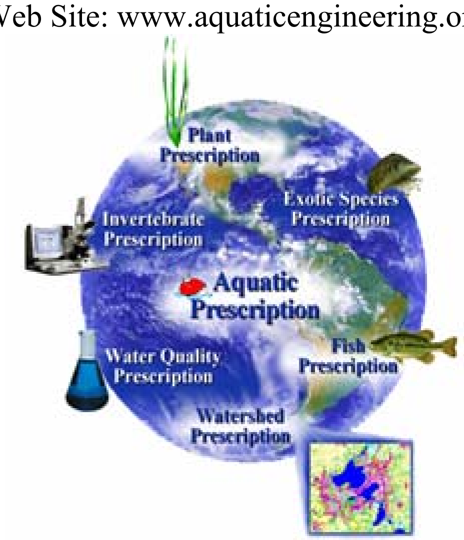
The Limnological Institute

A conservation organization providing research and solutions for the preservation of our inland waters.

2006 Silver Lake Water Quality Technical Report

Prepared by:

Aquatic Engineering
Post Office Box 3634
La Crosse, WI 54602-3634
Phone: 608-781-8770
Fax: 608-781-8771
E-mail: info@aquaticengineering.org
Web Site: www.aquaticengineering.org



2006 Silver Lake Water Quality
Technical Report

June 2008

By J. E. Britton[1] and The Limnological Institute[2]

In cooperation with the Wisconsin Department of Natural Resources and the City of Portage, WI.

1 Aquatic Engineering, Inc.; jbritton@aquaticengineering.org
PO Box 3634, La Crosse, WI 54602-3634
Phone: 866-781-8770
www.aquaticengineering.org

Signature   Date

2 The Limnological Institute; info@thelimnologicalinstitute.org
PO Box 304, La Crosse, WI 54602-3634
Phone: 800-485-1772
www.thelimnologicalinstitute.org

Signature   Date

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Jeff Grothman	City of Portage Mayor
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Timothy Raimer	City of Portage Parks, Recreation, and Forestry Manager

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Tim Larson	Fish biologist

Executive Summary

Silver Lake is a 74-acre spring-fed lake located in the city of Portage in Columbia County, Wisconsin. It is composed of two distinct basins divided by a public road. The basins are connected by a narrow channel that runs under the road. The area surrounding the lake contains a mix of commercial and residential development.

In 2005, the City of Portage contracted The Limnological Institute (TLI) to write a grant for Wisconsin Department of Natural Resources (WDNR) funding. Once the grant was awarded, TLI contracted Aquatic Engineering, Inc. (AEI) to perform the technical monitoring and the Wisconsin State Laboratory of Hygiene (WSLOH) to perform laboratory water quality analyses.

Water quality measurements collected in 2006 show that Silver Lake is a mesotrophic-eutrophic system that becomes thermally stratified in the summer and has physical parameters typical of spring-fed lakes. Total phosphorus, chlorophyll *a*, and Secchi readings were used to calculate the trophic status, and all support the eutrophic status.

Major water quality impacts are results of watershed runoff and groundwater interactions. There could also be possible inputs from septic systems and internal loading from sediments. More investigation is required to determine the exact nutrient inputs by category.

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1.0 Introduction

1.1 Project Scope

Silver Lake is a 74-acre spring-fed lake located in the City of Portage in Columbia County, Wisconsin (WBIC 107700; T12N R9E S6). Silver Lake is composed of two distinct basins divided by a public road. The basins are connected by a narrow channel that runs under the road. The two basins will be described as the east basin and the west basin for the remainder of this report. The west basin has a maximum depth of 42 feet and a mean depth of 20 feet while the east basin has a maximum depth of 15 feet and a mean depth of 5 feet. The area surrounding the lake contains a mix of commercial and residential development.

In 2006, the City of Portage contracted TLI to write a grant for WDNR funding. The purpose of the funding was to conduct baseline water quality monitoring in 2006. The WDNR approved the application and awarded the grant (LPL-1100-06A) to the City.

Once the grant was awarded, TLI contracted Aquatic Engineering, Inc. (AEI) to perform the technical monitoring and the Wisconsin State Laboratory of Hygiene (WSLOH) to perform laboratory water quality analyses. This report covers the water quality parameters sampled on site and water quality analyzed at the WSLOH.

Deliverables listed in the grant and covered in this report include:

Water Quality

- One year of current water quality, with a minimum of five Secchi disk readings from June 1 to August 31
- Summary of historical water quality data
- Temperature and dissolved oxygen levels at three-foot intervals in the deepest points of the lake during the summer
- Nutrient levels for TP, TKN, nitrate, ammonium, and nitrite throughout the summer with a nutrient budget

• Chlorophyll-α concentrations, turbidity, alkalinity, and pH throughout the summer

• TSI calculations from TP, Chl-α, and Secchi readings

Watershed Description

• Topographic map showing watershed boundaries, inflows, and outflows

• Determination of watershed area

• Quantification of land use areas within watershed

• Calculation of nutrient loading by area

• Location of all inputs into lake, including streams, drainage ditches, drain tile, etc.

• GIS map of above information

• Lake and watershed model to develop annual nutrient budget

Recreational Water Use

• Primary human use patterns in the lake and on shore

• Areas where use is restricted for any reason

• Water intakes for public water supply or irrigation

• GIS map of above information

The balance of this report covers these items and provides a discussion and recommendations for water quality management for Silver Lake.

2.0 Review of Existing Information

2.1 Water Clarity

Secchi depth data was available through the Self-Help section of the WDNR website. A review of available data back to 1991 indicates a slight decline in the clarity of water in Silver Lake, depicted by a trend line (Figure 1). The average rate of decline is about 0.5 inches per year.

