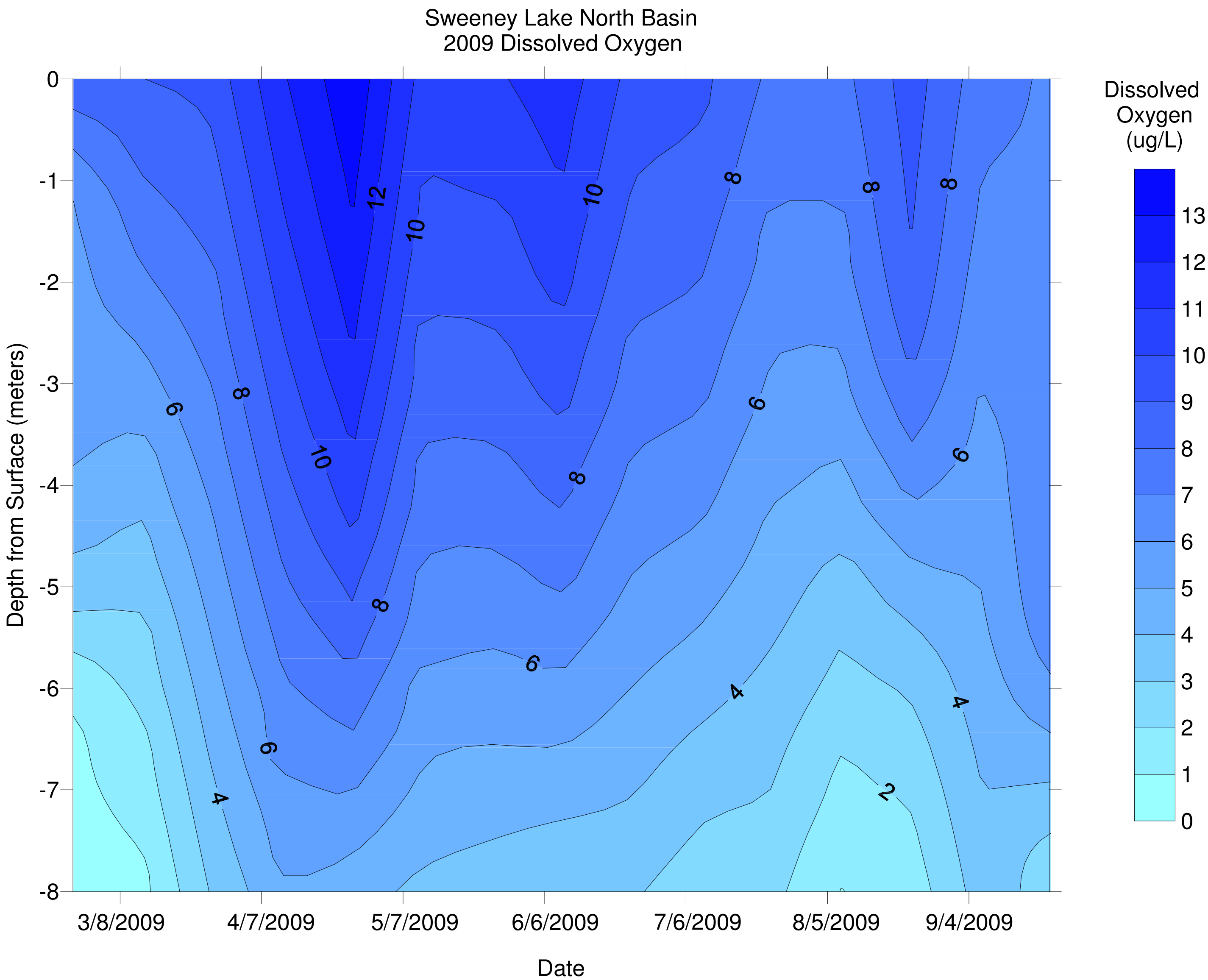

Sweeney Lake (North Basin)
2009 Total Phosphorus Concentration
Total Phosphorus (ug/L)
125
100
75
50
25
0
Hypereutrophic
Eutrophic
Mesotrophic
Oligotrophic
Summer Average = 90.1 ug/L
2/26
3/26
4/26
5/26
6/26
7/26
8/26


Sweeney Lake (North Basin)
2009 Chlorophyll a Concentration
Chlorophyll a (µg/L)
75
50
25
0
Hypereutrophic
Summer Average = 25.7 µg/L
Eutrophic
Oligotrophic
Mesotrophic
4/21
5/21
6/21
7/21
8/21
9/21

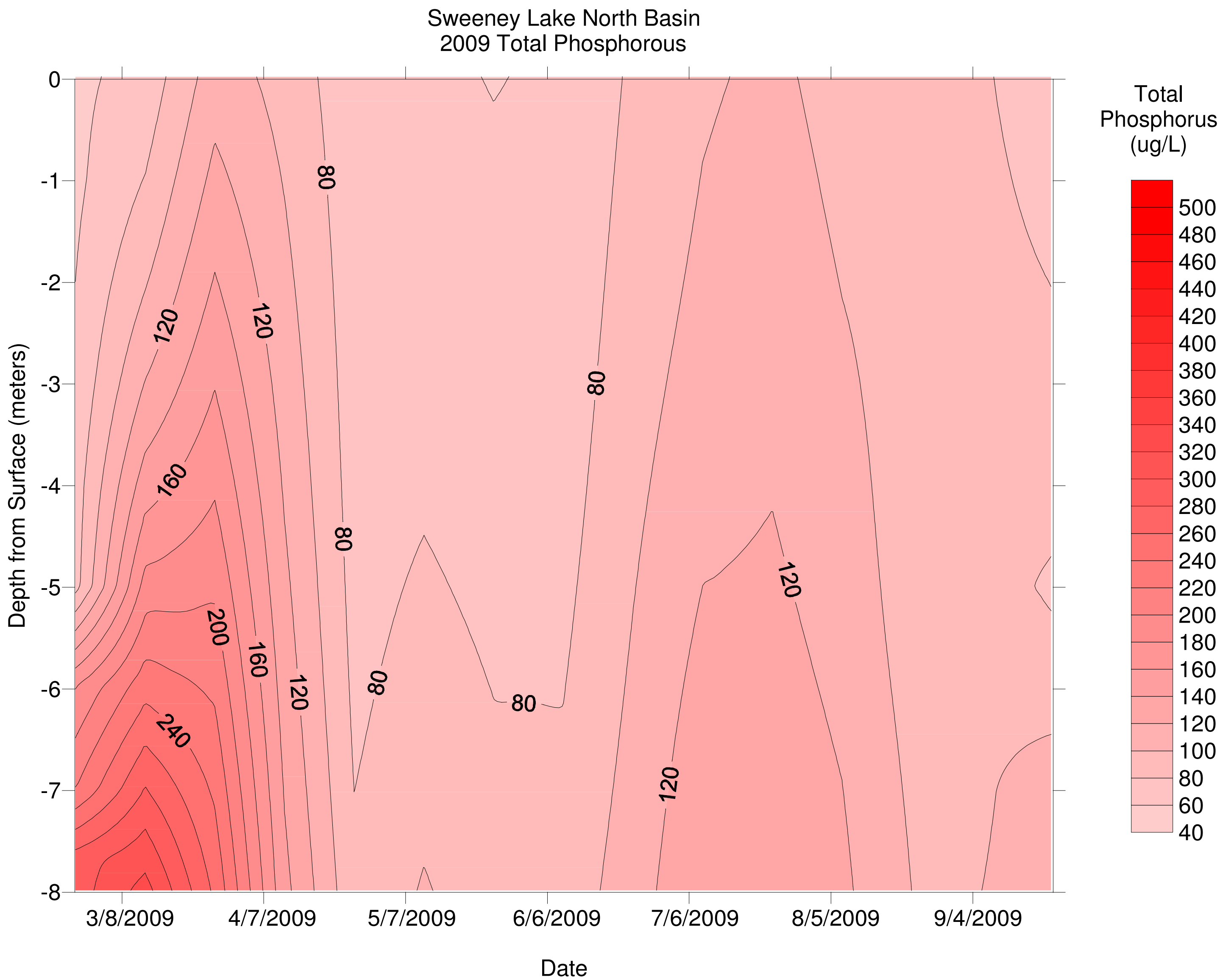

Sweeney Lake (North Basin)
2009 Secchi Depth
4/21
5/21
6/21
7/21
8/21
9/21
Secchi Depth (m)
0
1
2
3
4
5
Hypereutrophic
Eutrophic
Summer Average = 1.1 m
Mesotrophic
Oligotrophic



Sweeney Lake North Basin
2009 Temperature
Depth from Surface (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
3/8/2009
4/7/2009
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Date
Temperature (C)
24
22
20
18
16
14
12
10
8
6
4
2
0



Sweeney Lake North Basin
2009 Dissolved Oxygen
Depth from Surface (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
3/8/2009
4/7/2009
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Date
Dissolved Oxygen (ug/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0


Sweeney Lake North Basin
2009 Total Phosphorous
Depth from Surface (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
Date
3/8/2009
4/7/2009
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Total Phosphorus (ug/L)
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40

SWEENEY LAKE NORTH

SURFACE

STANDARD INVERTED MICROSCOPE ANALYSIS METHOD

DIVISION	TAXON	4/27/2009 units/mL	6/2/2009 units/mL	6/16/2009 units/mL	7/14/2009 units/mL	8/11/2009 units/mL	8/24/2009 units/mL	9/21/2009 units/mL
CHLOROPHYTA (GREEN ALGAE)	*Ankistrodesmus Brauni*	57	0	0	57	57	0	230
	Ankistrodesmus falcatus	287	0	0	115	230	96	57
	Carteria Klebsii	0	0	0	0	0	0	115
	Chlamydomonas globosa	5,571	2,585	1,436	3,676	9,132	6,516	4,537
	Coelastrum microporum	0	0	0	57	57	0	0
	Closterium sp.	0	0	0	57	57	0	0
	Cosmarium sp.	0	0	0	0	0	96	0
	Crucigenia sp.	0	0	0	0	172	0	0
	Oocystis parva	0	57	57	115	402	192	115
	Pandorina morum	0	0	0	0	57	0	0
	Rhizoclonium hieroglyphicum	0	0	57	0	287	575	172
	Scenedesmus quadricauda	57	0	0	0	57	96	0
	Scenedesmus sp.	0	0	57	0	0	0	57
	Schroederia Judayi	0	0	402	919	57	192	57
	Schroederia sp.	0	0	0	0	287	0	0
	Selenastrum minutum	0	57	0	57	57	96	115
	Selenastrum sp.	0	57	0	0	115	0	115
	Selenastrum sp.	115	0	0	0	0	0	0
	Sphaerocystis Schroeteri	0	0	57	0	0	192	0
	Tetraedron minimum	0	0	0	0	0	96	0
	Unidentified Green	0	0	0	0	57	0	0
	CHLOROPHYTA TOTAL	**6,088**	**2,757**	**2,068**	**5,054**	**11,028**	**8,145**	**5,571**
	Dinobryon sociale	0	0	57	0	0	0	0
CHRYSOPHYTA (YELLOW-BROWN ALGAE)	**CHRYSOPHYTA TOTAL**	**0**	**0**	**57**	**0**	**0**	**0**	**0**
CYANOPHYTA (BLUE-GREEN ALGAE)	*Anabaena affinis*	0	0	0	287	57	0	0
	Anabaena flos-aquae	0	0	0	0	0	96	57
	Aphanizomenon flos-aquae	0	747	3,446	3,331	1,436	575	574
	Cylindrospermopsis raciborski	0	0	0	230	4,365	12,745	2,125
	Gomphsphaeia Naegel.	0	57	0	0	0	0	0
	Lyngbya limnetica	0	0	0	0	0	0	402
	Merismopedia tenuissima	57	0	0	0	172	0	976
	Microcystis aeruginosa	0	0	115	57	0	383	0
	Microcystis incerta	345	1,436	172	230	1,321	0	862
	Oscillatoria limnetica	0	115	0	0	1,436	7,379	6,203
	Oscillatoria Agardhii	230	0	0	3,676	0	383	3,159
	Phormidium mucicola	57	57	0	57	172	287	57
	CYANOPHYTA TOTAL	**689**	**2,412**	**3,733**	**7,869**	**8,960**	**21,849**	**14,416**
BACILLARIOPHYTA (DIATOMS)	*Asterionella formosa*	459	1,034	0	230	172	287	0
	Cymbella sp.	0	0	0	0	0	0	57
	Fragilaria crotonensis	0	2,814	747	0	287	479	172
	Melosira granulata	0	0	0	0	574	287	0
	Navicula sp.	0	115	0	0	115	287	57
	Pinnularia sp.	0	57	57	0	0	0	0
	Stephanodiscus Hantzschii	747	0	0	0	1,206	4,504	172
	Stephanodiscus sp.	57	287	517	0	0	0	0
	Synedra ulna	287	0	57	0	0	383	287
	Tabellaria fenestrata	57	0	0	0	0	0	0
	BACILLARIOPHYTA TOTAL	**1,608**	**4,308**	**1,378**	**230**	**2,355**	**6,229**	**747**
CRYPTOPHYTA (CRYPTOMONADS)	*Cryptomonas erosa*	3,848	1,034	5,399	5,686	5,973	17,920	4,825
	CRYPTOPHYTA TOTAL	**3,848**	**1,034**	**5,399**	**5,686**	**5,973**	**17,920**	**4,825**
EUGLENOPHYTA (EUGLENOIDS)	**EUGLENOPHYTA TOTAL**	**0**		**0**	**0**	**0**	**0**	**0**
PYRRHOPHYTA (DINOFLAGELLATES)	*Ceratium hirundinella*	0	115	517	57	0	0	0
	Peridinium cinctum	0	0	0	0	172	0	0
	PYRRHOPHYTA TOTAL	**0**	**115**	**517**	**57**	**172**	**0**	**0**
	TOTALS	**12,234**	**10,626**	**13,153**	**18,896**	**28,488**	**54,143**	**25,559**

SWEENEY LAKE NORTH

ZOOPLANKTON ANALYSIS

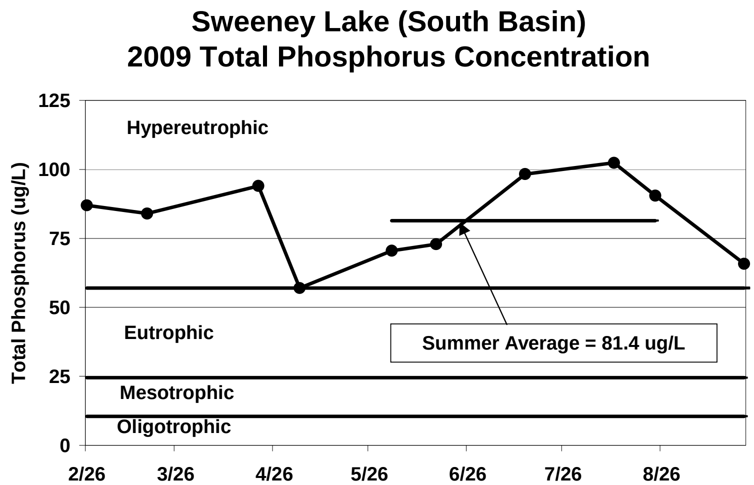
DIVISION	TAXON	Vertical Tow (m)	04/27/09 #/m2	06/02/09 #/m2	6/16/2009 #/m2	7/14/2009 #/m2	8/11/2009 #/m2	8/24/2009 #/m2	9/21/2009 #/m2
CLADOCERA	*Bosmina longirostris*		7,781	113,796	140,056	12,556	11,494	0	3,183
	Ceriodaphnia sp.		0	0	0	6,278	0	0	0
	Chydorus sphaericus		0	10,345	6,366	0	11,494	17,507	3,183
	Daphnia ambigua		0	0	0	0	0	0	0
	Daphnia galeata mendotae		46,685	72,415	133,690	470,832	86,209	11,671	9,549
	Daphnia pulex		31,124	31,035	6,366	18,833	11,494	0	0
	Daphnia retrocurva		0	0	0	113,000	0	5,836	0
	Diaphanosoma leuchtenbergianum		7,781	31,035	0	87,889	11,494	17,507	9,549
	Immature Cladocera		0	10,345	0	6,278	0	0	0
	CLADOCERA TOTAL		**93,371**	**268,971**	**286,478**	**715,665**	**132,187**	**52,521**	**25,465**
COPEPODA	*Cyclops sp.*		2,023,031	217,246	57,296	709,387	402,307	140,056	9,549
	Diaptomus sp.		15,562	93,105	50,929	113,000	103,450	0	19,099
	Copepodid		15,562	0	0	0	0	0	0
	Nauplii		1,758,481	579,323	401,070	1,029,553	850,593	268,441	66,845
	COPEPODA TOTAL		**3,812,636**	**889,674**	**509,295**	**1,851,940**	**1,356,351**	**408,497**	**95,493**
ROTIFERA	*Asplanchna priodonta*		0	31,035	184,619	31,389	0	0	0
	Brachionus havanensis		0	0	0	6,278	0	5,836	0
	Filinia longiseta		7,781	0	0	6,278	0	0	0
	Keratella cochlearis		38,904	2,534,537	993,125	332,721	51,725	5,836	9,549
	Keratella quadrata		93,371	31,035	6,366	6,278	0	0	0
	Kellicottia bostoniensis.		171,180	41,380	12,732	12,556	22,989	0	0
	Lecane sp.		0	0	25,465	25,111	11,494	5,836	6,366
	Polyarthra vulgaris		70,028	0	76,394	12,556	11,494	0	0
	Trichocerca cylindrica		0	0	0	0	0	0	0
	Trichocerca multicrinis		0	0	0	0	0	0	0
	Un identified Rotifer		0	0	0	0	0	0	0
	ROTIFERA TOTAL		**381,264**	**2,637,987**	**1,298,701**	**433,166**	**97,703**	**17,507**	**15,915**
	TOTALS		**4,287,270**	**3,796,632**	**2,094,474**	**3,000,771**	**1,586,241**	**478,525**	**136,873**

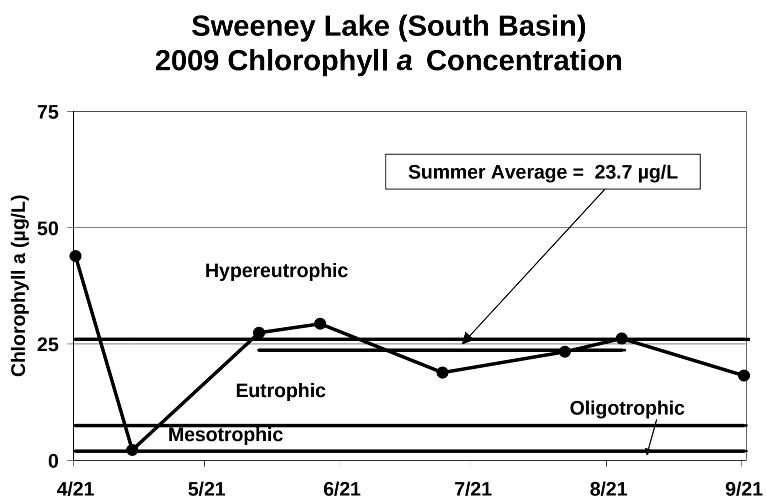
Sweeney Lake (North Basin) 2009

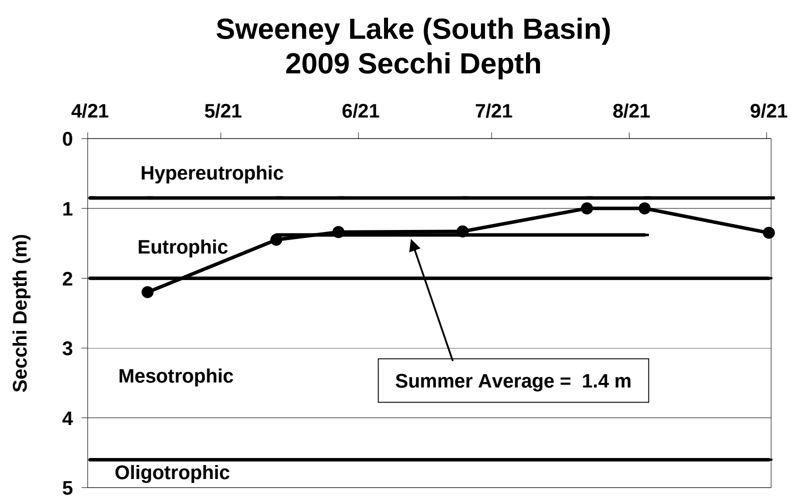
Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (µg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (µmhos/cm @25°C)	Total P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	pH
2/26/2009	8.2	0-2	.	.	.	.	.	.	56	.	.	.
		0	.	.	8.8	.	0.1	1277	.	.	.	7.7
		1	.	.	6.1	.	3	1437	.	.	.	7.7
		2	.	.	5.6	.	3.1	1468	.	.	.	7.7
		3	.	.	5.4	.	2.9	1535	64	.	.	7.7
		4	.	.	4.9	.	2.9	1578	70	.	.	7.7
		5	.	.	3.6	.	3.1	1643	72	.	.	7.7
		6	.	.	1.1	.	3.6	1783	180	.	.	7.6
		7	.	.	0.7	.	3.7	1871	220	.	.	7.6
		7.7	.	.	0.4	.	3.8	1930	290	.	.	7.6
3/17/2009	8.3	0-2	.	.	.	.	.	.	57	.	.	.
		0	.	.	11	.	0.99	684	.	.	.	7.82
		1	.	.	9.6	.	4.4	1522	.	.	.	7.82
		2	.	.	8.3	.	4.1	1540	.	.	.	7.78
		3	.	.	5.5	.	2.9	1630	67	.	.	7.67
		4	.	.	4	.	2.8	1656	63	.	.	7.85
		5	.	.	1.5	.	3.3	1676	72	.	.	7.62
		6	.	.	0.67	.	3.7	1758	190	.	.	7.61
		7	.	.	0.36	.	4	1875	270	.	.	7.58
		8	.	.	0.3	.	4.1	1888	490	.	.	7.56
4/21/2009	7.64	0-2	1	32.5	.	.	.	.	79.5	8.5	1.15	8.28
		0			14.62	131.9	10.59	1329				
		1	.	.	14.61	131.7	10.56	1329	.	.	.	8.28
		2	.	.	14.60	131.5	10.51	1330	.	.	.	8.28
		3	.	.	14.27	128.0	10.34	1331	.	.	.	8.25
		4	.	.	14.12	126.4	10.27	1333	.	.	.	8.23
		5	.	.	14.03	125.5	10.24	1332	83.2	7.2	.	8.23
		6	.	.	9.80	82.2	7.55	1369	66.0	8.7	.	7.77
		7	.	.	6.13	47.5	4.45	1676	62.2	8.6	.	7.55
		7.64	.	.	1.22	9.5	4.34	1665	.	.	.	7.3
5/4/2009	8	0-2	2.5	3.1	.	.	.	.	68.8	58.2	0.73	8.15
		0			11.19	111.6	15.11	1239				
		1	.	.	11.27	112.3	15.05	1238	.	.	.	8.14
		2	.	.	11.28	112.2	14.97	1236	.	.	.	8.15
		3	.	.	11.59	113.8	14.37	1232	.	.	.	8.14
		4	.	.	11.53	111.3	13.58	1236	.	.	.	8.08
		5	.	.	10.60	100.6	12.81	1241	.	.	.	8
		6	.	.	6.93	63.1	11.00	1264	53.0	32.5	.	7.72
		7	.	.	4.39	35.4	5.90	1598	63.3	40.2	.	7.39
		8	.	.	1.83	14.6	5.54	1499	130.9	55.0	.	7.24
6/2/2009	7.31	0-2	1.4	22.6	.	.	.	.	60.2	3.5	0.92	7.54
					11.90	130.4	19.61	1422				
		1	.	.	11.81	129.1	19.48	1422	.	.	.	7.7
		2	.	.	11.64	127.0	19.40	1421	.	.	.	7.80
		3	.	.	11.43	124.7	19.38	1421	.	.	.	7.86
		4	.	.	11.20	122.0	19.29	1421	.	.	.	7.86
		5	.	.	10.04	108.4	18.84	1424	58.4	6.1	.	7.8
		6	.	.	6.89	73.5	18.22	1423	57.3	2.8	.	7.65
		7	.	.	3.47	36.1	17.08	1432	85.3	13.9	.	7.52
		7.31	.	.	0.78	8.1	16.71	1438				7.12

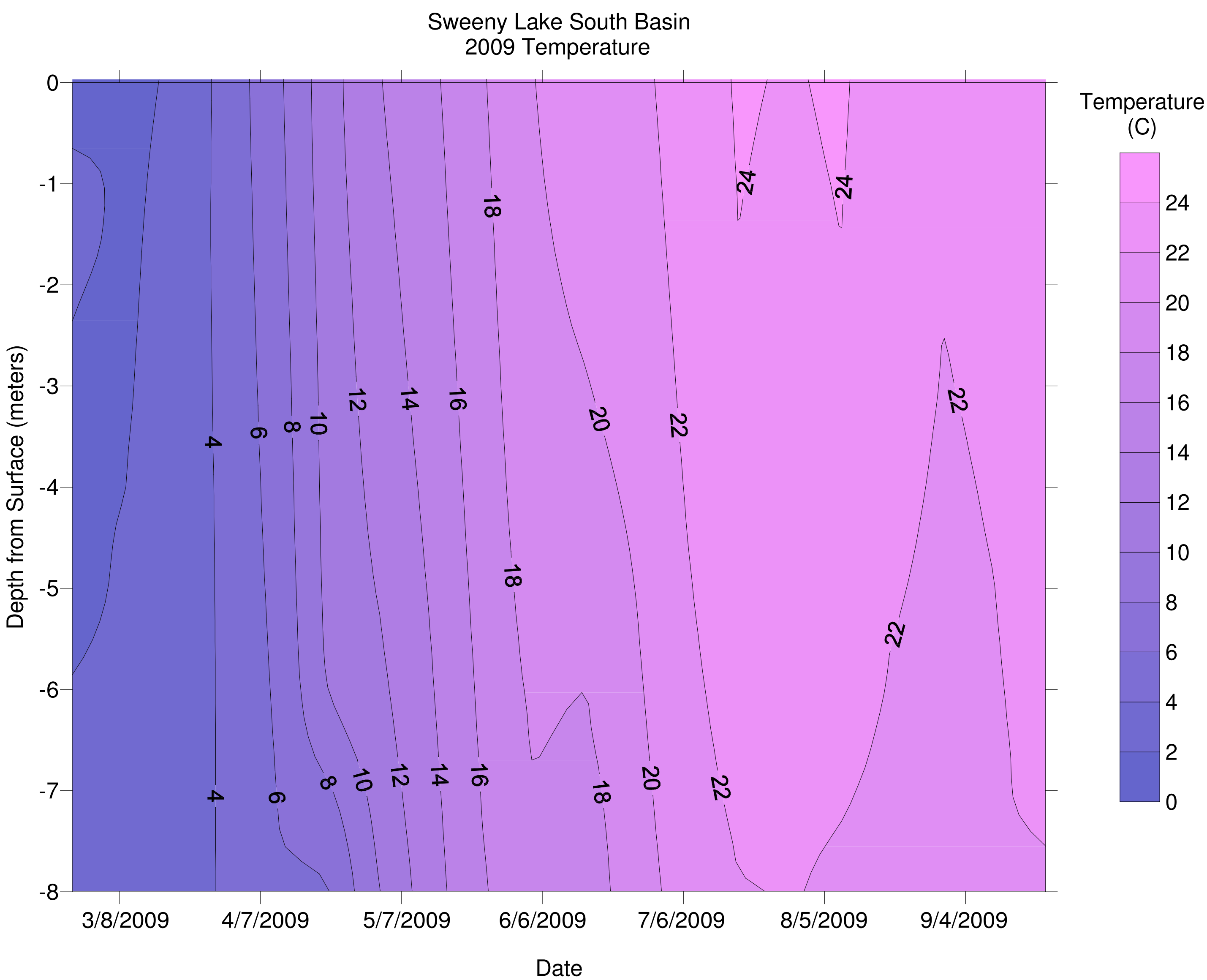
Sweeney Lake (North Basin) 2009

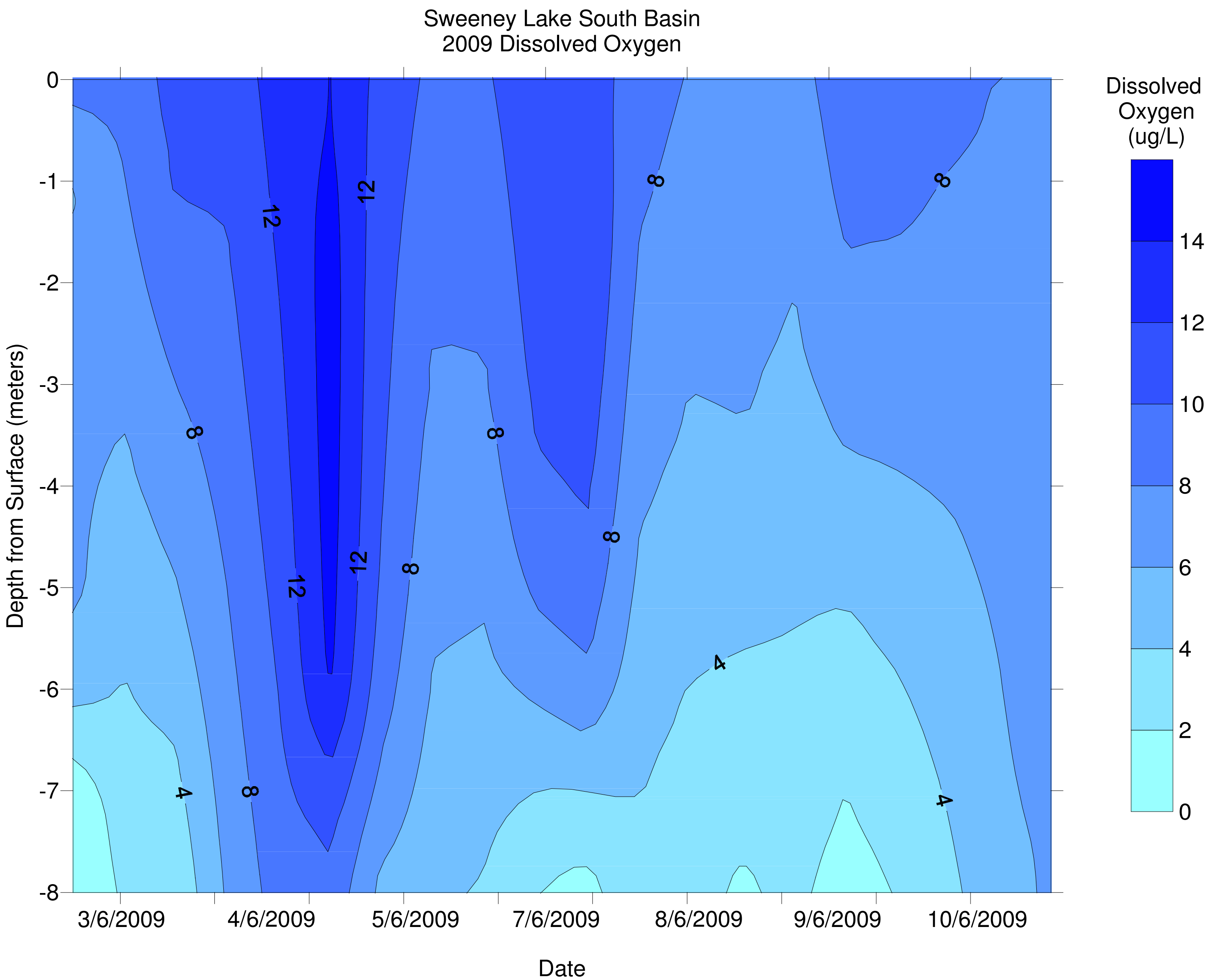
Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (µg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (µmhos/cm @25°C)	Total P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	pH
6/16/2009	7.25	0-2	1.3	34.9	.	.	.	.	73.1	0.0	0.85	7.89
		0			10.71	120.3	20.83	1614				
		1	.	.	12.00	133.6	20.38	1626	.	.	.	7.98
		2	.	.	11.89	132.1	20.28	1627	.	.	.	7.98
		3	.	.	11.21	124.3	20.16	1630	.	.	.	7.96
		4	.	.	10.91	120.6	19.98	1631	74.3	15.7	.	7.93
		5	.	.	8.97	96.0	18.42	1633	65.5	3.7	.	7.82
		6	.	.	6.72	70.9	17.72	1639	.	.	.	7.7
		7	.	.	2.73	28.4	16.99	1653	99.8	55.8	.	7.41
		7.25	.	.	1.06	11.0	16.78	1651	.	.	.	7.34
7/14/2009	7.528	0-2	1.3	20.7	.	.	.	.	103.1	18.4	0.79	7.63
		0			9.45	113.0	24.12	1333				
		1	.	.	9.36	111.9	24.12	1333	.	.	.	7.75
		2	.	.	9.19	109.8	24.11	1332	.	.	.	7.85
		3	.	.	8.92	106.4	24.07	1334	.	.	.	7.9
		4	.	.	7.85	93.5	23.98	1335	88.2	30.0	.	7.87
		5	.	.	6.43	76.4	23.78	1336	120.3	50.6	.	7.8
		6	.	.	4.34	51.3	23.56	1338	.	.	.	7.72
		7	.	.	1.08	12.6	23.05	1343	157.3	103.9	.	7.58
		7.528	.	.	0.80	9.2	22.02	1282	.	.	.	7.23
8/11/2009	7.56	0-2	1	10.9	.	.	.	.	89.0	26.4	0.87	7.65
		0			7.80	92.7	23.82	1224				
		1	.	.	7.72	92.0	24.03	1222	.	.	.	7.68
		2	.	.	7.95	94.7	24.00	1221	.	.	.	7.74
		3	.	.	7.54	89.8	23.96	1222	96.6	32.1	.	7.77
		4	.	.	6.39	75.7	23.69	1233	100.5	50.5	.	7.76
		5	.	.	2.00	23.4	22.88	1230	.	.	.	7.66
		6	.	.	1.33	15.4	22.73	1217	.	.	.	7.61
		7	.	.	0.62	7.1	22.45	1206	123.1	102.2	.	7.46
		7.56	.	.	0.49	5.6	21.82	1208	.	.	.	7.22
8/24/2009	7.62	0-2	0.85	36.6	.	.	.	.	95.3	13.1	1.07	8.19
		0			9.49	109.5	22.36	1083				
		1	.	.	9.44	109.1	22.38	1084	.	.	.	8.13
		2	.	.	9.61	111.0	22.39	1086	.	.	.	8.13
		3	.	.	9.57	110.4	22.32	1086	.	.	.	8.14
		4	.	.	6.32	72.6	22.03	1082	88.3	15.5	.	8.07
		5	.	.	4.03	46.1	21.89	1093	83.0	14.9	.	7.96
		6	.	.	2.38	27.1	21.69	1094	.	.	.	7.88
		7	.	.	2.25	25.7	21.65	1091	97.6	50.2	.	7.85
		7.62	.	.	1.41	16.0	21.49	1098	.	.	.	7.65
9/21/2009	7.529	0-2	1.3	20.9	.	.	.	.	69.0	15.8	0.94	7.5
		0			6.83	79.5	22.80	898				
		1	.	.	6.66	77.4	22.76	898	.	.	.	7.58
		2	.	.	6.46	75.1	22.73	898	.	.	.	7.65
		3	.	.	6.30	73.2	22.73	898	.	.	.	7.67
		4	.	.	6.73	78.3	22.72	897	90.4	12.8	.	7.74
		5	.	.	6.86	79.7	22.70	897	75.9	27.1	.	7.77
		6	.	.	6.02	69.8	22.61	897	.	.	.	7.81
		7	.	.	3.80	43.8	22.36	902	108.8	59.9	.	7.8
		7.529	.	.	2.80	31.9	21.70	852	.	.	.	7.77


Sweeney Lake (South Basin)
2009 Total Phosphorus Concentration
125
100
75
50
25
0
Total Phosphorus (ug/L)
Hypereutrophic
Eutrophic
Mesotrophic
Oligotrophic
Summer Average = 81.4 ug/L
2/26
3/26
4/26
5/26
6/26
7/26
8/26

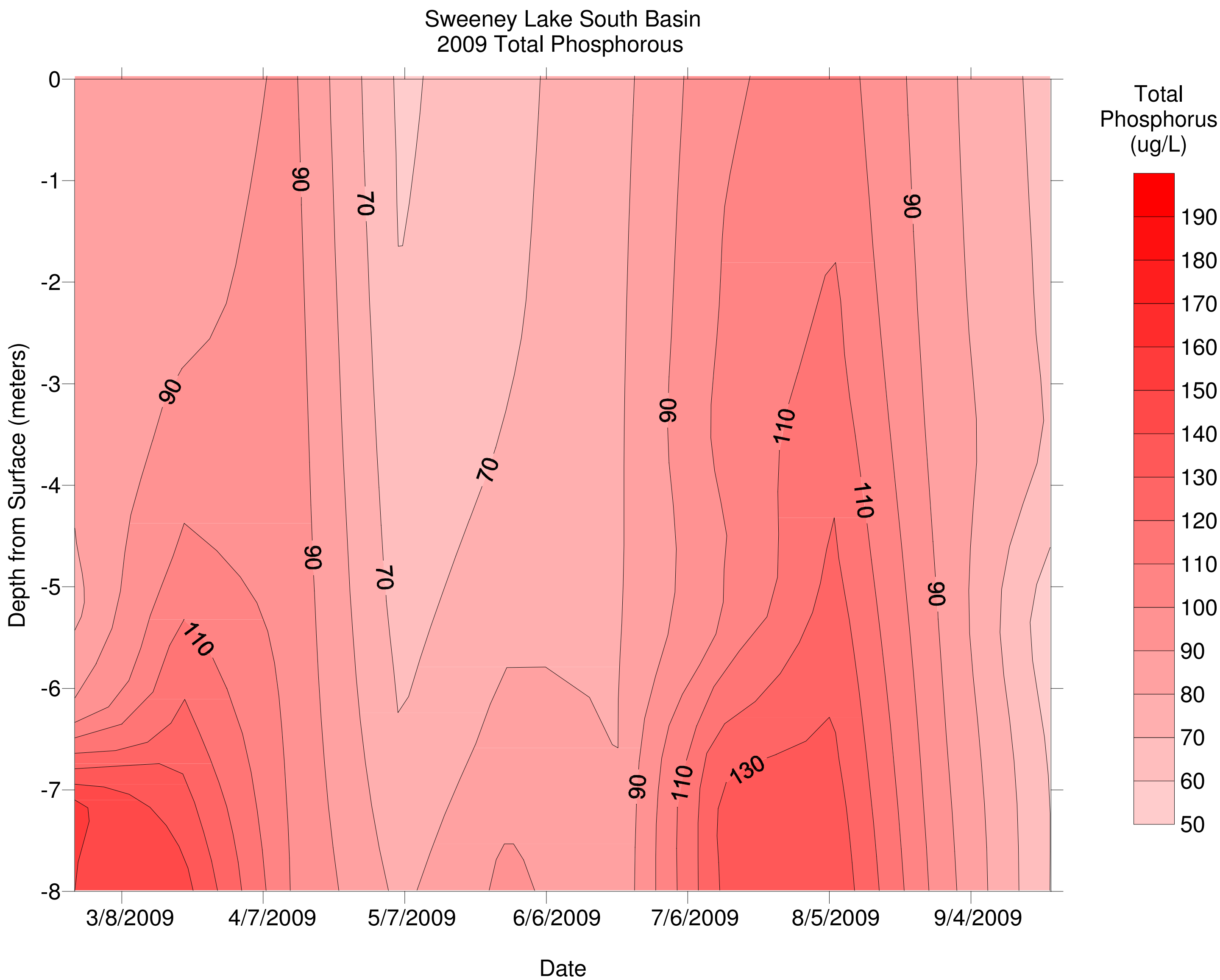

Sweeney Lake (South Basin)
2009 Chlorophyll a Concentration
75
50
25
0
Chlorophyll a (µg/L)
Summer Average = 23.7 µg/L
Hypereutrophic
Eutrophic
Oligotrophic
Mesotrophic
4/21
5/21
6/21
7/21
8/21
9/21


Sweeney Lake (South Basin)
2009 Secchi Depth
4/21
5/21
6/21
7/21
8/21
9/21
0
1
2
3
4
5
Secchi Depth (m)
Hypereutrophic
Eutrophic
Mesotrophic
Summer Average = 1.4 m
Oligotrophic


Sweeny Lake South Basin
2009 Temperature
Temperature
(C)
Depth from Surface (meters)
Date
3/8/2009
4/7/2009
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
0
-1
-2
-3
-4
-5
-6
-7
-8
24
22
20
18
16
14
12
10
8
6
4
2
0



Sweeney Lake South Basin
2009 Dissolved Oxygen
Depth from Surface (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
3/6/2009
4/6/2009
5/6/2009
7/6/2009
8/6/2009
9/6/2009
10/6/2009
Date
Dissolved
Oxygen
(ug/L)
14
12
10
8
6
4
2
0



Sweeney Lake South Basin
2009 Total Phosphorous
Depth from Surface (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
3/8/2009
4/7/2009
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Date
90
70
110
130
Total Phosphorus (ug/L)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50