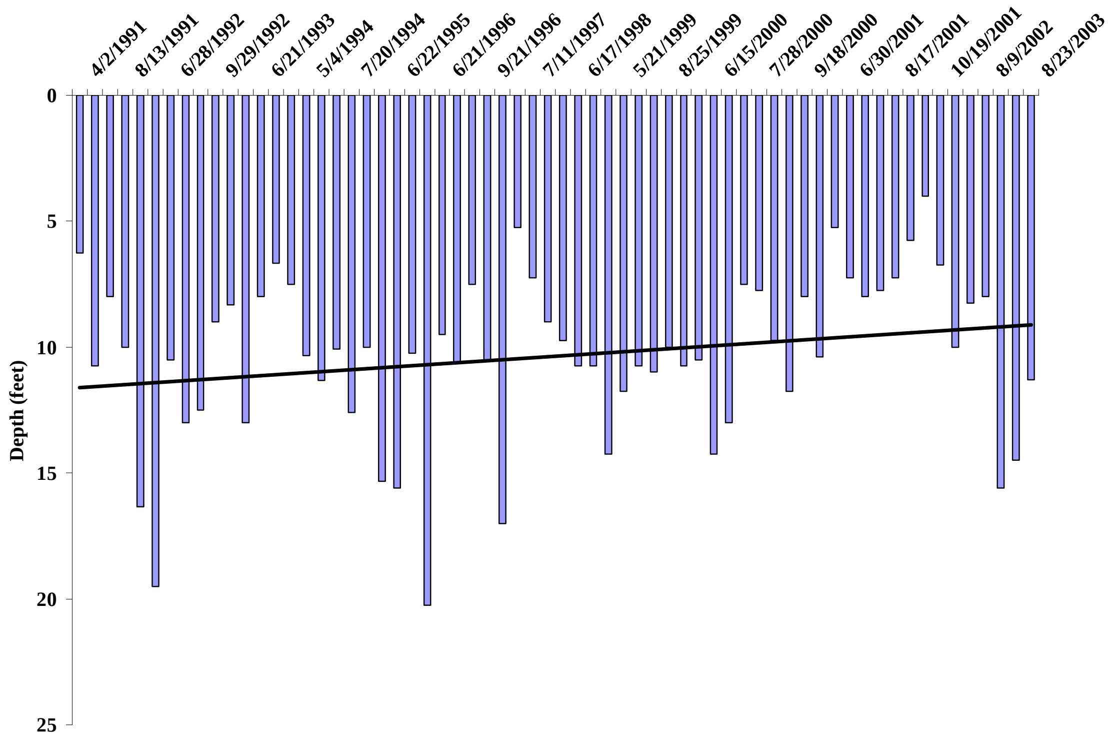

Figure 1. Secchi depth from 1991-2003, Silver Lake (Columbia County, WI).

2.2 Trophic Status

There is no existing information regarding the nutrient levels present in Silver Lake. The WDNR has not conducted previous monitoring, or the data is not available through the WDNR website. Using the historical Secchi data and a recent average of approximately 10 feet, the approximate trophic status is oligotrophic (WDNR 2006). The true trophic status of Silver Lake is unknown.

2.3 Watershed Analysis and Nutrient Modeling

There is no existing watershed analysis or nutrient response modeling information for Silver Lake. The City of Portage has not previously contracted professional monitoring or assessment.

3.0 Methods

3.1 Water Sample Collection

A sample site was established at the deepest location in both basins of the lake (Figure 2). The west basin had a maximum depth of approximately 42 feet, and the east basin maximum depth was approximately 13 feet deep. At these two sites, ecologists from AEI performed all water measurements and collections from May through October in 2006. Surface samples were collected at elbow depth (approximately 1.5 feet). Bottom samples were collected by lowering a Van Dorn sampling device to approximately one foot above the sediment. Water samples were placed on ice and delivered to the WSLOH in Madison, WI. Samples were analyzed for total phosphorus, chlorophyll *a*, total Kjeldahl nitrogen, and total suspended solids.

Figure 2. Water quality sampling locations, Silver Lake (Columbia County, WI) 2006.

3.2 On-Site Water Quality Measurements

Depth profiles were collected at each water quality sample site during the summer sampling events (May through October). Data were collected at three-foot intervals throughout the water column for dissolved oxygen, pH, and temperature. A Van Dorn sampling device was used to collect the water samples and a HACH Sension probe was used to measure the parameters. Probes were calibrated prior to each sampling event. The HACH dissolved oxygen probe was calibrated with water-saturated air. The pH probe was calibrated using a two-point bracketing standards method where the low standard was pH 7.0 and the upper standard was pH 10.01. Temperature readings were gathered using the sensor attached to the dissolved oxygen probe.

3.3 Trophic Status Calculations

Trophic status was calculated for Silver Lake water samples using the following equations (the units of measurement required for each parameter are included as a subscript in the equation):

$TSI_{SD} = 60 - 14.41 * \ln (SD_{m})$

$TSI_{chl} = 9.81 * \ln (chl_{\mu g}) + 30.6$

$TSI_{TP} = 14.42 * \ln (TP_{\mu g}) + 4.15$

The following scale is used to evaluate trophic status (Lillie and Mason 1983):

TSI < 40	oligotrophic
40 < TSI < 50	mesotrophic
TSI > 50	eutrophic

3.4 Watershed Delineation and WiLMS Analysis

The delineation was performed in cooperation with Central Engineering and the City of Portage. Central Engineering is a civil engineering firm contracted by the city of Portage to provide engineering solutions for the city. The storm water drain system was used to determine which parts of the City drained into the lake. A topographic map was used to verify slope in areas not impacted by the storm water system. The total watershed was able to be delineated using the storm water system and topographic maps. The final delineation was electronically reproduced using GIS software and used for analyzing nutrient inputs.

Land use data was obtained from the WDNR WebView service. The data were created between 1991 and 1993 by the DNR. Land use coverage was determined using spectral reflectance and ground truthing. Any land use changes after this period will not be reflected in the evaluation.

The data were imported into Arc GIS, clipped to the watershed boundaries, split into land use categories, and summed by total acreage. Nutrient load estimates were created using WiLMS modeling and data from the land use analysis and public use survey. Precipitation, evaporation, soil coefficients, and other Columbia County default data were used when available.

No point sources of pollution were identified during the scope of this work, and therefore no point sources were entered into WiLMS. Nutrient reduction scenarios were run based on reducing non-point source phosphorus loading by 25, 50, and 75 percent. The total expected annual phosphorus load was reported for each scenario.

4.0 Results

Water quality measurements collected in 2006 show that Silver Lake is a mesotrophic-eutrophic system that becomes thermally stratified in the west basin during summer and has physical parameters typical of spring-fed lakes. Total phosphorus, chlorophyll *a*, and Secchi readings all support the eutrophic status in the west basin.

4.1 Phosphorous

Total phosphorus (TP) was reported for each sampling event (Figure 3). The average monthly surface TP for the west basin of Silver Lake in 2006 was 22 µg/L and ranged from 18 µg/L to 29 µg/L. The TSI value for phosphorus was 49.4. These values approach the upper end of the mesotrophic status. The average hypolimnetic phosphorus concentration was 451 µg/L, ranging from 257-721 µg/L. Elevated concentrations of phosphorus at the bottom of the lake suggest that internal loading is contributing to the elevated phosphorus levels.

The average monthly surface TP in the east basin of Silver Lake was 20 µg/L (mesotrophic), with a range from 19-22 µg/L (Figure 4). This equals a TSI value of 47.1. The average phosphorus concentration one foot off the bottom was 302 µg/L (eutrophic). This suggests that internal loading is also contributing to elevated phosphorus levels in the east basin. The extremely high reading obtained from the east basin on September 12 is likely a result of capturing sediment particles in the water samples. If the sample is taken too close to the bottom, small particles of phosphorus-laced sediment or organic particulates (muck) can be collected. The particulates can drive the phosphorus artificially high.

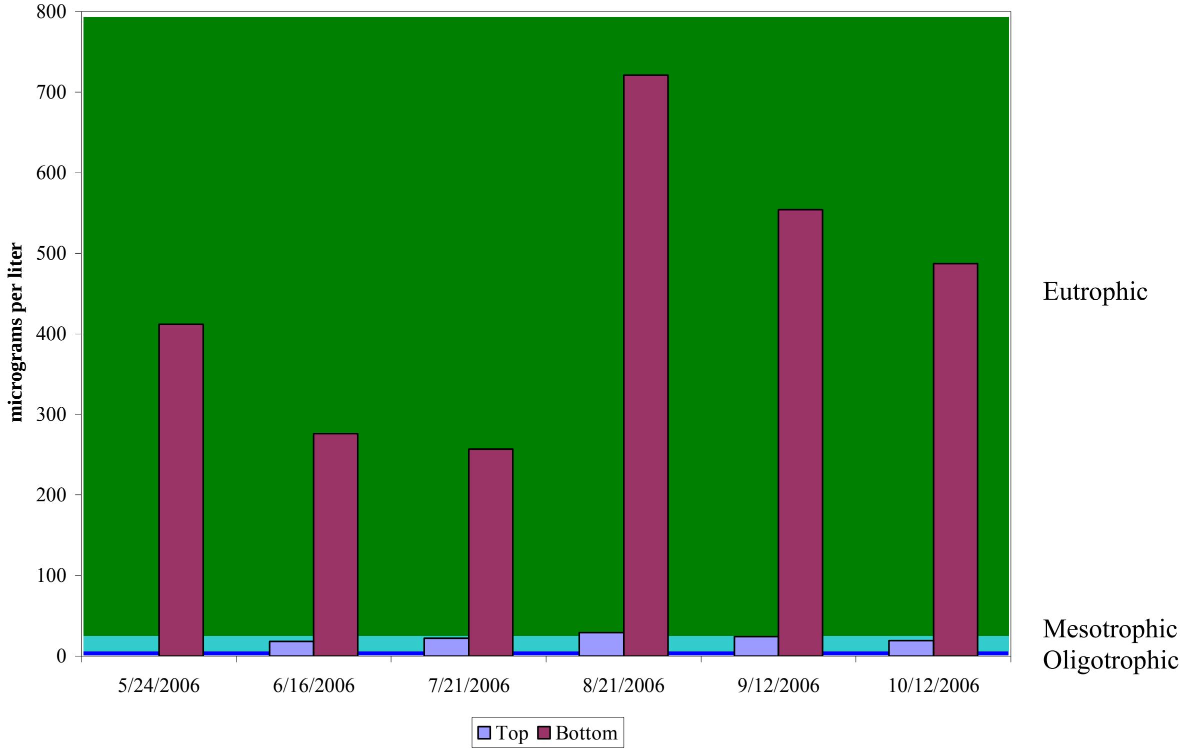

Figure 3. Total phosphorus measurements for the west basin of Silver Lake (Columbia County, WI) 2006.

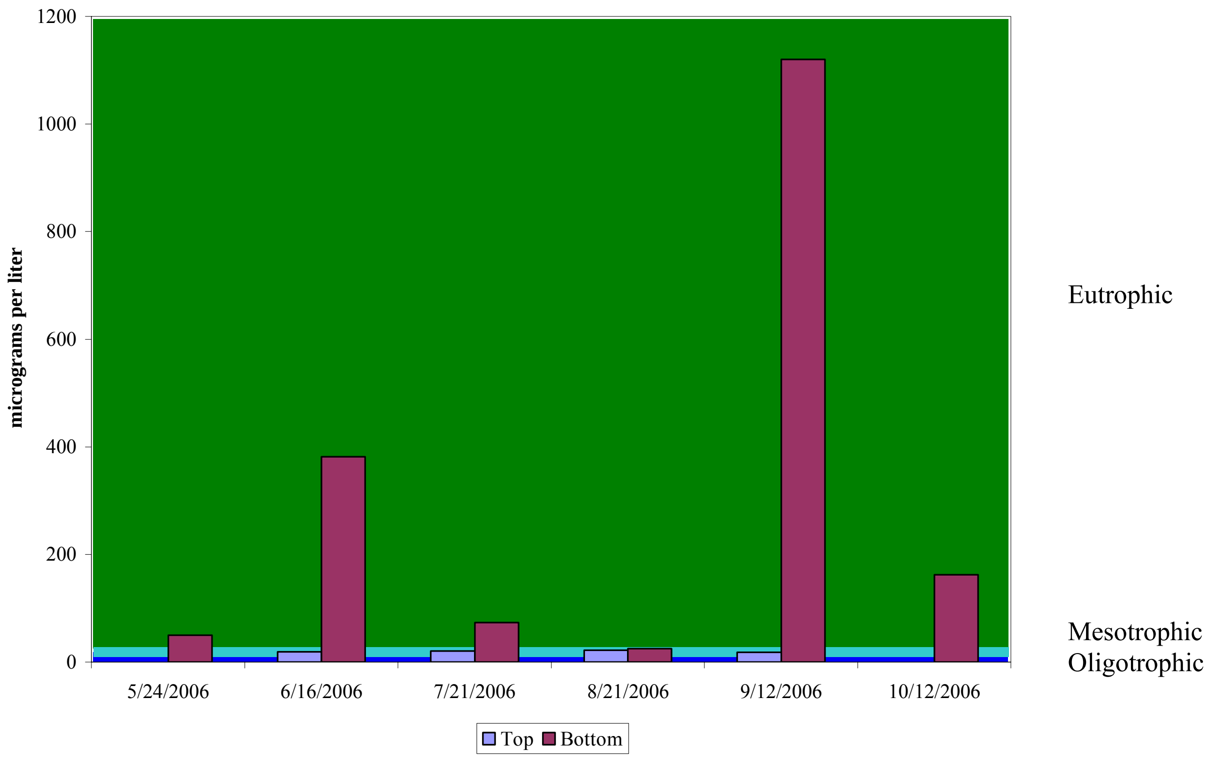

Figure 4. Total phosphorus measurements for the east basin of Silver Lake (Columbia County, WI) 2006.

4.2 Chlorophyll *a*

Chlorophyll *a* was reported at the surface for each sampling event. The average chlorophyll *a* in the west basin of Silver Lake in 2006 was 16.7 µg/L and ranged from 5.7 µg/L to 20.7 µg/L (Figure 5). The TSI_{Chl} was 60.5. These values are considered eutrophic. In the east basin, chlorophyll *a* averaged 5.5 µg/L, with a range from 4.0-8.5 µg/L (Figure 6). The TSI_{Chl} in the east basin was 46.7, which is mesotrophic.