SWEENEY LAKE SOUTH

SURFACE

STANDARD INVERTED MICROSCOPE ANALYSIS METHOD

DIVISION	TAXON	4/27/2009 units/mL	6/2/2009 units/mL	6/16/2009 units/mL	7/14/2009 units/mL	8/11/2009 units/mL	8/24/2009 units/mL	9/21/2009 units/mL
CHLOROPHYTA (GREEN ALGAE)	*Actinastrum Hantzschii*	0	0	0	0	57	0	0
	Ankistrodesmus Brauni	57	0	0	0	0	0	0
	Ankistrodesmus falcatus	402	0	115	0	230	115	0
	Carteria Klebsii	0	0	0	0	230	0	57
	Chlamydomonas globosa	10,051	1,264	2,412	2,814	7,524	2,125	2,068
	Closterium sp.	0	0	0	0	172	57	0
	Dictyosphaerium Ehrenbergianum	0	0	0	0	57	0	57
	Oocystis parva	0	0	0	115	345	345	0
	Rhizoclonium hieroglyphicum	0	57	0	0	517	0	0
	Scenedesmus dimorphus	0	0	0	0	0	57	115
	Scenedesmus quadricauda	0	0	0	0	115	57	0
	Scenedesmus sp.	57	57	57	0	0	57	0
	Schroederia Judayi	0	0	230	976	57	57	0
	Schroederia sp.	172	0	0	0	57	0	0
	Selenastrum minutum	115	0	57	57	57	172	57
	Selenastrum sp.	115	0	0	0	0	0	57
	Sphaerocystis Schroeteri	0	0	57	0	0	0	0
	Tetraedron minimum	0	0	0	0	57	0	0
	Tetraedron sp.	0	0	0	0	0	57	0
	CHLOROPHYTA TOTAL	**10,970**	**1,378**	**2,929**	**3,963**	**9,477**	**3,102**	**2,412**
CHRYSOPHYTA (YELLOW-BROWN ALGAE)	**CHRYSOPHYTA TOTAL**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
CYANOPHYTA (BLUE-GREEN ALGAE)	*Anabaena flos-aquae*	0	0	0	0	115	57	0
	Aphanizomenon flos-aquae	57	287	4,021	2,068	804	5,629	1,149
	Chroococcus sp.	0	0	0	0	115	0	0
	Cylindrospermopsis raciborski	0	0	0	57	5,686	1,321	3,274
	Lyngbya limnetica	115	57	0	0	230	230	57
	Merismopedia tenuissima	57	0	0	0	115	0	517
	Merismopedia sp.	0	0	0	0	57	0	0
	Microcystis aeruginosa	0	0	57	0	115	345	0
	Microcystis incerta	172	57	230	287	345	345	287
	Oscillatoria limnetica	57	0	0	0	976	3,848	3,906
	Oscillatoria Agardhii	0	0	0	2,297	402	4,078	1,781
	Phormidium mucicola	0	0	0	0	0	172	57
	CYANOPHYTA TOTAL	**459**	**402**	**4,308**	**4,710**	**8,960**	**16,025**	**11,028**
BACILLARIOPHYTA (DIATOMS)	*Asterionella formosa*	919	459	0	0	345	57	115
	Fragilaria crotonensis	0	2,297	402	115	172	172	230
	Melosira granulata	0	0	0	0	689	115	0
	Navicula sp.	57	0	0	0	57	172	57
	Stephanodiscus Hantzschii	689	230	230	0	632	3,102	172
	Stephanodiscus sp.	115	459	115	0	0	57	115
	Synedra ulna	402	172	57	0	230	345	57
	BACILLARIOPHYTA TOTAL	**2,183**	**3,618**	**804**	**115**	**2,125**	**4,021**	**747**
CRYPTOPHYTA (CRYPTOMONADS)	*Cryptomonas erosa*	10,626	976	5,858	4,825	6,375	3,848	862
	CRYPTOPHYTA TOTAL	**10,626**	**976**	**5,858**	**4,825**	**6,375**	**3,848**	**862**
EUGLENOPHYTA (EUGLENOIDS)	*Euglena sp.*	0	0	0	0	57	0	0
	EUGLENOPHYTA TOTAL	**0**	**0**	**0**	**0**	**57**	**0**	**0**
PYRRHOPHYTA (DINOFLAGELLATES)	*Ceratium hirundinella*	0	0	172	0	57	57	0
	Peridinium cinctum	0	0	0	0	115	0	57
	PYRRHOPHYTA TOTAL	**0**	**0**	**172**	**0**	**172**	**57**	**57**
	TOTALS	**24,238**	**6,375**	**14,072**	**13,612**	**27,167**	**27,052**	**15,106**

SWEENEY LAKE SOUTH

ZOOPLANKTON ANALYSIS

DIVISION	TAXON	Vertical Tow (m)	04/27/09 #/m2	06/02/09 #/m2	6/16/2009 #/m2	7/14/2009 #/m2	8/11/2009 #/m2	8/24/2009 #/m2	9/21/2009 #/m2
CLADOCERA	*Bosmina longirostris*		60,518	58,622	152,788	0	8,135	11,494	9,284
	Ceriodaphnia sp.		0	0	0	32,538	0	0	0
	Chydorus sphaericus		8,645	4,509	0	0	0	0	0
	Daphnia ambigua		0	0	6,366	0	0	0	0
	Daphnia galeata mendotae		95,100	76,659	89,127	235,902	113,884	11,494	3,095
	Daphnia pulex		0	4,509	12,732	73,211	24,404	5,747	0
	Daphnia retrocurva		0	0	0	48,807	32,538	22,989	3,095
	Diaphanosoma leuchtenbergianum		0	0	0	81,346	24,404	40,231	27,852
	Immature Cladocera		0	0	0	8,135	0	0	0
	CLADOCERA TOTAL		**164,263**	**144,300**	**261,013**	**479,939**	**203,364**	**91,956**	**43,325**
COPEPODA	*Cyclops sp.*		1,711,796	153,319	95,493	398,594	382,325	166,670	24,757
	Diaptomus sp.		34,582	76,659	95,493	65,077	81,346	11,494	24,757
	Copepodid		8,645	0	0	0	0	0	0
	Nauplii		2,498,530	419,372	572,956	1,163,243	658,900	304,604	64,988
	COPEPODA TOTAL		**4,253,553**	**649,351**	**763,942**	**1,626,913**	**1,122,570**	**482,769**	**114,503**
ROTIFERA	*Asplanchna priodonta*		8,645	0	305,577	0	0	0	0
	Brachionus havanensis		34,582	0	0	0	24,404	0	0
	Filinia longiseta		8,645	0	0	0	0	0	0
	Keratella cochlearis		34,582	1,122,835	1,190,476	146,422	97,615	28,736	9,284
	Keratella quadrata		293,945	9,019	19,099	8,135	0	0	0
	Kellicottia bostoniensis.		302,590	18,038	6,366	8,135	16,269	0	0
	Lecane sp.		8,645	0	38,197	32,538	0	5,747	0
	Polyarthra vulgaris		337,172	13,528	25,465	24,404	0	5,747	0
	Trichocerca cylindrica		0	0	0	0	0	0	0
	Trichocerca multicrinis		0	0	0	0	0	0	0
	Un identified Rotifer		0	9,019	0	0	0	0	0
	ROTIFERA TOTAL		**1,028,807**	**1,163,420**	**1,585,180**	**219,633**	**138,288**	**40,231**	**9,284**
	TOTALS		**5,446,623**	**1,957,071**	**2,610,135**	**2,326,486**	**1,464,222**	**614,956**	**167,112**

Sweeney Lake (South Basin) 2009

Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (µg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (µmhos/cm @25°C)	Total P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	pH
2/26/2009	7.8	0-2	.	.	.	.	.	.	87	.	.	.
		0	.	.	8.9	.	0.2	1401	.	.	.	7.5
		1	.	.	5.6	.	2.9	1510	.	.	.	7.5
		2	.	.	6.8	.	2.1	1535	.	.	.	7.6
		3	.	.	6.6	.	1.8	1624	82	.	.	7.6
		4	.	.	6.4	.	1.8	1664	80	.	.	7.7
		5	.	.	6.4	.	1.7	1740	80	.	.	7.7
		6	.	.	4.8	.	2.1	2008	75	.	.	7.6
		7	.	.	0.7	.	2.6	2294	150	.	.	7.5
		7.5	.	.	0.3	.	3.5	2346	150	.	.	7.4
3/17/2009	7.8	0-2	.	.	.	.	.	.	84	.	.	.
		0	.	.	10.6	.	0.69	296	.	.	.	7.89
		1	.	.	14.2	.	4.1	1549	.	.	.	8.1
		2	.	.	8.4	.	3.1	1592	.	.	.	7.71
		3	.	.	6.7	.	2.1	1681	65	.	.	7.65
		4	.	.	6.1	.	1.9	1726	61	.	.	7.64
		5	.	.	6.3	.	1.9	1777	72	.	.	6.65
		6	.	.	6	.	2.1	1909	67	.	.	7.64
		7	.	.	1.1	.	2.7	2140	200	.	.	7.5
		7.5	.	.	0.5	.	3.2	2269	180	.	.	7.48
4/21/2009	8	0-2	.	43.9	.	.	.	.	94.0	7.2	1.27	8.37
		0			13.98	127.6	11.09	1329				
		1	.	.	14.71	133.9	10.98	1331	.	.	.	8.37
		2	.	.	14.97	135.7	10.80	1327	.	.	.	8.34
		3	.	.	14.96	135.1	10.63	1331	.	.	.	8.33
		4	.	.	14.89	134.4	10.59	1331	.	.	.	8.32
		5	.	.	14.78	133.0	10.50	1332	80.6	9.1	.	8.31
		6	.	.	14.64	131.4	10.38	1333	90.1	10.2	.	8.29
		7	.	.	10.95	90.2	6.84	1392	.	.	.	7.86
		8	.	.	9.45	75.2	5.44	1736	76.6	11.0	.	7.6
5/4/2009	8	0-2	2.2	2.23	.	.	.	.	57.0	29.2	0.74	8.12
		0			10.78	106.0	14.41	1241				
		1	.	.	10.15	98.4	13.77	1243	.	.	.	8.11
		2	.	.	9.99	96.7	13.72	1242	.	.	.	8.11
		3	.	.	9.98	96.3	13.56	1242	.	.	.	8.1
		4	.	.	9.98	95.1	12.99	1242	.	.	.	8.08
		5	.	.	9.64	91.2	12.70	1242	.	.	.	8.04
		6	.	.	9.23	86.2	12.09	1248	66.1	45.3	.	7.96
		7	.	.	8.41	78.0	11.80	1252	66.4	35.7	.	7.9
		8	.	.	3.20	28.1	9.52	1481	83.0	51.0	.	7.33
6/2/2009	7.206	0-2	1.45	27.42	.	.	.	.	70.5	3.9	0.68	8.02
		0			10.92	120.1	19.76	1420				
		1	.	.	11.40	124.9	19.60	1418	.	.	.	8.05
		2	.	.	11.18	122.0	19.43	1418	.	.	.	8.04
		3	.	.	11.04	120.5	19.40	1419	.	.	.	8.03
		4	.	.	10.77	117.3	19.31	1418	.	.	.	8.01
		5	.	.	10.38	112.3	18.98	1420	54.8	5.2	.	7.99
		6	.	.	8.05	86.0	18.38	1424	60.8	2.3	.	7.86
		7	.	.	2.44	25.4	17.17	1437	108.2	30.1	.	7.34
		7.206	.	.	0.42	4.4	17.17	1438				7.22

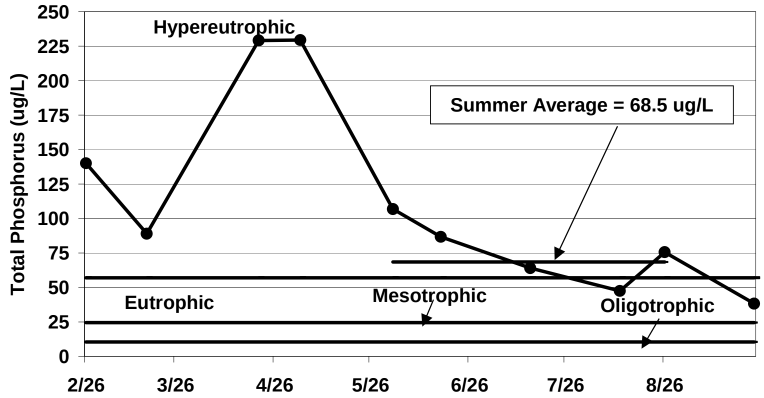
Sweeney Lake (South Basin) 2009

Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (µg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (µmhos/cm @25°C)	Total P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	pH
6/16/2009	7.267	0-2	1.34	29.36	.	.	.	.	72.9	5.2	0.77	8.02
		0			10.55	119.1	21.10	1617				
		1	.	.	12.74	143.1	20.83	1626	.	.	.	8.11
		2	.	.	12.15	135.1	20.32	1629	.	.	.	8.05
		3	.	.	11.33	125.3	20.05	1632	.	.	.	7.99
		4	.	.	10.55	115.9	19.71	1635	81.1	3.7	.	7.94
		5	.	.	9.39	100.6	18.47	1638	62.6	3.5	.	7.87
		6	.	.	8.66	92.2	18.12	1632	.	.	.	7.82
		7	.	.	3.60	37.3	16.82	1660	71.2	39.8	.	7.44
		7.267	.	.	0.72	7.5	16.72	1667	.	.	.	7.22
7/14/2009	7.774	0-2	1.33	18.87	.	.	.	.	98.3	35.2	0.82	7.69
		0			7.78	93.0	24.12	1338				
		1	.	.	7.85	93.7	24.03	1337	.	.	.	7.72
		2	.	.	7.66	91.3	23.95	1337	.	.	.	7.76
		3	.	.	7.23	86.1	23.93	1338	.	.	.	7.77
		4	.	.	6.93	82.5	23.90	1338	103.9	50.5	.	7.77
		5	.	.	6.33	75.2	23.85	1338	94.5	44.5	.	7.76
		6	.	.	3.65	43.3	23.64	1341	.	.	.	7.67
		7	.	.	0.78	9.1	22.93	1349	132.5	77.2	.	7.53
		7.774	.	.	0.71	7.9	20.61	1423	.	.	.	7.28
8/11/2009	7.465	0-2	1	23.35	.	.	.	.	102.4	25.0	0.93	7.79
		0			9.55	114.5	24.31	1183				
		1	.	.	9.43	112.5	24.09	1172	.	.	.	7.88
		2	.	.	9.05	107.8	23.99	1168	.	.	.	7.89
		3	.	.	8.01	95.2	23.88	1178	93.5	34.3	.	7.88
		4	.	.	5.43	64.2	23.61	1179	93.4	41.6	.	7.82
		5	.	.	4.03	47.3	23.10	1224	.	.	.	7.76
		6	.	.	2.24	25.9	22.60	1179	.	.	.	7.71
		7	.	.	1.04	11.9	21.94	1176	152.2	85.8	.	7.43
		7.465	.	.	0.58	6.5	21.12	1327	.	.	.	7.11
8/24/2009	7.552	0-2	1	26.17	.	.	.	.	90.5	11.3	0.84	8.11
		0			9.20	106.1	22.24	1088				
		1	.	.	9.21	106.1	22.25	1088	.	.	.	8.13
		2	.	.	9.04	104.0	22.20	1089	.	.	.	8.14
		3	.	.	8.39	96.4	22.10	1090	.	.	.	8.14
		4	.	.	7.53	86.5	22.07	1091	78.7	13.1	.	8.11
		5	.	.	4.34	49.7	21.88	1097	94.7	36.6	.	8.02
		6	.	.	3.42	39.1	21.72	1088	.	.	.	7.97
		7	.	.	2.09	23.7	21.48	1084	105.1	37.6	.	7.92
		7.552	.	.	1.60	18.1	21.15	1095	.	.	.	7.72
9/21/2009	7.447	0-2	1.35	18.22	.	.	.	.	65.8	11.2	0.77	7.87
		0			7.91	91.8	22.66	906				
		1	.	.	7.78	90.3	22.67	908	.	.	.	7.92
		2	.	.	7.74	89.8	22.63	909	.	.	.	7.95
		3	.	.	7.59	88.1	22.60	910	.	.	.	7.97
		4	.	.	7.50	86.9	22.57	910	69.2	15.7	.	7.99
		5	.	.	7.49	86.8	22.57	910	52.3	12.4	.	8
		6	.	.	7.39	85.4	22.43	914	.	.	.	8.01
		7	.	.	6.75	77.9	22.33	921	59.9	21.3	.	8.01
		7.477	.	.	6.38	73.1	21.94	1039	.	.	.	7.8

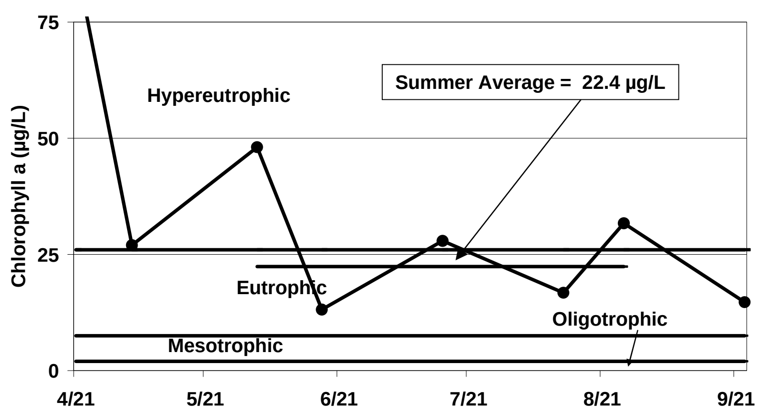
Appendix B

2009 Twin Lake Data

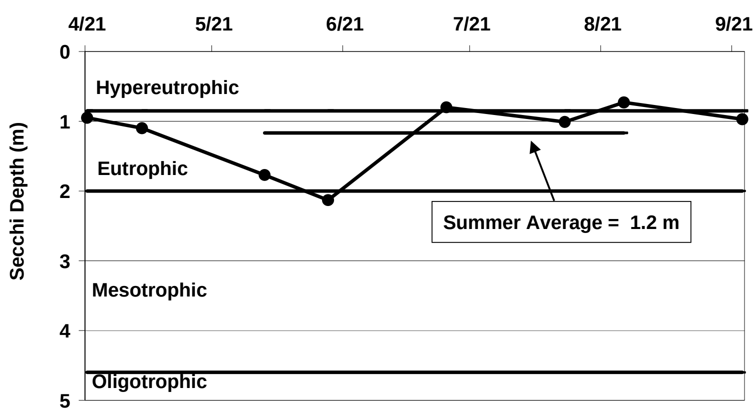
Twin Lake
2009 Total Phosphorus Concentration

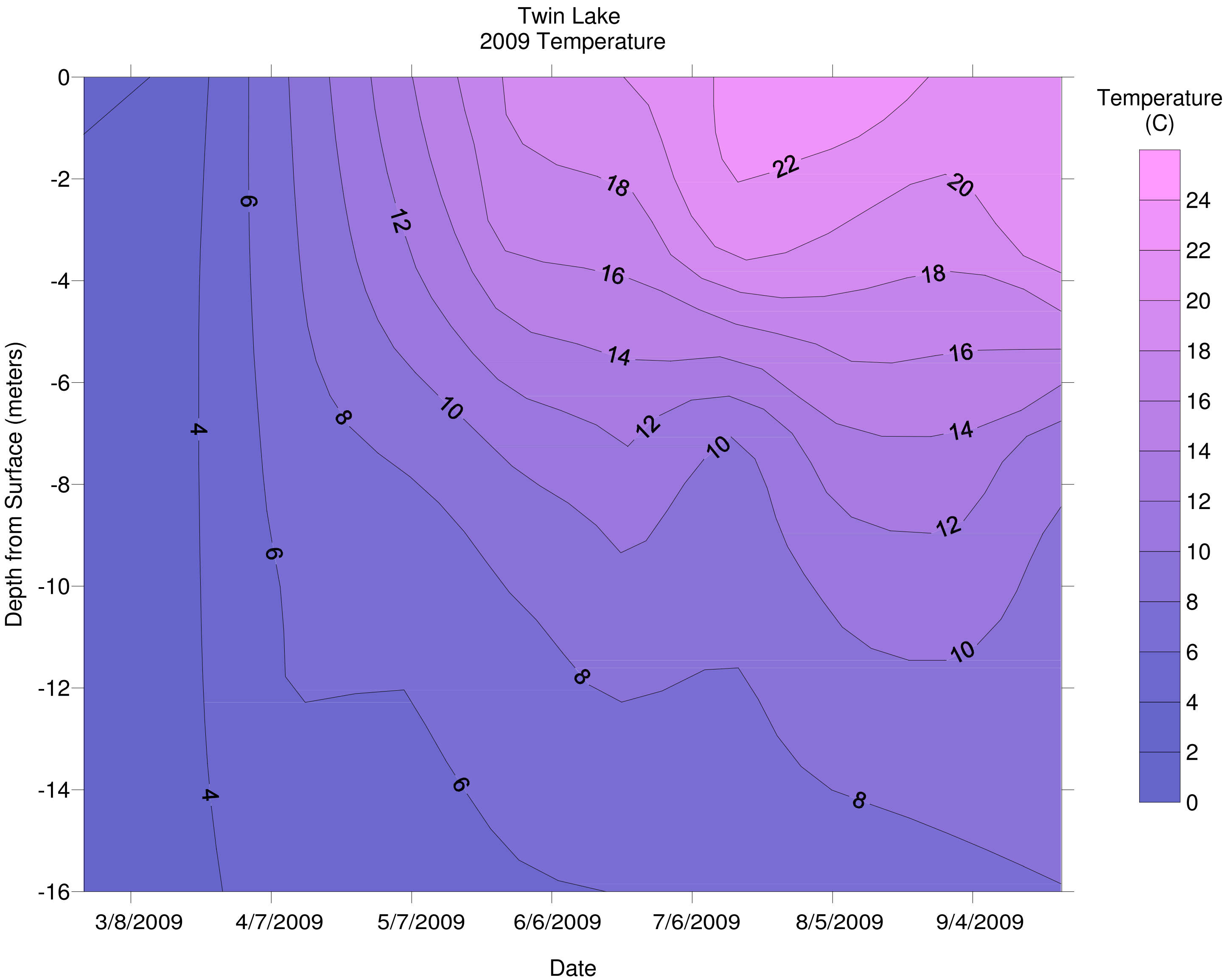


Twin Lake
2009 Chlorophyll *a* Concentration

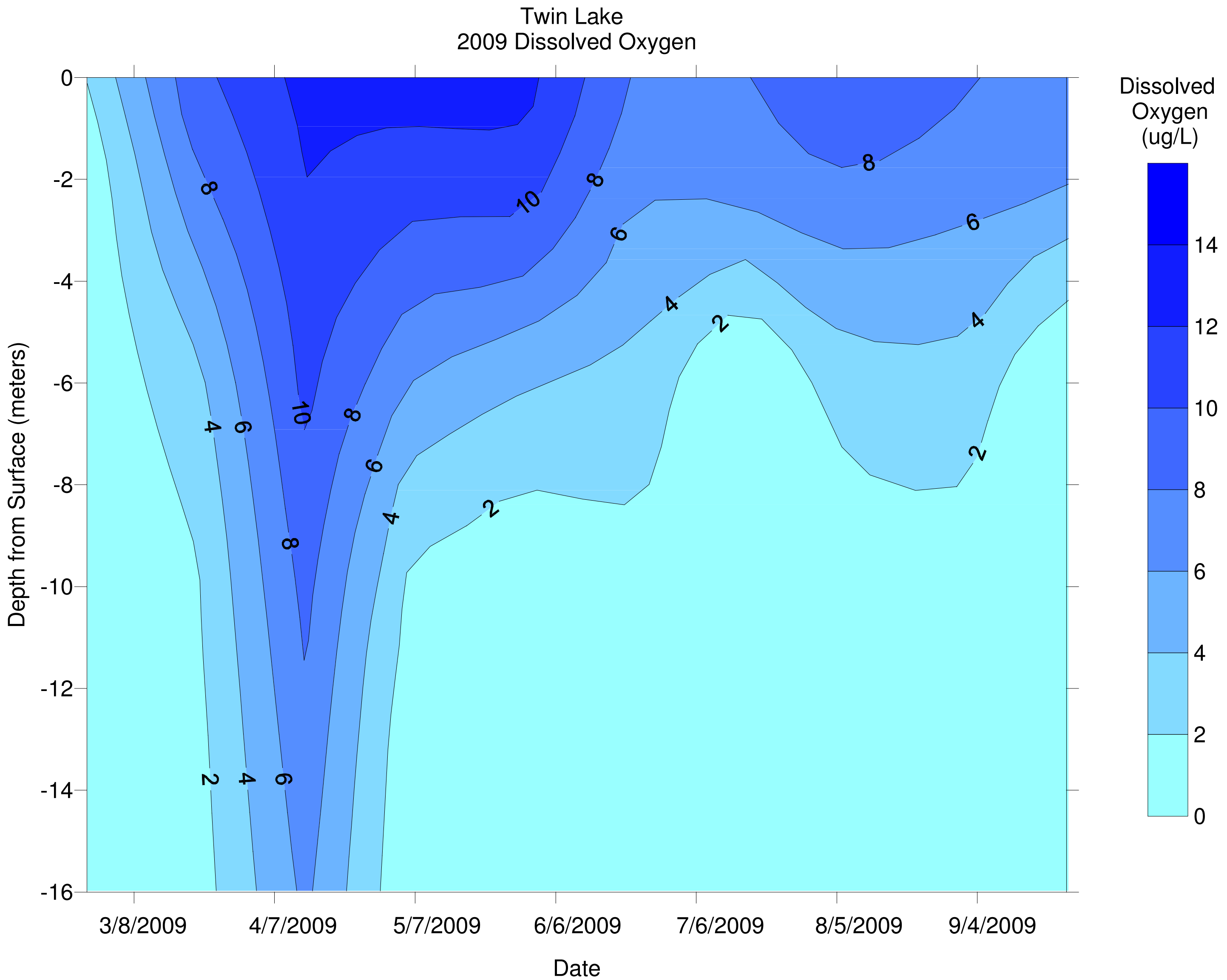


Twin Lake
2009 Secchi Depth

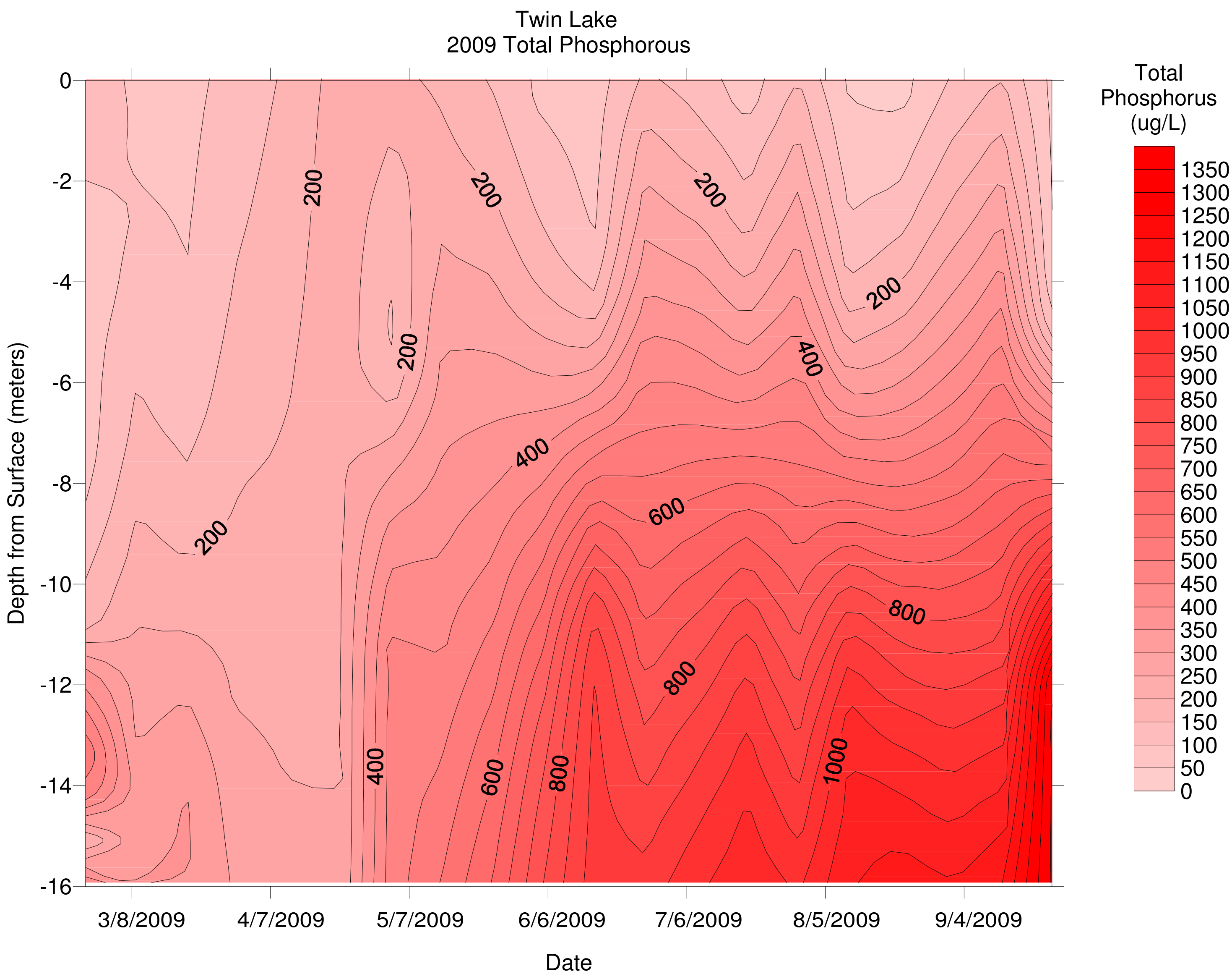




Twin Lake
2009 Temperature
Temperature (C)
Depth from Surface (meters)
Date
3/8/2009
4/7/2009
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
0
-2
-4
-6
-8
-10
-12
-14
-16
24
22
20
18
16
14
12
10
8
6
4
2
0



Twin Lake
2009 Dissolved Oxygen
Depth from Surface (meters)
0
-2
-4
-6
-8
-10
-12
-14
-16
3/8/2009
4/7/2009
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Date
Dissolved
Oxygen
(ug/L)
14
12
10
8
6
4
2
0



Twin Lake
2009 Total Phosphorous
Total
Phosphorus
(ug/L)
1350
1300
1250
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Depth from Surface (meters)
0
-2
-4
-6
-8
-10
-12
-14
-16
200
400
600
800
1000
3/8/2009
4/7/2009
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Date

TWIN LAKE

SURFACE

STANDARD INVERTED MICROSCOPE ANALYSIS METHOD

DIVISION	TAXON	4/27/2009 units/mL	6/2/2009 units/mL	6/17/2009 units/mL	7/15/2009 units/mL	8/12/2009 units/mL	8/26/2009 units/mL
	Ankistrodesmus Brauni	0	0	0	230	86	0
CHLOROPHYTA (GREEN ALGAE)	*Ankistrodesmus falcatus*	0	0	0	115	86	241
	Chlamydomonas globosa	7,237	862	172	11,832	4,030	3,849
	Oocystis parva	0	0	0	57	0	0
	Pandorina morum	0	689	57	0	0	0
	Scenedesmus sp.	57	0	0	0	0	0
	Schroederia Judayi	0	0	115	57	0	0
	Selenastrum minutum	0	0	0	0	0	241
	Selenastrum sp.	0	0	0	230	0	0
	Sphaerocystis Schroeteri	57	0	0	0	0	0
	Staurastrum sp.	0	0	0	57	86	0
	Tetraedron minimum	0	0	0	0	86	0
	CHLOROPHYTA TOTAL	**7,352**	**1,551**	**345**	**12,578**	**4,373**	**4,330**
CHRYSOPHYTA (YELLOW-BROWN ALGAE)	**CHRYSOPHYTA TOTAL**	**0**	**0**	**0**	**0**	**0**	**0**
CYANOPHYTA (BLUE-GREEN ALGAE)	*Anabaena affinis*	0	0	0	57	514	0
	Anabaena flos-aquae	0	57	0	57	0	0
	Anabaena spiroides v. crassa	0	0	0	632	0	0
	Aphanizomenon flos-aquae	0	230	804	976	86	1,684
	Cylindrospermopsis raciborski	0	0	0	0	10,375	38,005
	Gomphsphaeia Naegel.	0	0	517	115	0	0
	Lyngbya limnetica	0	0	0	0	86	2,285
	Merismopedia tenuissima	57	0	0	0	171	0
	Microcystis aeruginosa	0	0	57	115	257	241
	Microcystis incerta	747	0	115	3,216	4,030	3,728
	Oscillatoria limnetica	230	0	57	2,585	15,519	12,267
	Oscillatoria Agardhii	57	0	0	115	257	0
	Phormidium mucicola	57	0	115	57	943	241
	CYANOPHYTA TOTAL	**1,149**	**287**	**1,666**	**7,926**	**32,239**	**58,450**
BACILLARIOPHYTA (DIATOMS)	*Fragilaria capucina*	115	0	0	0	0	0
	Navicula sp.	57	0	0	0	0	0
	Nitzschia sp.	57	0	0	0	0	0
	Rhizosolenia sp.	0	0	0	0	0	120
	Rhoicosphenia curvata	57	0	0	0	0	0
	Stephanodiscus Hantzschii	459	0	0	115	0	0
	Stephanodiscus sp.	57	0	0	0	0	0
	Synedra ulna	57	0	0	57	0	1,323
	BACILLARIOPHYTA TOTAL	**862**	**0**	**0**	**172**	**0**	**1,443**
CRYPTOPHYTA (CRYPTOMONADS)	*Cryptomonas erosa*	22,457	919	345	1,378	4,201	3,608
	CRYPTOPHYTA TOTAL	**22,457**	**919**	**345**	**1,378**	**4,201**	**3,608**
EUGLENOPHYTA (EUGLENOIDS)	**EUGLENOPHYTA TOTAL**	**0**	**0**	**0**	**0**	**0**	**0**
PYRRHOPHYTA (DINOFLAGELLATES)	*Peridinium cinctum*	172	0	0	0	0	0
	PYRRHOPHYTA TOTAL	**172**	**0**	**0**	**0**	**0**	**0**
	TOTALS	**31,992**	**2,757**	**2,355**	**22,055**	**40,813**	**67,831**

TWIN LAKE

ZOOPLANKTON ANALYSIS

DIVISION	TAXON	*Vertical Tow (m)*	*04/27/09* #/m2	*06/02/09* #/m2	6/17/2009 #/m2	7/15/2009 #/m2	8/12/2009 #/m2	8/26/2009 #/m2
CLADOCERA	*Bosmina longirostris*		40,319	28,913	42,441	5,128	0	2,741
	Chydorus sphaericus		0	19,275	45,978	15,385	31,566	43,856
	Daphnia galeata mendotae		26,879	231,305	190,985	15,385	18,038	2,741
	Daphnia pulex		0	0	7,074	0	0	0
	Daphnia retrocurva		0	0	0	0	0	2,741
	Diaphanosoma leuchtenbergianum		6,720	19,275	0	0	40,584	21,928
	Immature Cladocera		0	9,638	0	0	0	0
	CLADOCERA TOTAL		**73,918**	**308,406**	**286,478**	**35,898**	**90,188**	**74,007**
COPEPODA	*Cyclops sp.*		1,606,046	154,203	21,221	46,155	49,603	46,597
	Diaptomus sp.		0	106,015	42,441	66,668	27,056	19,187
	Copepodid		0	19,275	3,537	10,257	0	0
	Nauplii		1,545,568	501,160	240,500	287,186	315,657	126,086
	COPEPODA TOTAL		**3,151,614**	**780,653**	**307,699**	**410,265**	**392,316**	**191,870**
ROTIFERA	*Asplanchna priodonta*		0	0	10,610	0	0	0
	Brachionus havanensis		383,032	0	0	0	0	0
	Keratella cochlearis		235,195	231,305	60,125	497,446	18,038	137,050
	Keratella quadrata		6,720	48,188	14,147	0	0	0
	Kellicottia bostoniensis.		6,720	9,638	0	25,642	9,019	16,446
	Lecane sp.		0	0	0	71,796	13,528	2,741
	Polyarthra vulgaris		0	9,638	0	5,128	0	2,741
	Trichocerca cylindrica		0	0	3,537	0	0	0
	Trichocerca multicrinis		0	0	0	5,128	4,509	0
	ROTIFERA TOTAL		**631,667**	**298,768**	**88,419**	**605,141**	**45,094**	**158,978**
	TOTALS		**3,857,199**	**1,387,828**	**682,596**	**1,051,304**	**527,597**	**424,854**

Twin Lake 2009

Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (µg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (µmhos/cm @25°C)	Total P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	pH
2/26/2009	16.4	0-2	.	.	.	.	.	.	140	.	.	.
	.	0	.	.	2.1	.	0.2	819	.	.	.	8.2
	.	1	.	.	1.2	.	2.9	826	.	.	.	7.6
	.	2	.	.	0.5	.	3.1	827	.	.	.	7.6
	.	3	.	.	0.4	.	3.1	826	62	.	.	7.6
	.	4	.	.	0.4	.	3.1	826	64	.	.	7.6
	.	5	.	.	0.3	.	3.3	832	76	.	.	7.6
	.	6	.	.	0.3	.	3.4	832	79	.	.	7.6
	.	7	.	.	0.3	.	3.5	835	77	.	.	7.6
	.	8	.	.	0.3	.	3.5	841	86	.	.	7.5
	.	9	.	.	0.3	.	3.5	851	120	.	.	7.5
	.	10	.	.	0.3	.	3.5	860	150	.	.	7.4
	.	11	.	.	0.3	.	3.6	876	200	.	.	7.4
	.	12	.	.	0.3	.	3.8	887	400	.	.	7.2
	.	13	.	.	0.3	.	3.7	895	490	.	.	7.2
	.	14	.	.	0.2	.	3.8	904	600	.	.	7.2
	.	15	.	.	0.2	.	3.8	910	160	.	.	7.2
	.	16	.	.	0.2	.	3.8	960	430	.	.	7.2
3/17/2009	16.4	0-2	.	.	.	.	.	.	89	.	.	.
	.	0	.	.	10.5	.	1.1	421	.	.	.	7.76
	.	1	.	.	8.7	.	3.7	810	.	.	.	7.78
	.	2	.	.	8.5	.	3.7	812	.	.	.	7.8
	.	3	.	.	8.7	.	3.7	812	85	.	.	7.82
	.	4	.	.	0.87	.	3.4	817	86	.	.	7.55
	.	5	.	.	0.33	.	3.4	816	90	.	.	7.53
	.	6	.	.	0.28	.	3.4	817	91	.	.	7.5
	.	7	.	.	0.26	.	3.5	824	110	.	.	7.42
	.	8	.	.	0.24	.	3.5	832	120	.	.	7.38
	.	9	.	.	0.23	.	3.5	842	170	.	.	7.36
	.	10	.	.	0.22	.	3.5	852	200	.	.	7.31
	.	11	.	.	0.22	.	3.5	864	220	.	.	7.21
	.	12	.	.	0.22	.	3.6	871	370	.	.	7.17
	.	13	.	.	0.22	.	3.8	882	220	.	.	7.12
	.	14	.	.	0.2	.	3.7	893	570	.	.	7.16
	.	15	.	.	0.2	.	3.5	917	500	.	.	7.19
	.	16	.	.	0.2	.	3.5	956	290	.	.	7.2
4/21/2009	7.883	0-2	0.95	88.06	.	.	.	.	229.0	21.4	2.55	8.98
		0			13.10	116.1	9.95	544				
		1	.	.	13.09	116.0	9.93	543	.	.	.	8.97
		2	.	.	13.11	116.0	9.88	543	.	.	.	8.94
		3	.	.	13.04	115.4	9.90	543	.	.	.	8.94
		4	.	.	12.98	114.7	9.83	544	229.9	26.1	.	8.92
		5	.	.	12.83	113.2	9.75	544	228.0	18.1	.	8.9
		6	.	.	12.70	112.0	9.74	544	.	.	.	8.9
		7	.	.	12.68	111.7	9.69	544	234.8	24.4	.	8.87
		7.883	.	.	7.29	61.9	8.17	573	.	.	.	7.6