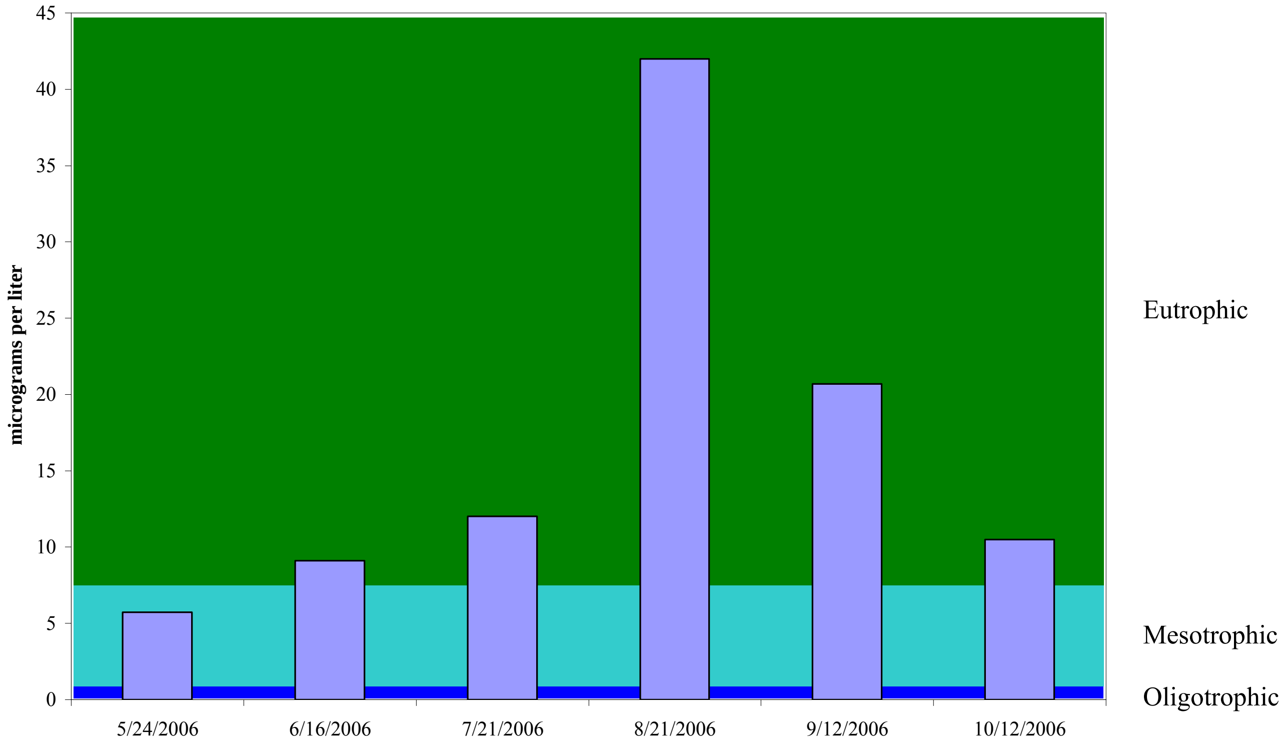

Figure 5. Chlorophyll *a* measurements for the west basin of Silver Lake (Columbia County, WI) 2006.

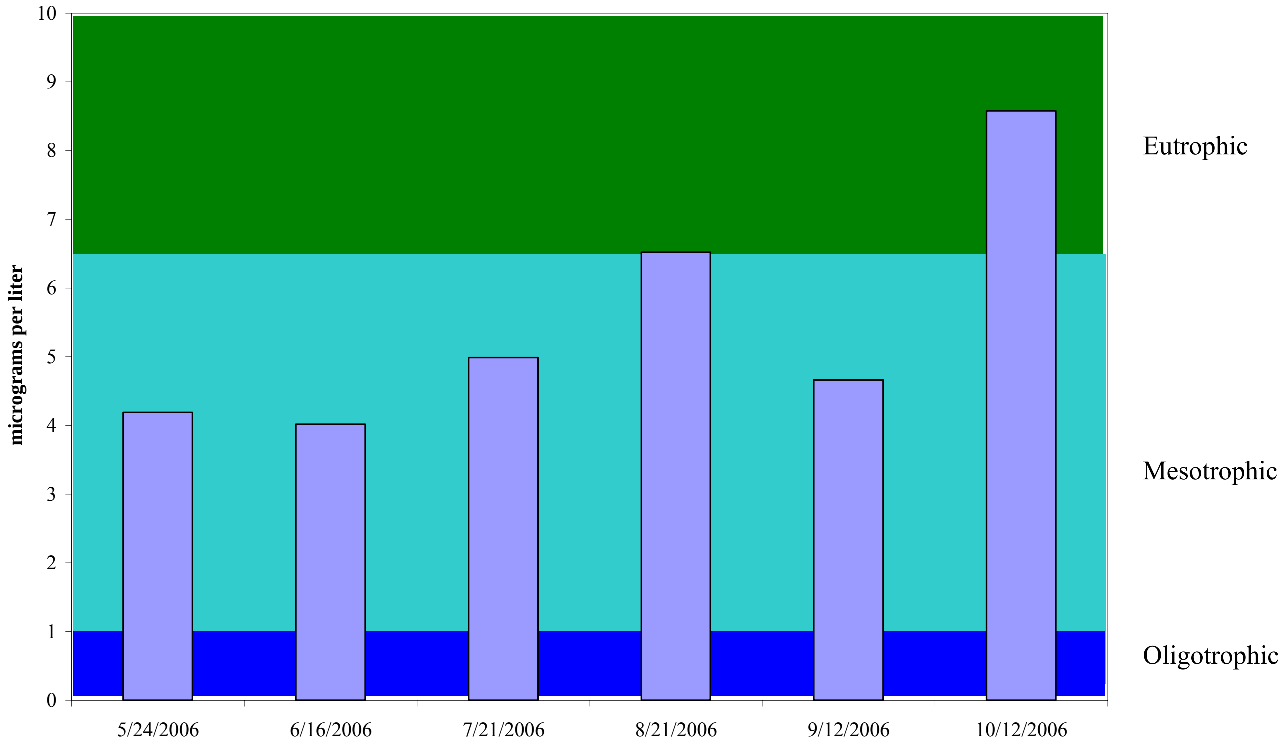

Figure 6. Chlorophyll *a* measurements for the east basin of Silver Lake (Columbia County, WI) 2006.