Twin Lake 2009

Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (μg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (μmhos/cm @25°C)	Total P (μg/L)	Ortho P (μg/L)	Total N (mg/L)	pH
5/4/2009	77.775	0-2	1.1	26.98	.	.	.	.	229.4	18.2	2.46	8.98
		0			14.00	135.3	13.75	520				
		1	.	.	13.67	131.7	13.61	519	.	.	.	8.94
		2	.	.	12.15	114.5	12.61	523	.	.	.	8.63
		3	.	.	9.90	92.5	12.24	524	.	.	.	8.37
		4	.	.	8.75	81.3	11.96	524	.	.	.	8.33
		5	.	.	8.33	76.5	11.51	526	.	.	.	8.24
		6	.	.	6.27	54.5	9.13	541	107.3	55.1	.	7.98
		7	.	.	4.50	37.4	7.30	562	265.2	150.5	.	7.8
		8	.	.	2.06	16.8	6.44	578	.	.	.	7.63
		9	.	.	1.46	11.8	6.17	583	.	.	.	7.56
		10	.	.	0.86	6.9	6.00	586	.	.	.	7.47
		11	.	.	0.65	5.2	5.95	587	483.7	375.9	.	7.43
		11.775	.	.	0.33	2.6	5.79	666	.	.	.	6.94
6/2/2009	13.208	0-2	1.77	48.08	.	.	.	.	106.8	2.4	1.75	8.85
		0			13.30	145.1	19.53	620				
		1	.	.	13.62	148.6	19.50	621	.	.	.	8.89
		2	.	.	13.65	148.7	19.44	621	.	.	.	8.88
		3	.	.	11.89	127.7	18.76	624	.	.	.	8.67
		4	.	.	10.32	109.6	18.18	626	.	.	.	8.5
		5	.	.	2.16	21.3	14.78	628	100.2	15.6	.	7.97
		6	.	.	0.30	2.8	11.31	637	317.9	215.2	.	7.68
		7	.	.	0.21	1.8	8.66	660	.	.	.	7.53
		8	.	.	0.18	1.5	7.59	670	.	.	.	7.43
		9	.	.	0.16	1.3	7.40	669	.	.	.	7.36
		10	.	.	0.15	1.2	7.30	670	.	.	.	7.32
		11	.	.	0.13	1.1	7.23	671	.	.	.	7.28
		12	.	.	0.13	1.0	7.22	672	.	.	.	7.26
		13	.	.	0.11	0.9	6.98	717	749.9	591.9	.	6.91
		13.208	.	.	0.10	0.9	6.93	778	.	.	.	6.82
6/17/2009	12	0-2	2.13	13.12	.	.	.	.	86.7	12.2	1.38	8.45
		0			9.05	102.0	21.15	612				
		1	.	.	8.66	97.4	21.02	614	.	.	.	8.47
		2	.	.	8.55	95.7	20.79	625	.	.	.	8.45
		3	.	.	8.39	88.5	17.86	615	82.8	25.6	.	8.41
		4	.	.	4.16	42.8	16.67	626	88.0	38.9	.	8.04
		5	.	.	2.23	22.5	15.67	638	.	.	.	7.93
		6	.	.	1.93	17.8	11.63	659	.	.	.	7.91
		7	.	.	1.51	13.2	9.15	687	.	.	.	7.82
		8	.	.	0.78	6.7	8.55	685	.	.	.	7.53
		9	.	.	0.69	5.9	8.29	687	.	.	.	7.49
		10	.	.	0.58	4.9	7.72	697	.	.	.	7.38
		11	.	.	0.49	4.1	7.68	698	923.6	769.2	.	7.33
		12	.	.	0.41	3.5	7.46	809	.	.	.	7.01

Twin Lake 2009

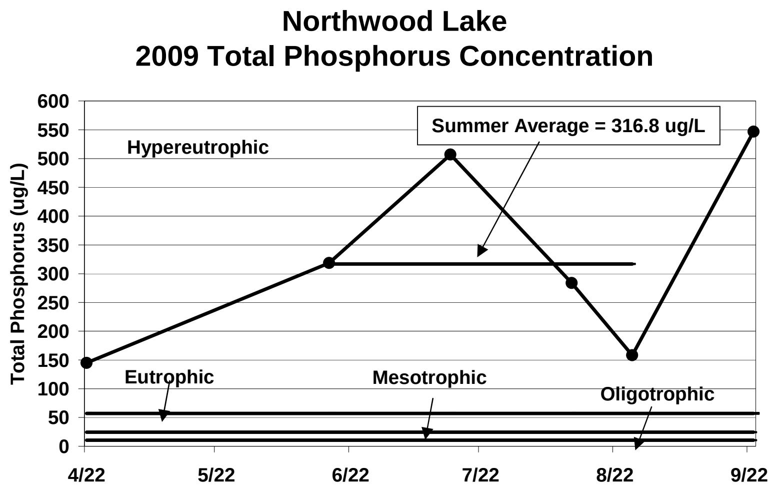
Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (µg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (µmhos/cm @25°C)	Total P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	pH
7/15/2009	11.614	0-2	0.8	27.91	.	.	.	.	64.0	6.7	0.72	7.94
		0			7.80	90.1	22.40	600				
		1	.	.	7.56	87.3	22.41	600	.	.	.	8.12
		2	.	.	7.55	87.1	22.36	600	.	.	.	8.16
		3	.	.	7.42	85.5	22.29	600	77.5	7.0	.	8.18
		4	.	.	0.67	7.1	18.03	636	65.8	7.1	.	7.74
		5	.	.	0.59	5.9	15.23	636	.	.	.	7.7
		6	.	.	0.46	4.3	12.83	653	.	.	.	7.64
		7	.	.	0.40	3.5	9.46	694	.	.	.	7.51
		8	.	.	0.37	3.2	9.21	696	.	.	.	7.45
		9	.	.	0.36	3.1	8.80	700	.	.	.	7.4
		10	.	.	0.33	2.9	8.46	704	.	.	.	7.34
		11	.	.	0.29	2.5	8.25	709	1032.8	918.0	.	7.28
		11.614	.	.	0.22	1.9	8.03	722	.	.	.	7.03
8/12/2009	12.272	0-2	1.01	16.76	.	.	.	.	47.5	3.4	1.21	8.26
		0			11.42	138.5	25.05	616				
		1	.	.	12.09	145.9	24.78	614	.	.	.	8.55
		2	.	.	11.35	134.9	23.96	618	.	.	.	8.67
		3	.	.	10.59	123.8	23.10	621	.	.	.	8.67
		4	.	.	0.83	9.1	19.71	644	60.8	3.3	.	8.32
		5	.	.	0.63	6.6	16.97	663	146.8	76.3	.	8.28
		6	.	.	0.49	4.7	13.64	685	.	.	.	8.19
		7	.	.	0.30	2.7	10.62	728	.	.	.	8.04
		8	.	.	0.16	1.4	9.76	734	.	.	.	7.94
		9	.	.	0.19	1.6	9.24	740	.	.	.	7.84
		10	.	.	0.14	1.2	9.16	741	.	.	.	7.82
		11	.	.	0.20	1.7	9.06	742	.	.	.	7.78
		12	.	.	0.22	1.9	8.91	752	1088.4	992.1	.	7.67
		12.272	.	.	0.09	0.8	8.65	773	.	.	.	7.54
8/26/2009	12.184	0-2	0.73	31.7	.	.	.	.	75.6	3.8	1.42	8.57
		0			9.88	114.8	22.79	517				
		1	.	.	10.34	118.8	22.18	517	.	.	.	8.78
		2	.	.	9.66	110.4	21.88	498	.	.	.	8.83
		3	.	.	8.36	95.2	21.73	519	.	.	.	8.8
		4	.	.	5.01	56.2	21.00	528	76.1	4.2	.	8.6
		5	.	.	1.30	13.4	16.67	620	60.1	6.2	.	8.28
		6	.	.	0.92	9.1	14.91	623	.	.	.	8.2
		7	.	.	0.68	6.3	11.81	662	.	.	.	8.11
		8	.	.	0.58	5.2	10.53	674	.	.	.	8.03
		9	.	.	0.54	4.8	9.94	680	.	.	.	7.98
		10	.	.	0.41	3.6	9.30	687	.	.	.	7.89
		11	.	.	0.36	3.1	9.15	690	.	.	.	7.82
		12	.	.	0.32	2.8	8.98	716	1112.0	984.2	.	7.68
		12.184	.	.	0.26	2.3	8.81	774	.	.	.	7.43

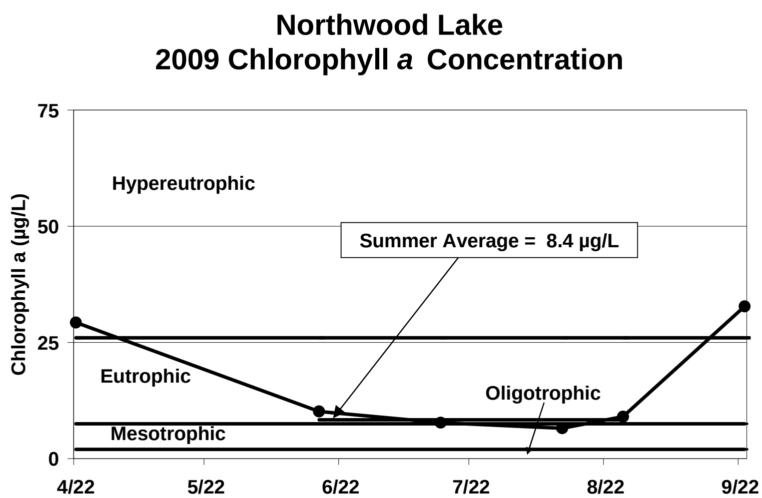
Twin Lake 2009

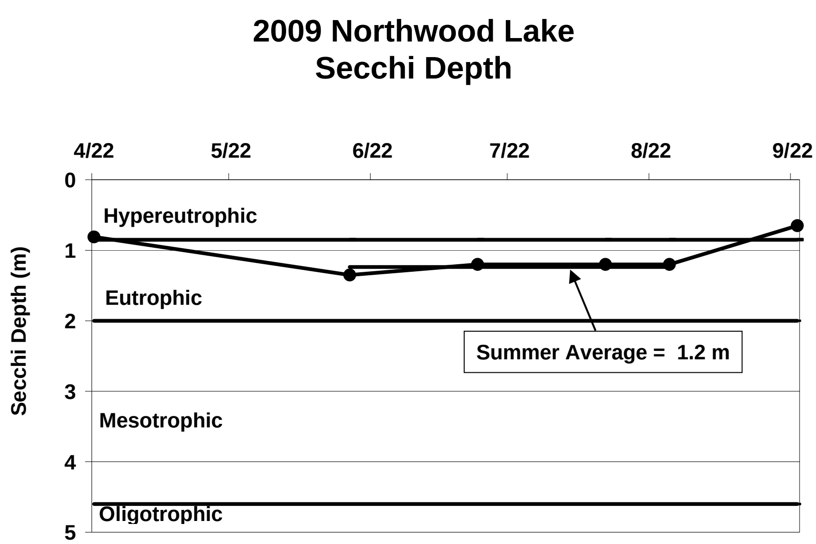
Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (µg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (µmhos/cm @25°C)	Total P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	pH
9/23/2009	12.41	0-2	0.97	14.73	.	.	.	.	38.3	5.1	1.03	7.99
		0			6.41	72.4	21.30	479				
		1	.	.	6.57	74.2	21.28	479	.	.	.	8.11
		2	.	.	6.60	74.5	21.26	479	.	.	.	8.21
		3	.	.	6.51	73.5	21.24	479	.	.	.	8.33
		4	.	.	0.55	6.1	20.36	488	57.2	7.1	.	8.13
		5	.	.	0.55	5.7	16.88	573	128.3	69.3	.	8.03
		6	.	.	0.45	4.3	13.99	596	.	.	.	7.94
		7	.	.	0.35	3.1	11.02	631	.	.	.	7.83
		8	.	.	0.31	2.8	10.29	637	.	.	.	7.77
		9	.	.	0.26	2.3	9.57	646	.	.	.	7.67
		10	.	.	0.24	2.1	9.42	648	.	.	.	7.61
		11	.	.	0.21	1.9	9.35	649	.	.	.	7.54
		12	.	.	0.21	1.8	9.33	649	1357.5	1256.7	.	7.51
		12.41	.	.	0.17	1.5	9.06	685	.	.	.	7.27

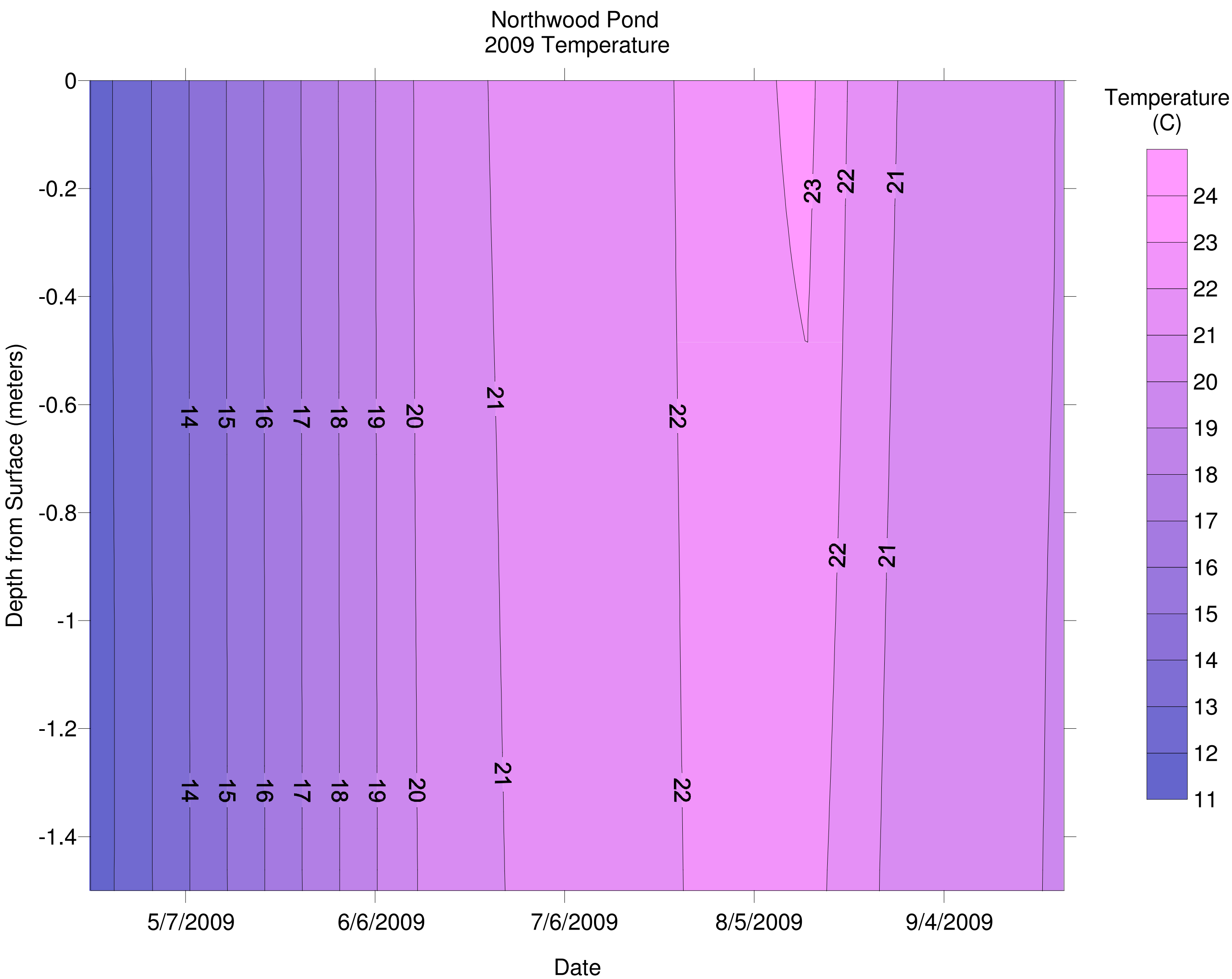
Appendix C

2009 Northwood Lake Data

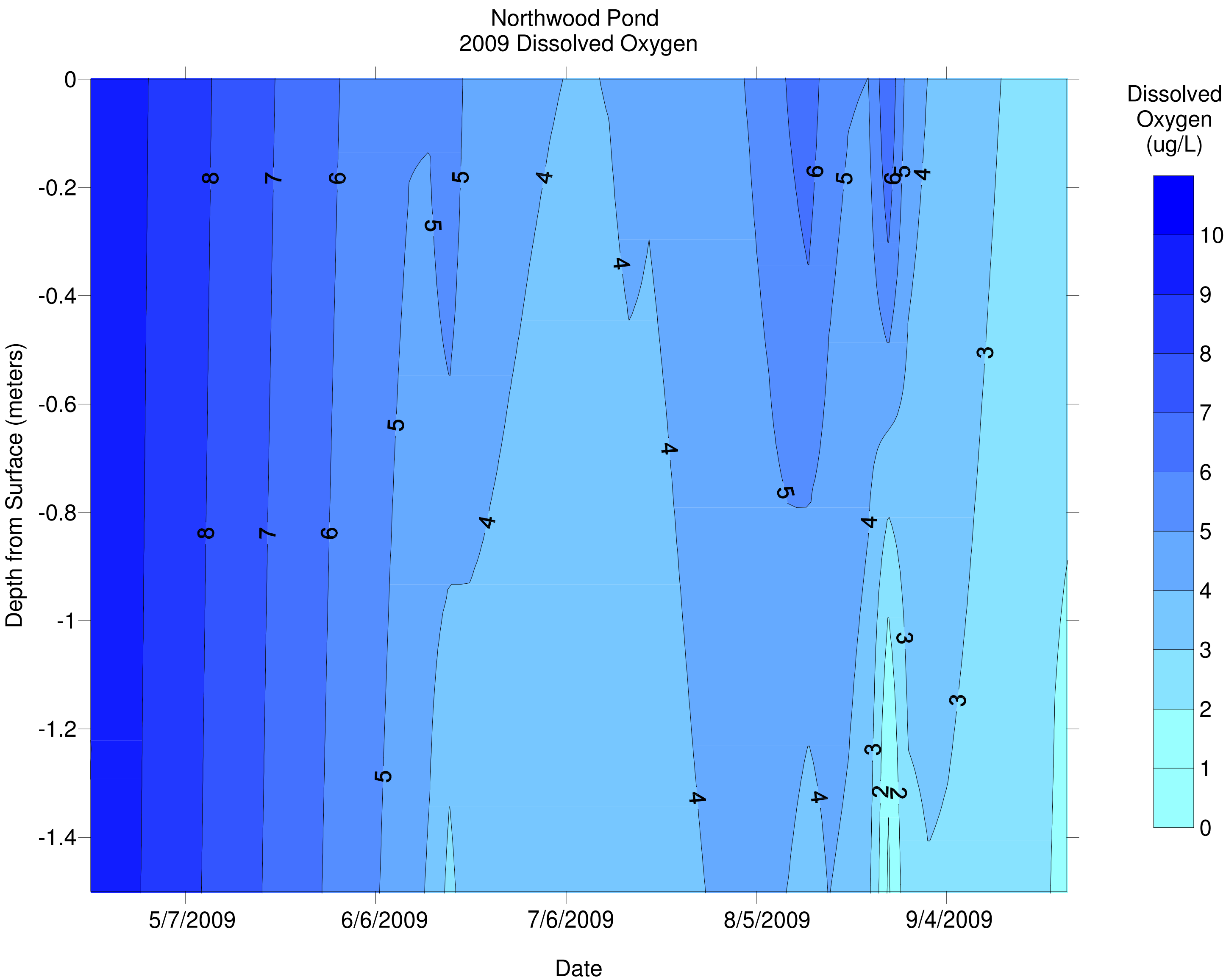

Northwood Lake
2009 Total Phosphorus Concentration
Summer Average = 316.8 ug/L
Hypereutrophic
Eutrophic
Mesotrophic
Oligotrophic
Total Phosphorus (ug/L)
600
550
500
450
400
350
300
250
200
150
100
50
0
4/22
5/22
6/22
7/22
8/22
9/22


Northwood Lake
2009 Chlorophyll a Concentration
Hypereutrophic
Summer Average = 8.4 µg/L
Eutrophic
Oligotrophic
Mesotrophic
Chlorophyll a (µg/L)
75
50
25
0
4/22
5/22
6/22
7/22
8/22
9/22