4.3 Secchi Depth

Secchi disk readings were collected six times in 2006 and averaged 4.63 feet in the west basin, with a maximum value of 7.0 feet and a minimum of 3.0 feet (Figure 7). The TSI_{SD} for the west basin of Silver Lake in 2006 was 57.1. This value is eutrophic. The east basin averaged 7.58 feet, with a maximum was 9.0 feet and a minimum of 6.5 feet (Figure 8). The TSI_{SD} in the east basin was 47.2, which is mesotrophic.

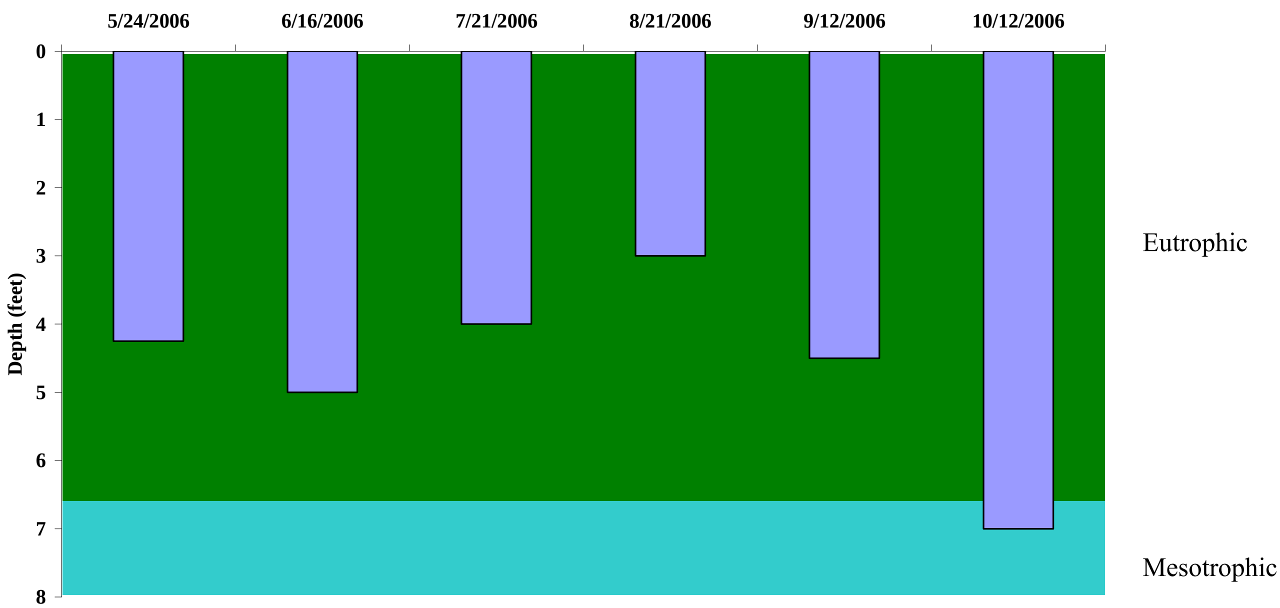

Figure 7. Secchi depth readings from the water quality sample location in the west basin of Silver Lake (Columbia County, WI) 2006.

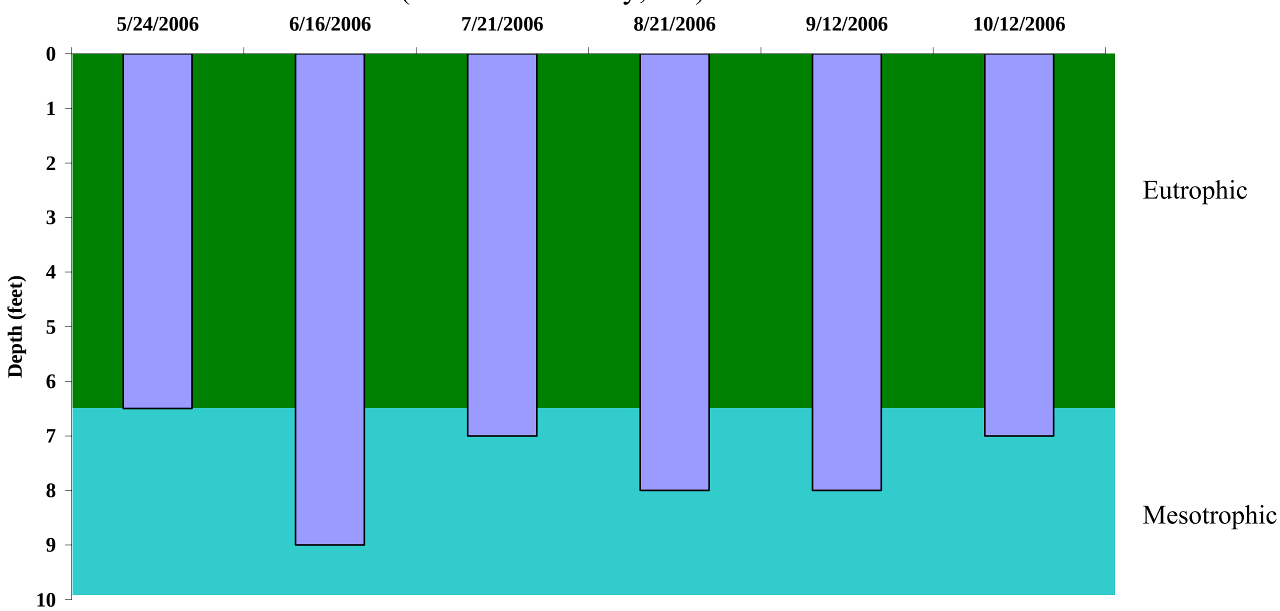

Figure 8. Secchi depth readings from the water quality sample location in the east basin of Silver Lake (Columbia County, WI) 2006.

4.4 Other Parameters

Other parameters measured were total suspended solids, total Kjeldahl nitrogen, temperature, conductivity, and pH. These chemical and physical parameters affect water quality in many different ways and are discussed separately in the following sections.

Total Suspended Solids (TSS)

Total suspended solids are considered the solids in water that can be trapped by a filter and may include materials like silt, decaying plants, animal matter, and sewage. A high concentration of TSS can lead to problems for aquatic life because TSS can block light penetration. Decreased light amounts can lead to a decrease in photosynthesis. This often decreases plant growth of high-value species which allows species of lesser value to dominate. Another adverse effect of high TSS is that reduced visibility of the lake water makes it difficult for predators to locate and capture their prey. Total suspended solids were determined each month for the surface and bottom of each basin.

In the west basin, TSS averaged 4.2 mg/L at the top and 17.2 mg/L at the bottom (Figure 9). The east basin did not have lab data for the top and averaged 105 mg/L at the bottom (Figure 10). The TSS in the east basin is substantially higher than the TSS of the west basin. There could be several reasons for this but the most likely are that increased plant decay, biological activity (possibly zooplankton), and natural flow from the west basin create the bulk of increased suspended solids. As the Secchi depth shows, the increased TSS is not creating decreased water clarity.