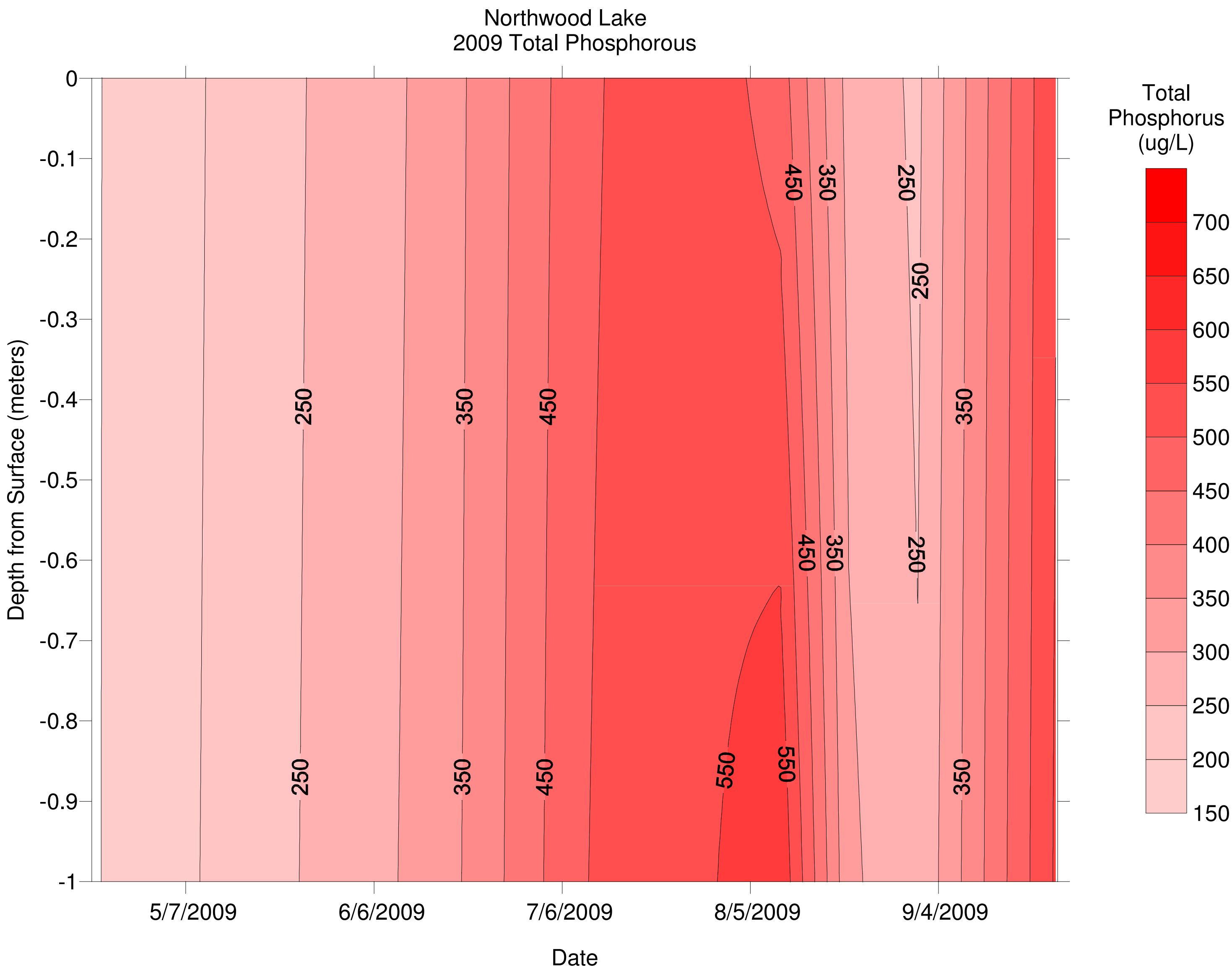

2009 Northwood Lake
Secchi Depth
4/22
5/22
6/22
7/22
8/22
9/22
Hypereutrophic
Eutrophic
Summer Average = 1.2 m
Mesotrophic
Oligotrophic
Secchi Depth (m)
0
1
2
3
4
5



Northwood Pond
2009 Temperature
Temperature (C)
Depth from Surface (meters)
Date
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
24
23
22
21
20
19
18
17
16
15
14
13
12
11



Northwood Pond
2009 Dissolved Oxygen
Depth from Surface (meters)
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Date
Dissolved
Oxygen
(ug/L)
10
9
8
7
6
5
4
3
2
1
0


Northwood Lake
2009 Total Phosphorous
Depth from Surface (meters)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Date
250
350
450
550
Total Phosphorus (ug/L)
700
650
600
550
500
450
400
350
300
250
200
150

NORTHWOOD LAKE

SURFACE

STANDARD INVERTED MICROSCOPE ANALYSIS METHOD

DIVISION	TAXON	6/17/2009 units/mL	7/15/2009 units/mL	8/12/2009 units/mL	8/26/2009 units/mL
CHLOROPHYTA (GREEN ALGAE)	*Ankistrodesmus Brauni*	57	0	95	0
	Ankistrodesmus falcatus	976	0	381	57
	Chlamydomonas globosa	2,068	1,034	6,577	1,149
	Cosmarium sp.	0	0	0	57
	Oocystis parva	57	0	286	115
	Pandorina morum	0	0	95	0
	Quadrigula sp.	57	0	0	0
	Rhizoclonium hieroglyphicum	57	0	0	0
	Scenedesmus dimorphus	0	0	286	115
	Scenedesmus quadricauda	172	115	953	115
	Scenedesmus sp.	57	57	953	230
	Selenastrum minutum	287	57	1,239	172
	Selenastrum sp.	459	0	0	57
	Tetraedron minimum	0	0	191	57
	Tetraedron muticum	0	0	0	115
	Tetraedron sp.	0	0	191	0
	Treubaria setigerum	0	57	0	0
	CHLOROPHYTA TOTAL	**4,250**	**1,264**	**11,057**	**2,125**
	Dinobryon sociale	0	0	0	0
CHRYSOPHYTA (YELLOW-BROWN ALGAE)	**CHRYSOPHYTA TOTAL**	**0**	**0**	**0**	**0**
CYANOPHYTA (BLUE-GREEN ALGAE)	*Anabaena affinis*	0	230	0	0
	Aphanizomenon flos-aquae	0	57	572	57
	Merismopedia tenuissima	1,493	1,321	32,504	57
	Merismopedia sp.	57	0	0	0
	Microcystis aeruginosa	115	0	477	172
	Microcystis incerta	919	747	4,385	459
	Oscillatoria limnetica	747	0	381	0
	Oscillatoria Agardhii	0	0	0	287
	Phormidium mucicola	230	230	572	57
	CYANOPHYTA TOTAL	**3,561**	**2,585**	**38,890**	**1,091**
BACILLARIOPHYTA (DIATOMS)	*Cocconeis placentula*	0	172	0	345
	Cymbella sp.	115	0	0	0
	Fragilaria capucina	115	0	0	0
	Gomphonema olivaceaum	0	0	0	57
	Navicula sp.	115	57	95	57
	Stephanodiscus Hantzschii	402	0	95	804
	Surirella sp.	0	0	0	57
	Synedra ulna	172	0	286	115
	BACILLARIOPHYTA TOTAL	**919**	**230**	**477**	**1,436**
CRYPTOPHYTA (CRYPTOMONADS)	*Cryptomonas erosa*	2,585	919	1,906	919
	CRYPTOPHYTA TOTAL	**2,585**	**919**	**1,906**	**919**
	Euglena sp.	57	57	667	287
	Trachelomonas sp.	0	0	95	172
EUGLENOPHYTA (EUGLENOIDS)	**EUGLENOPHYTA TOTAL**	**57**	**57**	**763**	**459**
PYRRHOPHYTA (DINOFLAGELLATES)	*Peridinium cinctum*	287	0	0	57
	PYRRHOPHYTA TOTAL	**287**	**0**	**0**	**57**
	TOTALS	**11,659**	**5,054**	**53,093**	**6,088**

NORTHWOOD LAKE

ZOOPLANKTON ANALYSIS

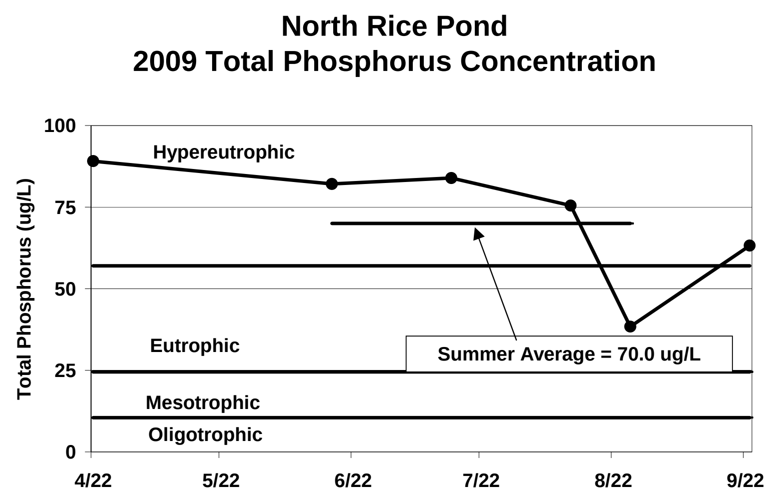
DIVISION	TAXON	Vertical Tow (m)	06/17/09 #/m2	07/15/09 #/m2	8/12/2009 #/m2	8/26/2009 #/m2
CLADOCERA	*Chydorus sphaericus*		4,509	4,244	0	0
	Daphnia galeata mendotae		1,503	8,488	5,305	0
	Daphnia retrocurva		0	12,732	5,305	0
	Diaphanosoma leuchtenbergianum		0	4,244	2,653	0
	Immature Cladocera		0	4,244	0	0
	CLADOCERA TOTAL		**6,013**	**33,953**	**13,263**	**0**
COPEPODA	*Cyclops sp.*		3,006	33,953	0	0
	Diaptomus sp.		0	25,465	5,305	0
	Copepodid		0	0	0	0
	Nauplii		10,522	131,568	31,831	30,239
	COPEPODA TOTAL		**13,528**	**190,985**	**37,136**	**30,239**
ROTIFERA	*Brachionus havanensis*		1,503	0	0	0
	Keratella cochlearis		7,516	4,244	7,958	60,479
	Kellicottia bostoniensis.		1,503	0	0	0
	Polyarthra vulgaris		3,006	0	5,305	0
	ROTIFERA TOTAL		**13,528**	**4,244**	**13,263**	**60,479**
	TOTALS		**33,069**	**229,183**	**63,662**	**90,718**

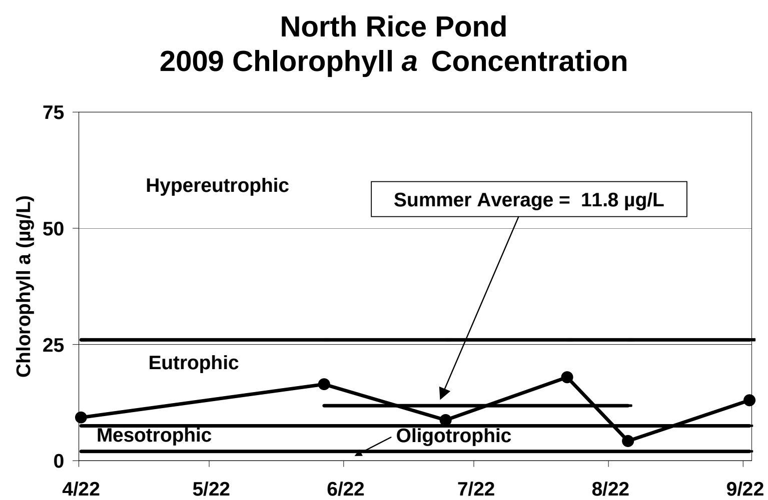
Northwood Lake 2009

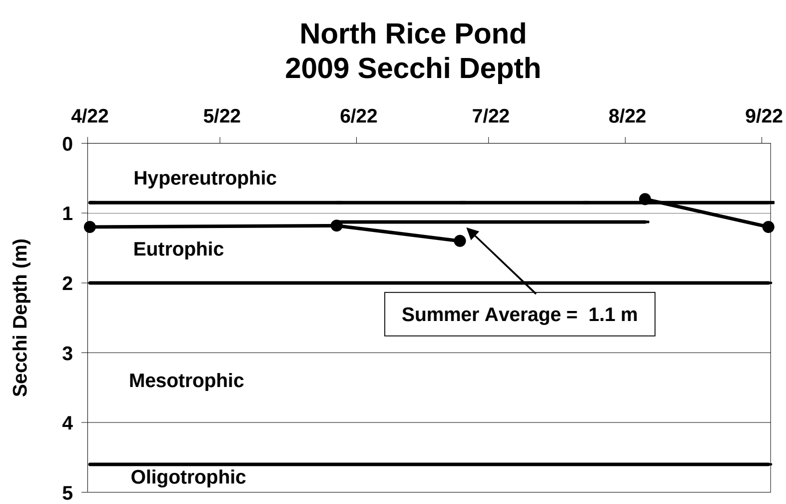
Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (µg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (µmhos/cm @25°C)	Total P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	pH
4/22/2009	1.22	0-2	0.81	29.3	.	.	.	.	144.8	9.8	1.13	7.98
		0			9.72	89.4	11.41	1425				
		1	.	.	9.70	89.0	11.33	1420	.	.	.	7.76
		1.221	.	.	10.01	91.9	11.33	1416	.	.	.	7.68
6/17/2009	1.365	0-2	1.35	10.17	.	.	.	.	318.4	220.5	1.04	8.44
		0			6.20	69.5	20.87	1069				
		1	.	.	3.92	44.0	20.78	1044	322.7	233.2	.	8.1
		1.365	.	.	2.09	23.3	20.62	1055	.	.	.	7.75
7/15/2009	1	0-2	1.2	7.75	.	.	.	.	506.8	389.3	3.60	8.92
		0			4.46	50.6	21.43	807				
		1	.	.	2.77	31.5	21.54	811	562.4	409.2	.	8.5
8/12/2009	1.212	0-2	1.2	6.54	.	.	.	.	283.7	223.2	0.78	9.02
		0			7.81	92.8	23.94	586				
		1	.	.	3.38	39.0	22.33	648	773.5	426.1	.	8.72
		1.212	.	.	2.40	27.5	22.14	664	.	.	.	8.57
8/26/2009	1.23	0-2	1.2	9.04	.	.	.	.	158.3	99.0	0.65	8.8
		0			7.16	81.0	21.40	357				
		1	.	.	0.94	10.5	20.45	373	188.8	113.7	.	7.95
		1.23	.	.	0.69	7.6	20.21	388	.	.	.	7.76
9/23/2009	1.1	0-2	0.65	32.77	.	.	.	.	546.7	374.8	1.34	8.09
		0			2.61	28.8	19.96	391				
		1	.	.	1.83	20.1	19.92	409	556.3	383.2	.	7.93
		1.1	.	.	1.68	18.5	19.92	419	.	.	.	7.83

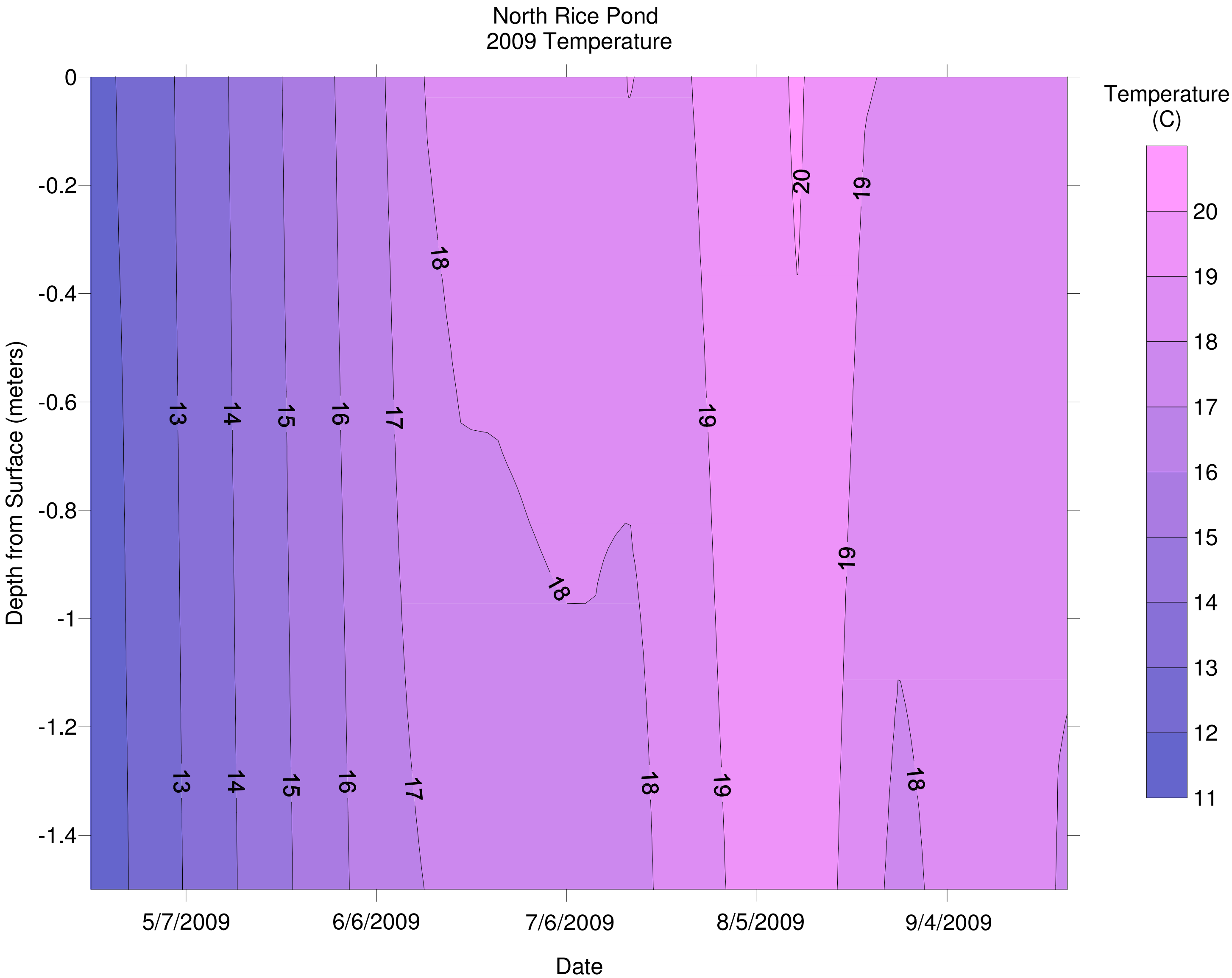
Appendix D

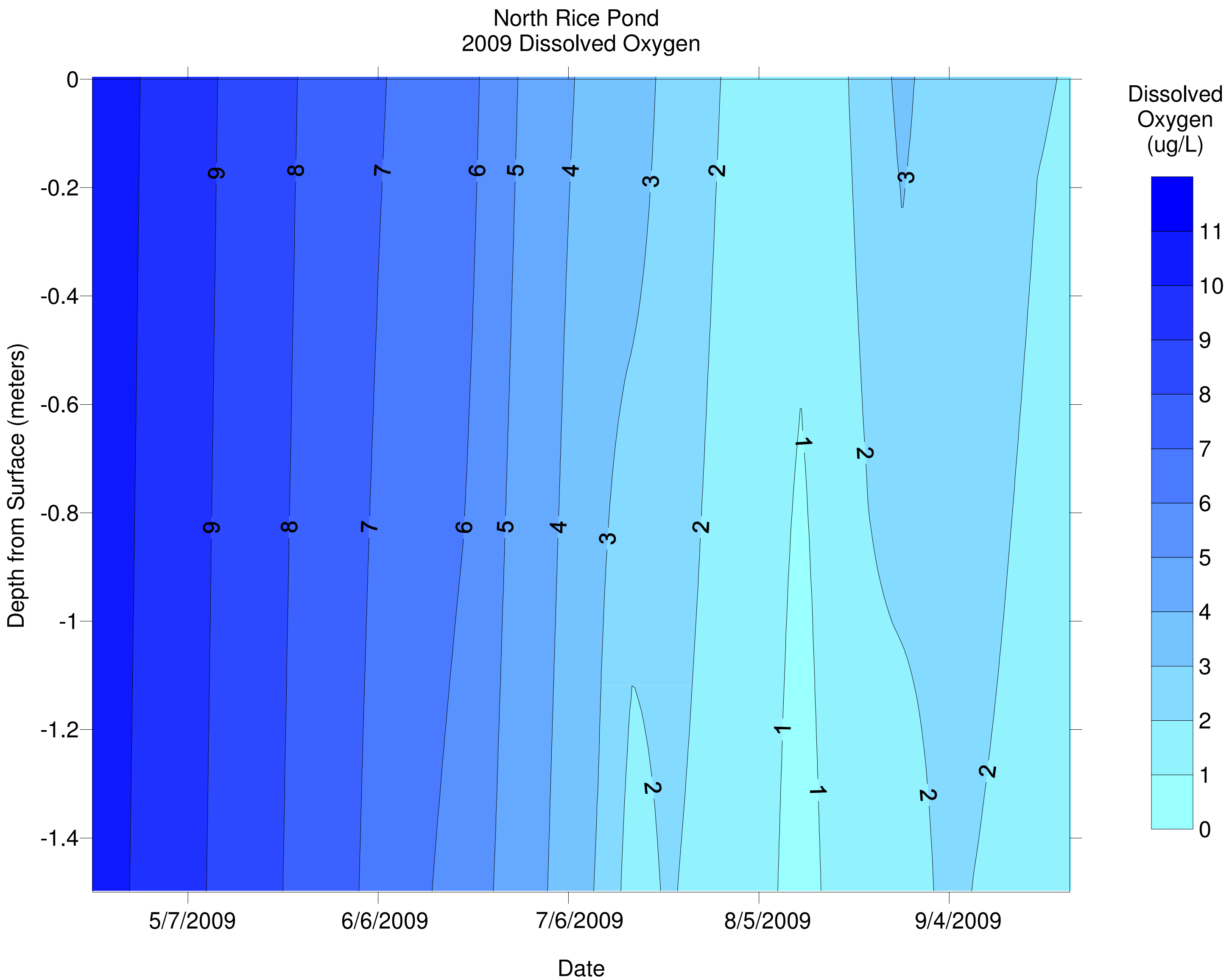
2009 North and South Rice Pond Data


North Rice Pond
2009 Total Phosphorus Concentration
Total Phosphorus (ug/L)
100
75
50
25
0
Hypereutrophic
Eutrophic
Mesotrophic
Oligotrophic
Summer Average = 70.0 ug/L
4/22
5/22
6/22
7/22
8/22
9/22

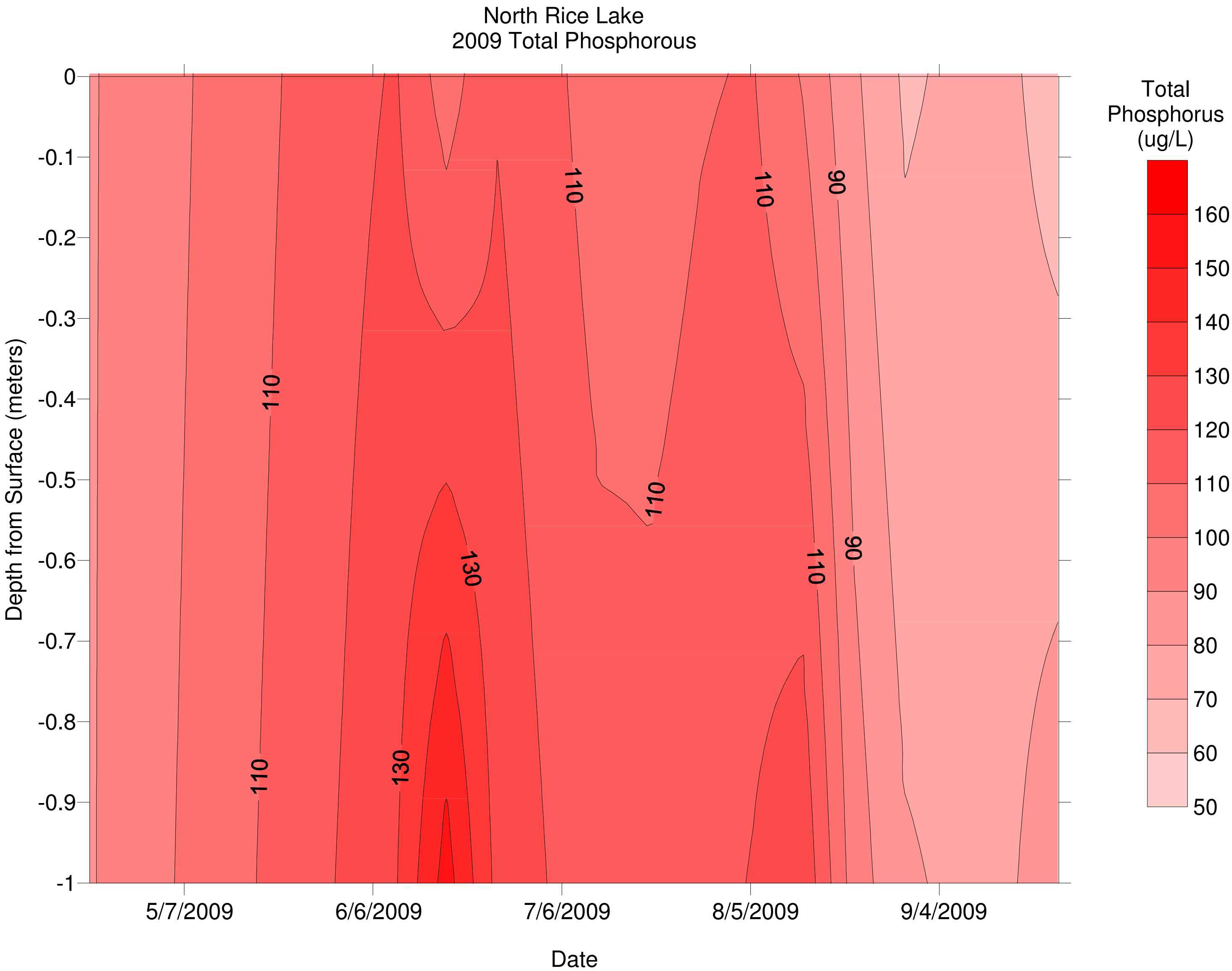

North Rice Pond
2009 Chlorophyll a Concentration
Chlorophyll a (µg/L)
75
50
25
0
Hypereutrophic
Summer Average = 11.8 µg/L
Eutrophic
Mesotrophic
Oligotrophic
4/22
5/22
6/22
7/22
8/22
9/22


North Rice Pond
2009 Secchi Depth
4/22
5/22
6/22
7/22
8/22
9/22
Secchi Depth (m)
0
1
2
3
4
5
Hypereutrophic
Eutrophic
Summer Average = 1.1 m
Mesotrophic
Oligotrophic


North Rice Pond
2009 Temperature
Temperature (C)
11
12
13
14
15
16
17
18
19
20
Depth from Surface (meters)
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
Date
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009



North Rice Pond
2009 Dissolved Oxygen
Depth from Surface (meters)
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Date
Dissolved
Oxygen
(ug/L)
11
10
9
8
7
6
5
4
3
2
1
0


North Rice Lake
2009 Total Phosphorous
Depth from Surface (meters)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Date
110
110
130
130
110
110
110
110
90
90
Total Phosphorus (ug/L)
160
150
140
130
120
110
100
90
80
70
60
50

NORTH RICE POND

SURFACE

STANDARD INVERTED MICROSCOPE ANALYSIS METHOD

DIVISION	TAXON	6/17/2009 units/mL	7/15/2009 units/mL	8/12/2009 units/mL	8/26/2009 units/mL
CHLOROPHYTA (GREEN ALGAE)	*Ankistrodesmus falcatus*	115	57	287	0
	Chlamydomonas globosa	2,010	2,872	2,814	1,034
	Cosmarium sp.	0	57	0	0
	Oocystis parva	57	115	0	0
	Pandorina morum	632	0	0	0
	Scenedesmus sp.	0	57	57	57
	Selenastrum minutum	0	57	0	0
	Selenastrum sp.	0	0	57	172
	Tetraedron minimum	57	0	0	0
	CHLOROPHYTA TOTAL	**2,872**	**3,216**	**3,216**	**1,264**
CHRYSOPHYTA (YELLOW-BROWN ALGAE)	**CHRYSOPHYTA TOTAL**	**0**	**0**	**0**	**0**
CYANOPHYTA (BLUE-GREEN ALGAE)	*Anabaena affinis*	0	57	0	57
	Gloethece sp.	345	230	57	57
	Merismopedia tenuissima	0	0	459	115
	Microcystis aeruginosa	115	0	2,585	402
	Microcystis incerta	287	345	1,781	689
	Oscillatoria limnetica	115	1,034	1,895	976
	Oscillatoria Agardhii	0	0	287	0
	Phormidium mucicola	57	402	517	862
	CYANOPHYTA TOTAL	**919**	**2,068**	**7,582**	**3,159**
BACILLARIOPHYTA (DIATOMS)	*Cymbella sp.*	57	0	57	0
	Gomphonema olivaceaum	0	0	57	0
	Gomphonema sp.	0	0	57	57
	Navicula sp.	0	0	57	57
	Pinnularia sp.	0	0	57	57
	Stephanodiscus Hantzschii	57	0	0	0
	Synedra ulna	0	0	57	57
	BACILLARIOPHYTA TOTAL	**115**	**0**	**345**	**230**
CRYPTOPHYTA (CRYPTOMONADS)	*Cryptomonas erosa*	1,723	632	747	402
	CRYPTOPHYTA TOTAL	**1,723**	**632**	**747**	**402**
	Euglena sp.	172	0	115	230
	Phacus sp.	0	57	0	345
	Trachelomonas sp.	172	0	0	0
EUGLENOPHYTA (EUGLENOIDS)	**EUGLENOPHYTA TOTAL**	**345**	**57**	**115**	**574**
PYRRHOPHYTA (DINOFLAGELLATES)	**PYRRHOPHYTA TOTAL**	**0**	**0**	**0**	**0**
	TOTALS	**5,973**	**5,973**	**12,004**	**5,629**

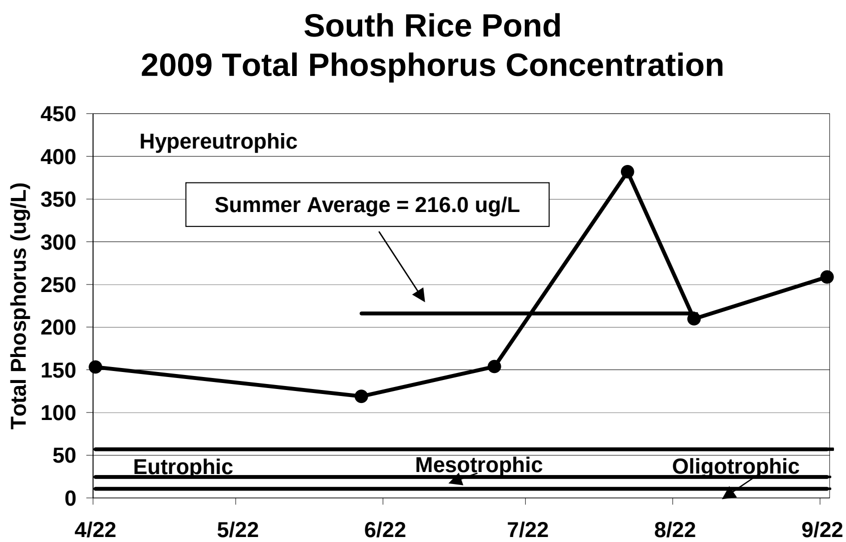
NORTH RICE LAKE

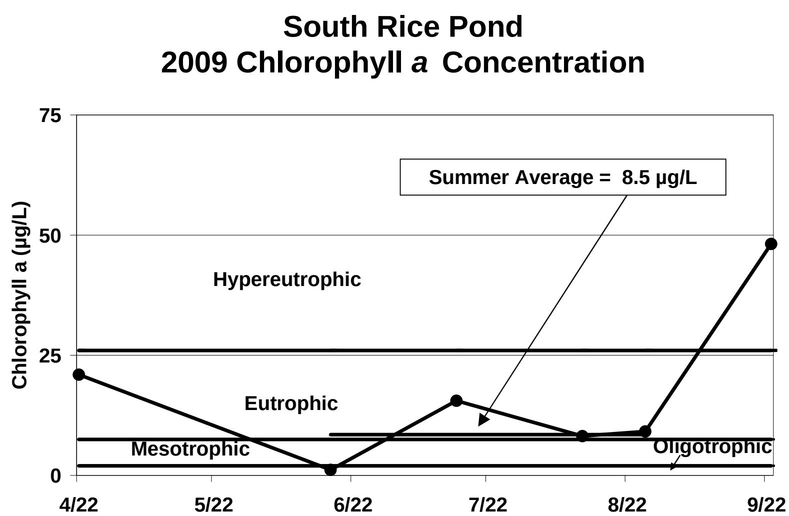
ZOOPLANKTON ANALYSIS

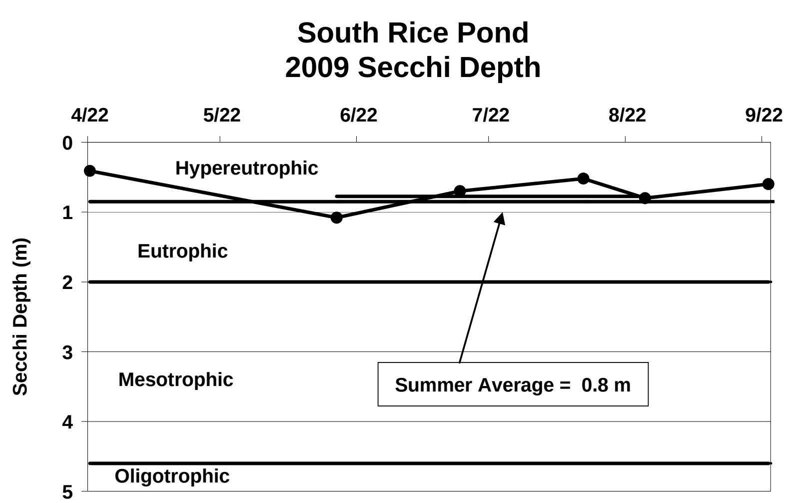
DIVISION	TAXON	Vertical Tow (m)	06/17/09 #/m2	07/15/09 #/m2	8/12/2009 #/m2	8/26/2009 #/m2
CLADOCERA	*Bosmina longirostris*		1,400,207	38,374	3,979	31,300
	Ceriodaphnia sp.		0	21,928	0	5,217
	Chydorus sphaericus		13,086	142,532	0	10,433
	Daphnia galeata mendotae		0	0	0	5,217
	Daphnia retrocurva		0	0	0	5,217
	CLADOCERA TOTAL		**1,413,293**	**202,834**	**3,979**	**57,384**
COPEPODA	*Cyclops sp.*		0	49,338	11,937	5,217
	Nauplii		85,059	1,134,772	151,197	62,601
	COPEPODA TOTAL		**85,059**	**1,184,110**	**163,133**	**67,818**
ROTIFERA	*Asplanchna priodonta*		0	71,266	19,894	10,433
	Brachionus havanensis		0	54,820	15,915	36,517
	Filinia longiseta		13,086	5,482	3,979	52,167
	Keratella cochlearis		130,860	60,302	51,725	5,217
	Keratella quadrata		26,172	0	0	0
	Lecane sp.		6,543	0	7,958	20,867
	Monostyla sp.		0	0	3,979	0
	Polyarthra vulgaris		130,860	21,928	11,937	10,433
	Trichocerca cylindrica		0	0	3,979	5,217
	Trichocerca multicrinis		0	5,482	0	0
	ROTIFERA TOTAL		**307,522**	**219,280**	**119,366**	**140,852**
	TOTALS		**1,805,874**	**1,606,223**	**286,478**	**266,053**

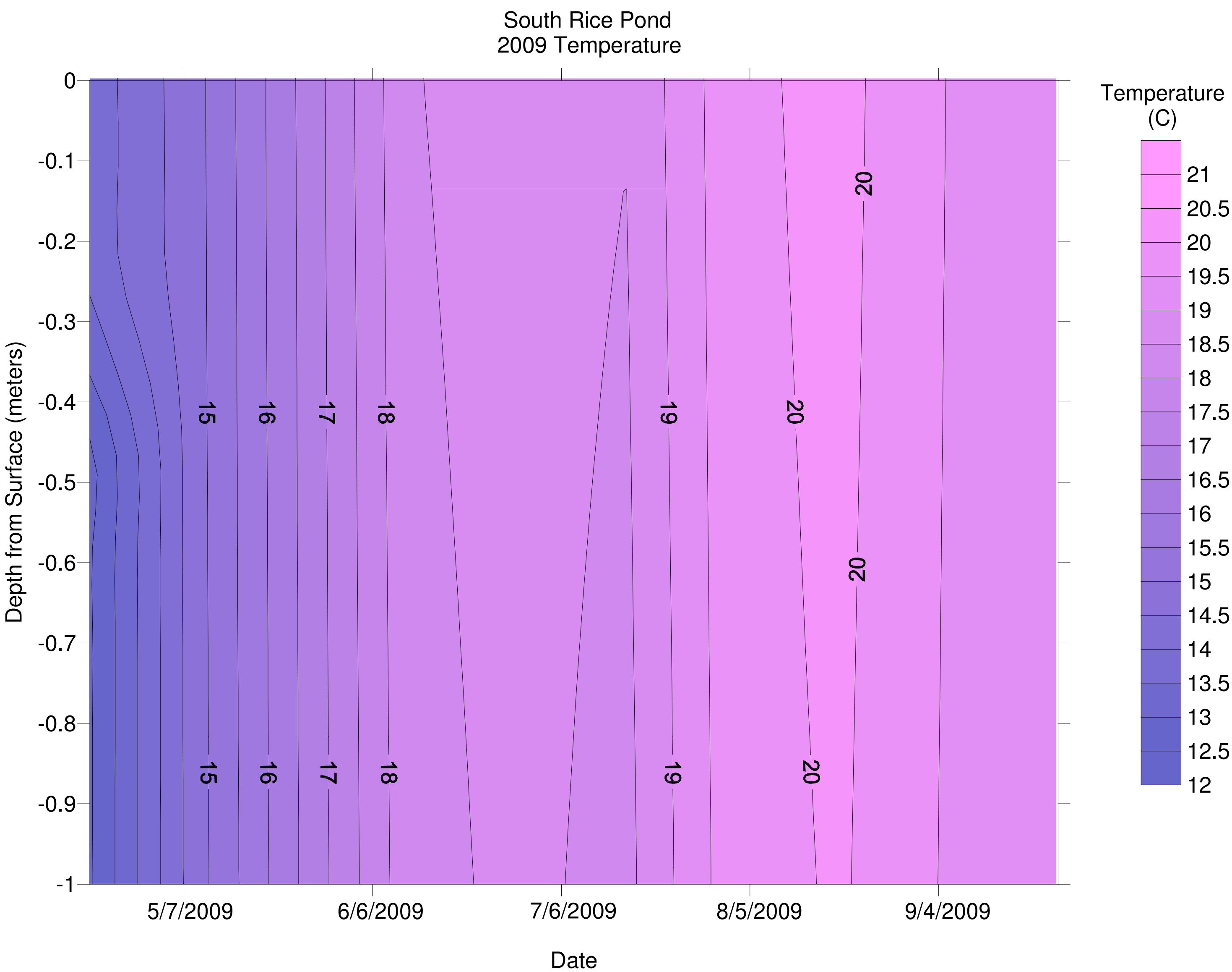
North Rice Pond 2009

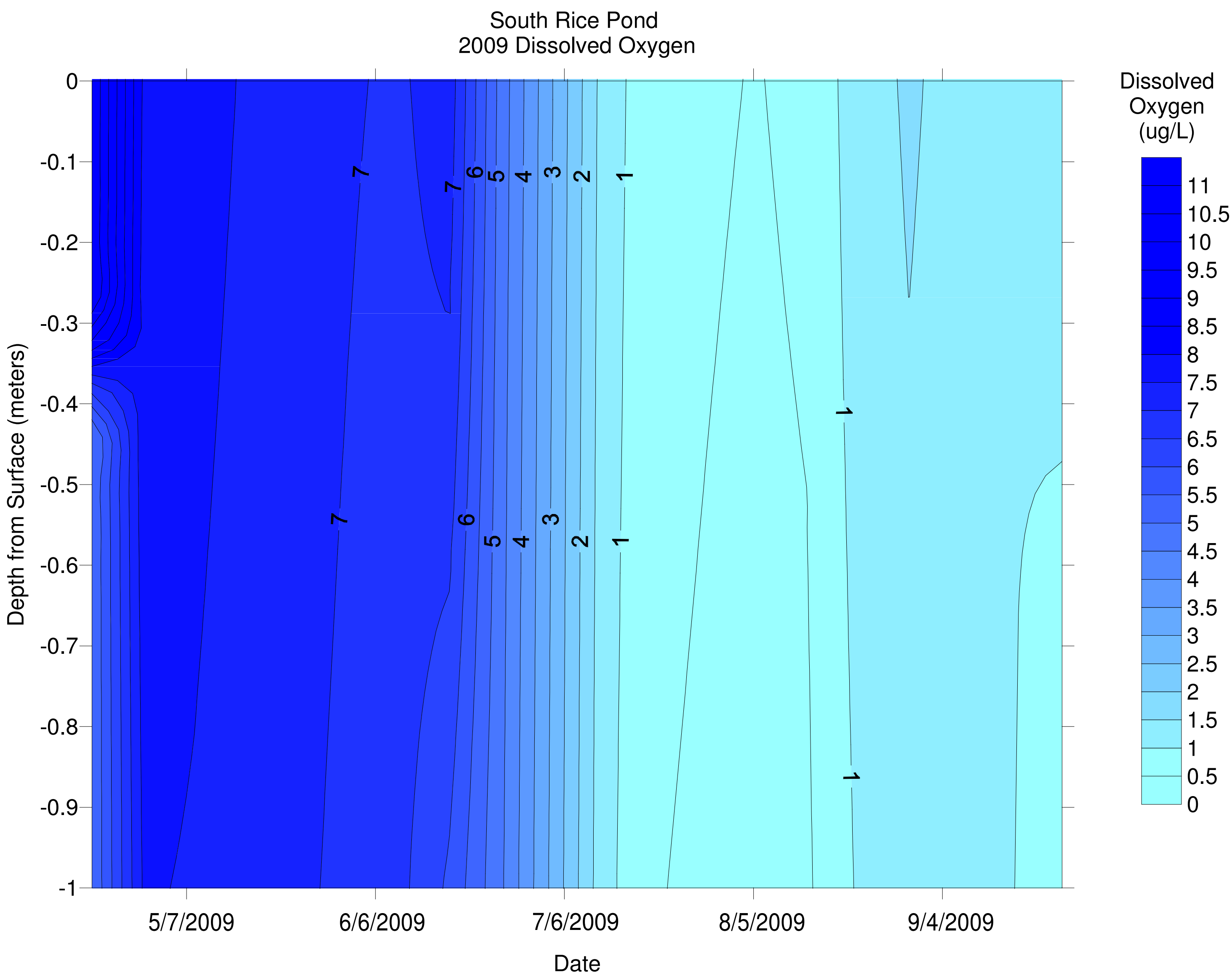
Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (µg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (µmhos/cm @25°C)	Total P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	pH
4/22/2009	1.159	0-2	1.2	9.3	.	.	.	.	89.1	18.3	1.02	8.01
		0			10.68	98.8	11.72	1005				
		1	.	.	10.73	98.2	11.25	1012	.	.	.	7.61
		1.159	.	.	10.38	94.7	11.11	1007	.	.	.	7.34
6/17/2009	1.52	0-2	1.18	16.45	.	.	.	.	82.1	22.0	1.04	8.13
		0			7.50	82.4	19.82	950				
		1	.	.	8.38	85.9	16.39	1091	178.0	20.0	.	7.94
		1.52	.	.	4.25	43.1	15.92	1141	.	.	.	7.59
7/15/2009	1.434	0-2	1.4	8.72	.	.	.	.	83.9	14.5	1.23	7.45
		0			4.71	51.7	19.67	1024				
		1	.	.	1.20	12.5	16.97	1139	131.7	56.1	.	6.95
		1.434	.	.	0.99	10.2	16.70	1172	.	.	.	6.84
8/12/2009	1	0-2	.	17.95	.	.	.	.	75.5	14.2	1.35	7.45
		0			1.25	13.8	20.16	1122				
		1	.	.	0.75	8.2	19.69	1157	159.3	17.1	.	7.34
8/26/2009	1	0-2	0.8	4.21	.	.	.	.	38.4	7.6	0.73	7.48
		0			4.32	47.2	19.63	739				
		1	.	.	0.87	9.2	17.57	1102	112.5	10.8	.	7.05
		1.541	.	.	0.51	5.3	16.97	1183	.	.	.	6.9
9/23/2009	1	0-2	1.2	12.99	.	.	.	.	63.2	9.0	1.16	7.25
		0			1.94	20.8	18.81	769				
		1	.	.	1.63	17.3	17.91	923	88.0	11.1	.	7.1