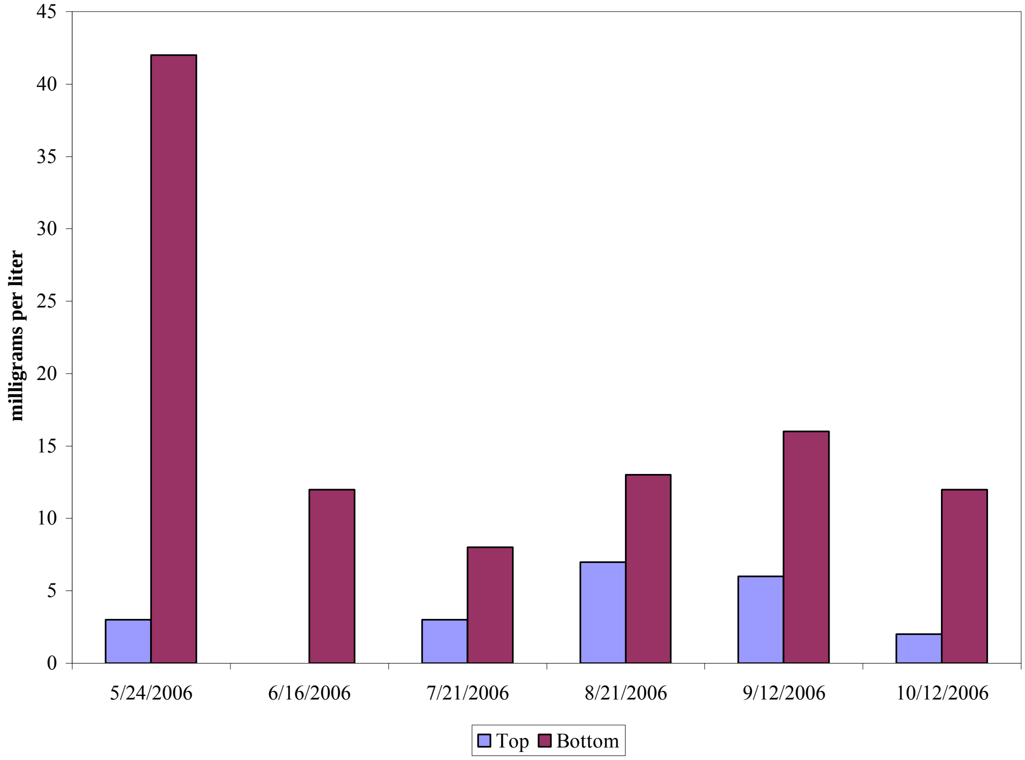

Figure 9. Total suspended solids in the west basin of Silver Lake (Columbia County, WI) 2006.

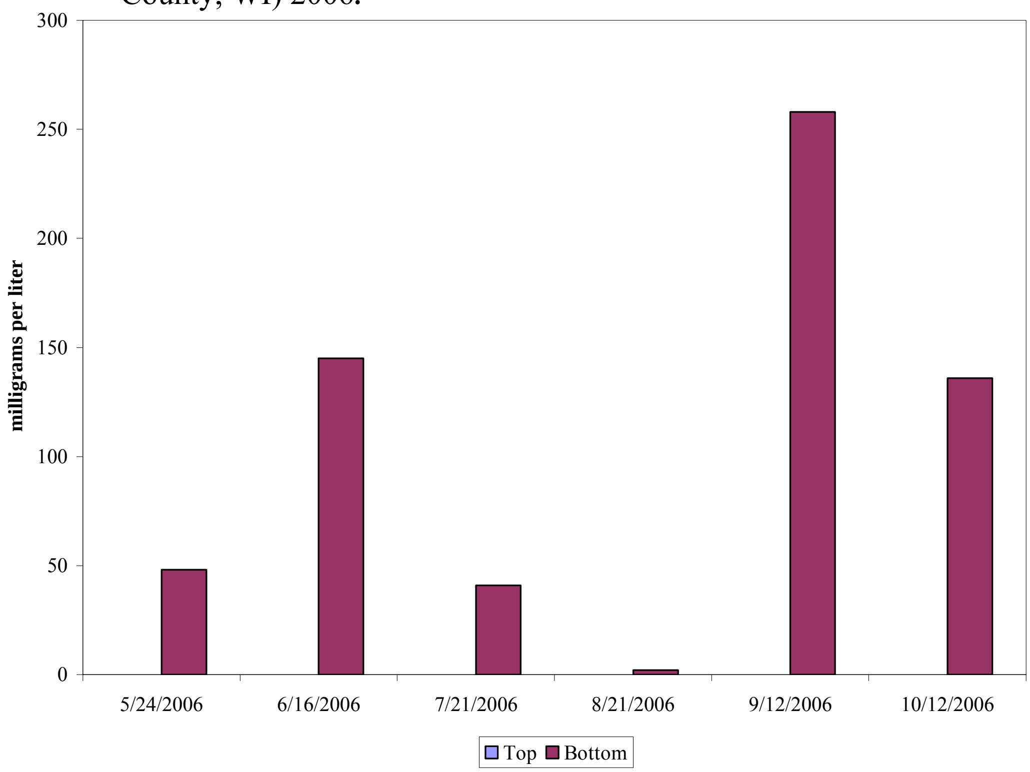

Figure 10. Total suspended solids in the east basin of Silver Lake (Columbia County, WI) 2006.

Total Kjeldahl Nitrogen (TKN)

The Kjeldahl technique is a laboratory test for measuring the amount of organic nitrogen contained in water. The organic nitrogen concentration is actually the total Kjeldahl nitrogen concentration minus the ammonia concentration. Organic nitrogen may be either dissolved or suspended particulate matter in water. High levels of organic nitrogen in water may indicate excessive production of organic pollution from the watershed. Animal and human waste, decaying organic matter, and live organic material like tiny algae cells can cause organic nitrogen enrichment of lake water (Tippecanoe Environmental Lake and Watershed Foundation 2006). Nitrogen, like phosphorus, is an essential macronutrient needed for algal production. Most lakes, however, are phosphorus limited, and attempts to reduce lake nitrogen levels may have little effect on algal biomass (Holdren and Taggart 2001).

The average surface TKN for Silver Lake in 2006 was 1.1 mg/L (Figure 11). The N:P ratio (TKN:TP) was approximately 49 to 1 (by mass) and supports the fact that Silver Lake is phosphorus-limited (generally any ratio over 15 to 1 N:P by weight is phosphorus-limited). The TKN at the bottom of the west basin averaged 6.1 mg/L. This equals a N:P ratio of 14 to 1, which also indicates a phosphorus-limited system. Implications of phosphorus driven systems are further discussed in Chapter 5.