South Rice Pond
2009 Total Phosphorus Concentration
Total Phosphorus (ug/L)
450
400
350
300
250
200
150
100
50
0
Hypereutrophic
Summer Average = 216.0 ug/L
Eutrophic
Mesotrophic
Oligotrophic
4/22
5/22
6/22
7/22
8/22
9/22

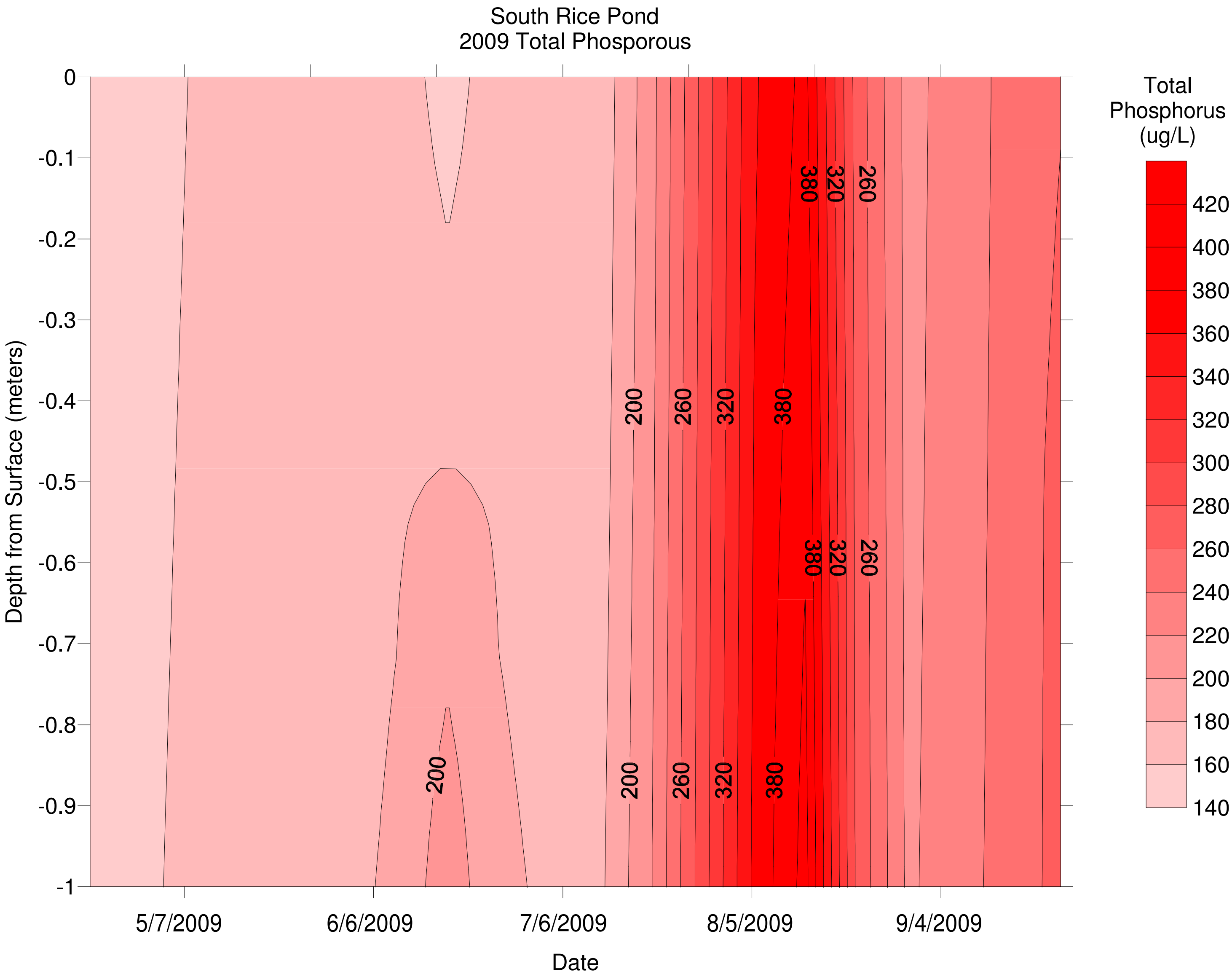

South Rice Pond
2009 Chlorophyll *a* Concentration
Chlorophyll a (µg/L)
75
50
25
0
Summer Average = 8.5 µg/L
Hypereutrophic
Eutrophic
Mesotrophic
Oligotrophic
4/22
5/22
6/22
7/22
8/22
9/22


South Rice Pond
2009 Secchi Depth
4/22
5/22
6/22
7/22
8/22
9/22
Secchi Depth (m)
0
1
2
3
4
5
Hypereutrophic
Eutrophic
Mesotrophic
Summer Average = 0.8 m
Oligotrophic


South Rice Pond
2009 Temperature
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
Depth from Surface (meters)
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
Date
15
16
17
18
19
20
Temperature (C)
21
20.5
20
19.5
19
18.5
18
17.5
17
16.5
16
15.5
15
14.5
14
13.5
13
12.5
12


South Rice Pond
2009 Dissolved Oxygen
Dissolved Oxygen (ug/L)
Depth from Surface (meters)
Date
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
5/7/2009
6/6/2009
7/6/2009
8/5/2009
9/4/2009
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

South Rice Pond
2009 Total Phosporous



SOUTH RICE POND

SURFACE
STANDARD INVERTED MICROSCOPE ANALYSIS METHOD

DIVISION	TAXON	6/17/2009 units/mL	7/15/2009 units/mL	8/12/2009 units/mL	8/26/2009 units/mL
CHLOROPHYTA (GREEN ALGAE)	*Ankistrodesmus Brauni*	0	0	0	115
	Ankistrodesmus falcatus	0	0	287	57
	Carteria Klebsii	57	57	0	0
	Chlamydomonas globosa	1,206	2,010	689	0
	Oocystis parva	0	57	0	57
	Selenastrum minutum	0	287	0	0
	CHLOROPHYTA TOTAL	**1,264**	**2,412**	**976**	**230**
CHRYSOPHYTA (YELLOW-BROWN ALGAE)	**CHRYSOPHYTA TOTAL**	**0**	**0**	**0**	**0**
CYANOPHYTA (BLUE-GREEN ALGAE)	*Anabaena affinis*	0	57	0	0
	Aphanizomenon flos-aquae	0	57	0	0
	Gloethece sp.	0	0	0	115
	Merismopedia tenuissima	0	1,321	2,872	0
	Microcystis aeruginosa	0	57	0	517
	Microcystis incerta	57	2,872	7,984	517
	Oscillatoria limnetica	0	4,767	459	57
	Phormidium mucicola	459	1,034	0	0
	CYANOPHYTA TOTAL	**517**	**10,166**	**11,315**	**1,206**
BACILLARIOPHYTA (DIATOMS)	*Amphora sp.*	0	0	57	0
	Cocconeis placentula	0	0	0	57
	Fragilaria capucina	0	57	0	0
	Gomphonema sp.	0	57	0	0
	Navicula sp.	115	230	57	57
	Rhopolodia gibba	57	0	0	0
	Stephanodiscus Hantzschii	0	287	57	230
	Synedra ulna	287	976	0	0
	BACILLARIOPHYTA TOTAL	**459**	**1,608**	**172**	**345**
CRYPTOPHYTA (CRYPTOMONADS)	*Cryptomonas erosa*	345	287	115	0
	CRYPTOPHYTA TOTAL	**345**	**287**	**115**	**0**
	Euglena sp.	0	230	517	0
	Phacus sp.	115	57	287	0
EUGLENOPHYTA (EUGLENOIDS)	**EUGLENOPHYTA TOTAL**	**115**	**287**	**804**	**0**
PYRRHOPHYTA (DINOFLAGELLATES)	*Peridinium cinctum*	0	57	0	0
	PYRRHOPHYTA TOTAL	**0**	**57**	**0**	**0**
	TOTALS	**2,699**	**14,818**	**13,383**	**1,781**

SOUTH RICE LAKE

ZOOPLANKTON ANALYSIS

DIVISION	TAXON	Vertical Tow (m)	06/17/09 #/m2	07/15/09 #/m2	8/12/2009 #/m2	8/26/2009 #/m2
CLADOCERA	*Bosmina longirostris*		4,598	0	0	9,726
	Chydorus sphaericus		0	12,202	0	4,863
	Daphnia galeata mendotae		4,598	0	3,006	0
	Daphnia pulex		0	0	0	0
	Daphnia retrocurva		0	0	0	0
	Diaphanosoma leuchtenbergianum		0	0	3,006	0
	Immature Cladocera		0	0	0	0
	CLADOCERA TOTAL		**9,196**	**12,202**	**6,013**	**14,589**
COPEPODA	*Cyclops sp.*		4,598	48,807	3,006	34,041
	Diaptomus sp.		0	0	3,006	0
	Copepodid		0	0	0	0
	Nauplii		64,369	418,930	12,025	53,494
	COPEPODA TOTAL		**68,967**	**467,738**	**18,038**	**87,535**
ROTIFERA	*Asplanchna priodonta*		0	0	48,100	9,726
	Brachionus havanensis		0	435,199	9,019	9,726
	Filinia longiseta		0	0	102,213	24,315
	Keratella cochlearis		4,598	0	0	34,041
	Keratella quadrata		4,598	0	0	0
	Kellicottia bostoniensis.		0	0	0	0
	Lecane sp.		0	73,211	3,006	0
	Polyarthra vulgaris		0	0	0	4,863
	Trichocerca cylindrica		0	0	0	0
	Trichocerca multicrinis		0	20,336	0	0
	ROTIFERA TOTAL		**9,196**	**528,747**	**162,338**	**82,672**
	TOTALS		**87,358**	**1,008,686**	**186,388**	**184,796**

South Rice Pond 2009

Date	Max Depth (m)	Sample Depth (m)	Secchi Depth (m)	Chlorophyll-a (µg/L)	D.O. (mg/L)	D.O. % sat.	Temp (°C)	Sp. Cond. (µmhos/cm @25°C)	Total P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	pH
4/22/2009	1	0-2	0.41	20.96	.	.	.	.	153.2	16.2	1.28	7.97
		0			10.99	106.2	13.68	1075				
		1	.	.	5.04	47.4	12.42	1061	.	.	.	7.44
6/17/2009	1	0-2	1.08	1.15	.	.	.	.	118.8	70.7	0.65	8.9
		0			7.85	85.3	19.32	426				
		1	.	.	5.19	55.5	18.41	831	244.3	84.0	.	8.3
7/15/2009	1	0-2	0.7	15.52	.	.	.	.	153.8	32.7	1.02	7.76
		0			0.77	8.2	18.52	479				
		1	.	.	0.56	5.9	18.12	723	191.7	43.4	.	7.44
8/12/2009	1	0-2	0.52	8.17	.	.	.	.	381.8	65.7	1.46	7.94
		0			0.50	5.6	20.97	329				
		1	.	.	0.30	3.4	20.21	529	447.5	87.1	.	7.6
8/26/2009	1	0-2	0.8	9.14	.	.	.	.	209.7	62.3	1.09	7.72
		0			2.23	24.5	19.90	444				
		1	.	.	0.75	8.1	19.50	528	212.8	76.1	.	7.32
9/23/2009	1	0-2	0.6	48.15	.	.	.	.	258.6	29.6	1.57	7.36
		0			1.30	14.1	19.07	586				
		0.5	.	.					266.4	37.2	.	
		1	.	.	0.57	6.2	19.11	660	.	.	.	7.06

Appendix E

1972-2009 Twin Cities Monthly and Yearly Precipitation Data

Twin Cities Monthly and Yearly Precipitation Totals (inches)

1972 - 2009

http://climate.umn.edu/text/historical/msppre.txt

Twin Cities International Airport (MSP)

Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Annual*	Above 118yr Avg	Above 72-09 Avg	Jun-Aug total	Above Jun-Aug Avg
1972	0.84	0.49	1.25	1.69	2.18	3.31	5.12	2.48	1.96	1.77	1.11	1.57	23.77	-3.82	-5.65	10.91	-1.44
1973	0.92	0.84	1.12	2.32	2.48	1.06	2.9	3.05	2.08	1.29	1.97	1.1	21.13			7.01	
1974	0.17	1.06	1	2.42	2.08	5.21	1.14	2.75	0.58	1.69	0.66	0.35	19.11			9.10	
1975	2.82	0.79	1.67	5.4	3.81	7.99	0.58	4.92	1.31	0.27	4.8	0.79	35.15			13.49	
1976	0.87	0.59	2.83	0.8	1.13	3.86	2.45	1.39	1.42	0.49	0.16	0.51	16.5			7.70	
1977	0.65	0.93	2.66	1.84	2.86	3.57	3.72	9.31	4.43	2.34	1.42	1.15	34.88	7.29	5.46	16.60	4.25
1978	0.38	0.24	0.79	3.63	3.79	7.09	3.19	5.77	2.47	0.19	1.84	0.88	30.26			16.05	
1979	1.09	1.39	2.55	0.66	4.55	4.78	2.34	7.04	2.2	3.16	0.98	0.33	31.07			14.16	
1980	0.94	0.67	1.12	0.83	2.29	5.52	2.3	3.26	3.68	0.66	0.26	0.24	21.77			11.08	
1981	0.3	2.14	0.71	2.17	2.18	4.42	4.09	4.73	1.46	2.69	2.16	0.92	27.97			13.24	
1982	2.45	0.63	2.09	1.62	4.99	1.44	0.92	3.8	1.5	3.45	3.27	4.27	30.43	2.84	1.01	6.16	-6.19
1983	0.67	1.19	3.22	3.97	6.2	5.22	3.07	3.12	3.34	2.61	4.93	1.53	39.07			11.41	
1984	0.88	1.64	1.47	3.86	2.29	7.95	3.03	5.15	2.65	5.48	0.31	2.24	36.95			16.13	
1985	0.87	0.5	4.48	1.81	3.65	2.18	2.2	5.02	4.37	3.66	1.72	1.2	31.66	4.07	2.24	9.40	-2.95
1986	0.9	0.84	2.03	5.88	3.48	5.34	4.11	4.44	6.9	1.77	0.62	0.31	36.62			13.89	
1987	0.63	0.13	0.64	0.16	1.88	1.95	17.9	3.67	1.28	0.6	2.07	1.25	32.16			23.52	
1988	1.37	0.3	1.33	1.58	1.7	0.22	1.17	4.29	2.79	0.8	2.86	0.67	19.08			5.68	
1989	0.52	1.04	2.19	2.66	3.38	3.5	3.5	2.92	1.28	0.53	1.38	0.42	23.32			9.92	
1990	0.1	0.77	3.66	3.8	3.36	9.82	5.06	1.71	1.88	1.23	0.65	1.01	33.05			16.59	
1991	0.49	1.03	2.29	3.58	6.35	2.57	2.95	3.14	5.43	2.52	5.29	1.05	36.69			8.66	
1992	0.66	0.57	1.56	1.99	1.15	3.68	5.21	4.54	5.2	2.11	1.95	1.05	29.67	2.08	0.25	13.43	1.08
1993	1.25	0.39	1.25	1.99	4.02	6.28	5.58	6.5	2.04	0.79	1.57	0.55	32.21			18.36	
1994	1.17	0.78	0.32	3.77	2.21	3.09	4.12	2.9	4.74	4.65	1.39	0.53	29.67			10.11	
1995	0.36	0.25	2.11	1.9	2.43	3.38	2.72	4.59	2.21	3.68	0.88	1.15	25.66			10.69	
1996	1.87	0.24	1.39	0.76	2.37	4.76	2.09	1.43	1.3	3.01	5.08	1.75	26.05	-1.54	-3.37	8.28	-4.07
1997	1.71	0.3	1.18	1.01	1.7	3.7	12.6	6.01	3.19	2.03	0.69	0.31	34.43			22.31	
1998	1.64	0.8	4.56	1.56	4.4	6.52	2.63	5.99	1.32	2.19	1.32	0.46	33.39			15.14	
1999	2.67	0.4	1.86	3.43	6.56	3.68	4.55	2.64	2.73	0.92	0.77	0.33	30.54			10.87	
2000	0.9	1.08	1.12	1.12	4.56	4.56	6.1	3.19	2.15	1.09	3.38	1.23	30.48	2.89	1.06	13.85	1.50

2001	1.21	1.33	1.09	7	4.53	6.35	2.12	2.31	3.5	1.28	2.77	0.74	34.23			10.78	
2002	0.46	0.36	1.38	3.23	2.83	8.3	5.19	8.3	3.89	4.21	0.09	0.21	38.45			21.79	
Twin Cities Monthly and Yearly Precipitation Totals (inches)																	
1891 - 2009	(abridged)																
http://climate.umn.edu/text/historical/msppre.txt																	
Twin Cities International Airport (MSP)																	
Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Annual*	Above 118yr Avg	Above 72-09 Avg	Jun-Aug total	Above Jun-Aug Avg
2003	0.22	0.54	1.44	2.4	6.14	4.66	2.06	1.12	2.2	0.62	0.71	0.62	22.69			7.84	
2004	0.23	1.09	2.11	2.06	6.39	3.06	3.36	1.19	4.21	2.32	0.93	0.44	27.39			7.61	
2005	**1.21**	**0.96**	**1.37**	**2.3**	**2.78**	**4.24**	**2.94**	**5.22**	**4.44**	**5.45**	**1.53**	**0.97**	**33.41**	**5.82**	**3.99**	**12.40**	**0.05**
2006	0.71	0.32	2.01	5.97	1.66	2.81	1.29	6.9	2.44	0.41	0.92	2.13	27.57			11.00	
2007	**0.31**	**1.37**	**3.64**	**1.11**	**1.99**	**2.05**	**3.29**	**9.32**	**6.04**	**3.63**	**0.09**	**1.48**	**34.32**	**6.73**	**4.90**	**14.66**	**2.31**
2008	**0.15**	**0.4**	**1.97**	**3.12**	**2.53**	**2.7**	**2.13**	**3.35**	**1.78**	**1.96**	**1.14**	**1.15**	**22.38**	**-5.21**	**-7.04**	**8.18**	**-4.17**
2009	**0.57**	**0.93**	**1.5**	**1.57**	**0.53**	**2.86**	**2.17**	**6.43**	**0.46**	**5.57**	**0.38**	**1.78**	**24.75**		**-4.67**	**11.46**	**-0.89**
118 Year Avg	0.85	0.83	1.63	2.24	3.4	4.17	3.58	3.51	2.92	2.07	1.45	0.93	27.59				
1972-2009 Avg	0.93	0.77	1.87	2.55	3.25	4.31	3.73	4.31	2.81	2.19	1.69	1.02	29.42		Jun-Aug Avg	12.35	
				2009 - avg	-2.72	-1.45	-1.56	2.12									
				2008 - avg	-0.72	-1.61	-1.60	-0.96									
				2005 - avg	-0.47	-0.07	-0.79	0.91									