In the east basin of Silver Lake, TKN averaged 0.85 mg/L at the surface and 6.8 mg/L at the bottom (Figure 12). The N:P ratio was 38 to 1 at the top and 15 to 1 at the bottom. These values also indicate a phosphorus-limited system in the east basin.

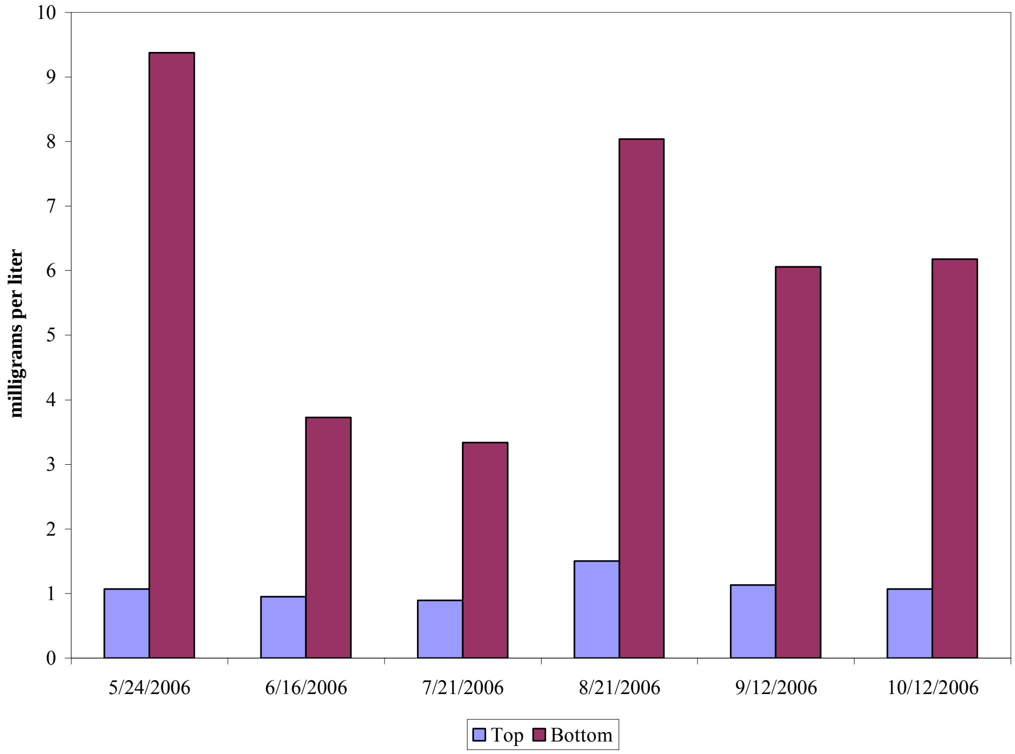

Figure 11. Total Kjeldahl nitrogen in the west basin of Silver Lake (Columbia County, WI) 2006.

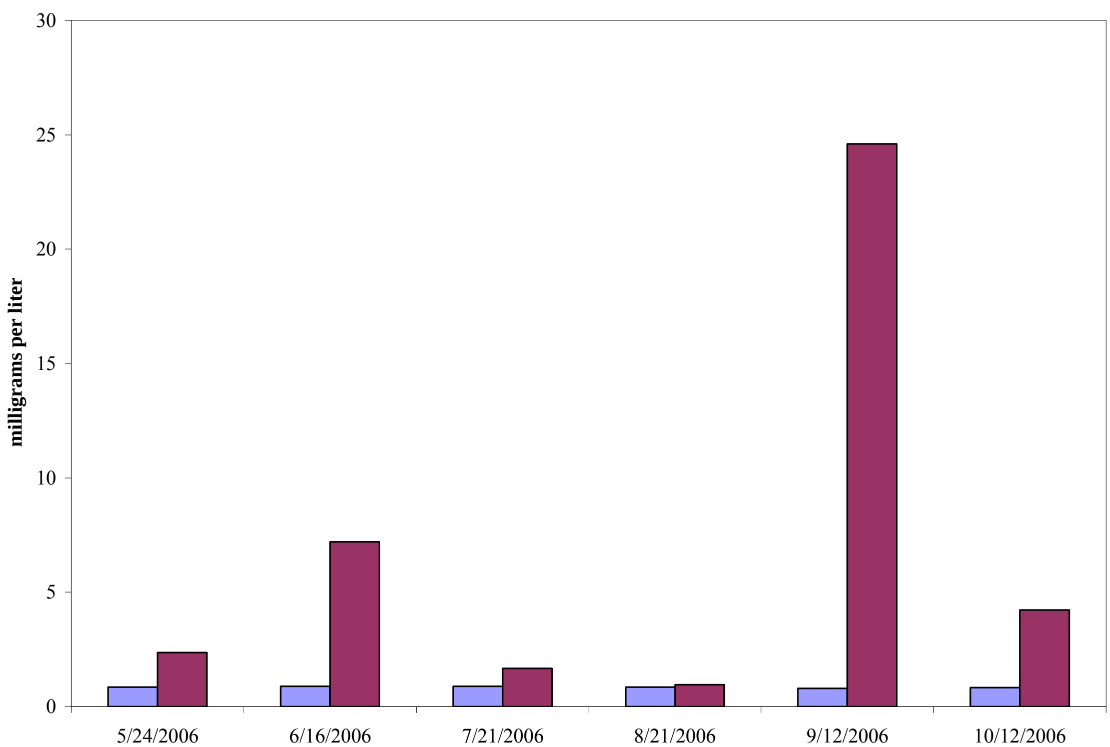

Figure 12. Total Kjeldahl nitrogen in the east basin of Silver Lake (Columbia County, WI) 2006.

Temperature

Temperature plays a major role in water quality, especially in lakes that become thermally stratified. Thermal stratification occurs when water in the top layer of a lake becomes heated by the sun and insufficient mixing action allows the warm water layer at the surface (epilimnion) to “float” on top of a cooler, more dense layer of water near the bottom (hypolimnion). As summer progresses, the difference in density between the two layers increases, and when the difference becomes too great for wind energy to mix, the lake becomes stratified (Holdren 2001). The region between the epilimnion and hypolimnion is called the metalimnion. The particular depth within the metalimnion where the rate of change in temperature is greatest is called the thermocline (Holdren 2001).

In 2006, the west basin of Silver Lake became thermally stratified. The difference in temperature from surface to bottom, approximately 15 degrees Celsius, was greatest during the August and September sampling periods, with August showing the strongest thermocline (Figure 13).

The east basin of Silver Lake stays more well mixed than the west basin since it is only 13 feet deep. The largest temperature difference from top to bottom was approximately 4 degrees Celsius. The greatest differences occurred in May and June, with June showing the greatest difference (Figure 14). The east basin did not thermally stratify during our investigation.

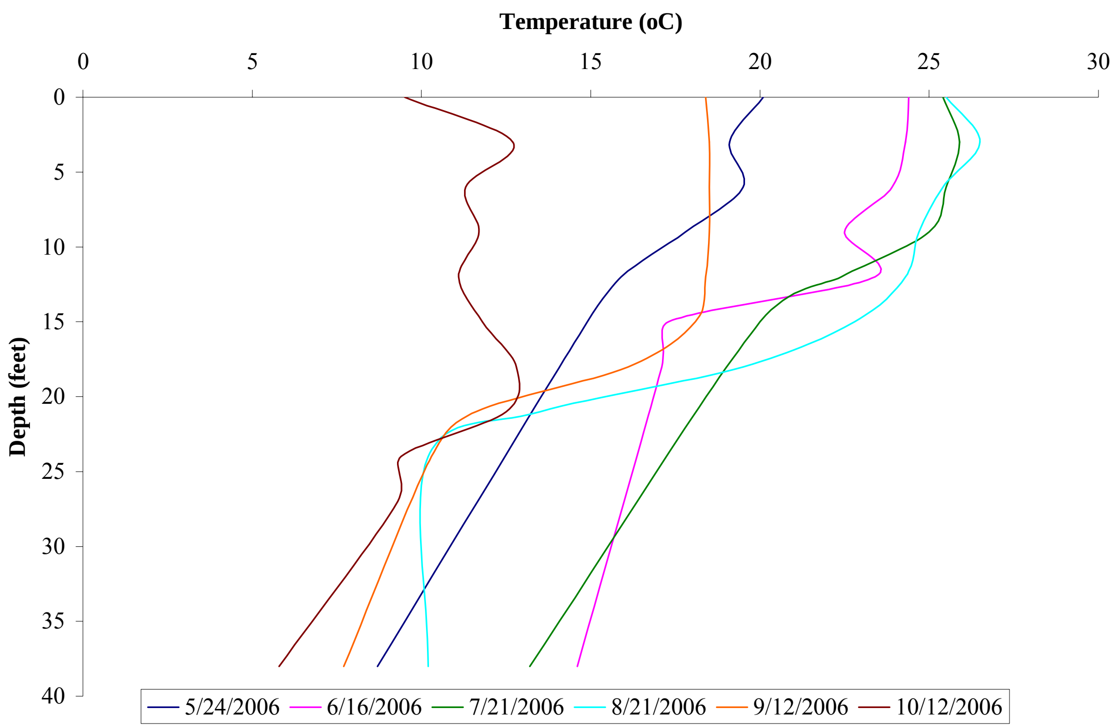

Figure 13. Temperature profiles of the west basin on Silver Lake (Columbia County, WI) 2006.

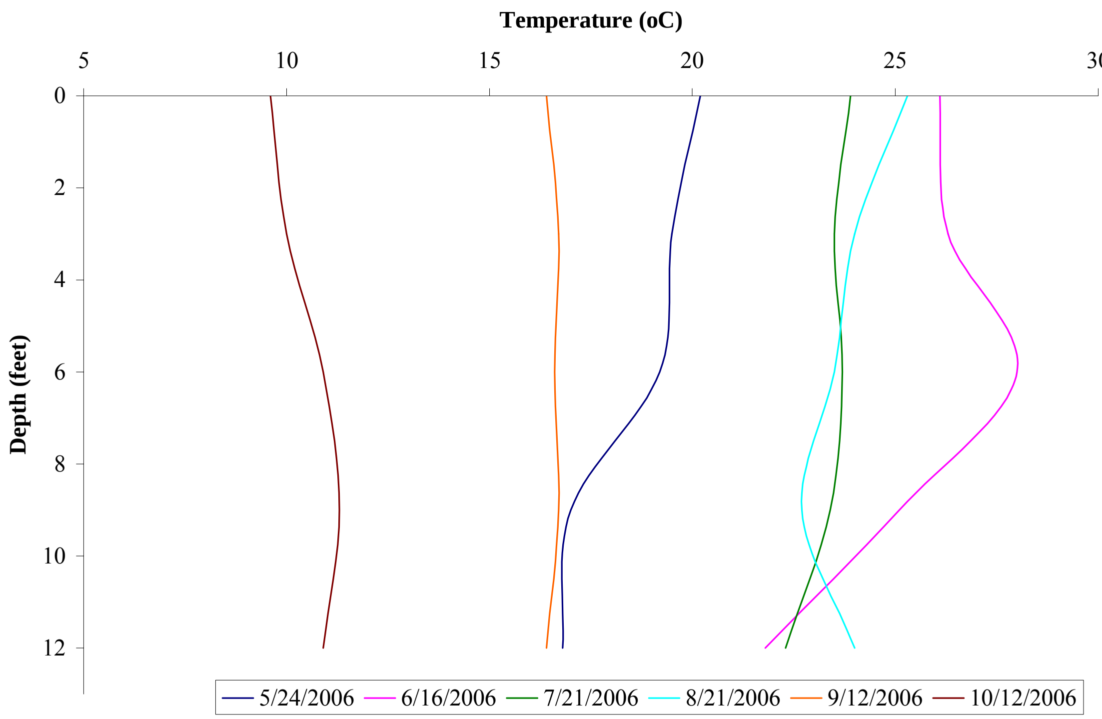

Figure 14. Temperature profiles of the east basin on Silver Lake (Columbia County, WI) 2006.

Dissolved Oxygen

Dissolved oxygen plays an important role in both lake biology and chemical properties because anoxic conditions make certain compounds more soluble in water. The chemical and biological properties are most affected during summer stratification when the oxygen-poor hypolimnion does not mix with the oxygen-rich epilimnion. As reported earlier, the west basin of Silver Lake thermally stratified in 2006. In addition to thermal stratification, an oxygen gradient was present in the lake from May to September (Figures 15 and 16). Readings from those months show that dissolved oxygen levels began dropping sharply between 10- and 15-foot sample points. The surface oxygen saturation in June was 110%, while at 25 feet deep it was near 15%. Similar, but less dramatic, decreases in oxygen saturation occurred during the other months. This oxygen depletion was due to the strong thermocline that formed and prevented mixing of the water column. Oxygen concentrations are usually low near the sediment regardless of the presence of a thermocline because of the biological oxygen demand of algae, plankton, and bacteria. Decomposition of organic waste near the sediment consumes oxygen faster than it can be replaced by photosynthesis and natural water mixing in the lake. A potential adverse effect of oxygen depletion is phosphorus release.

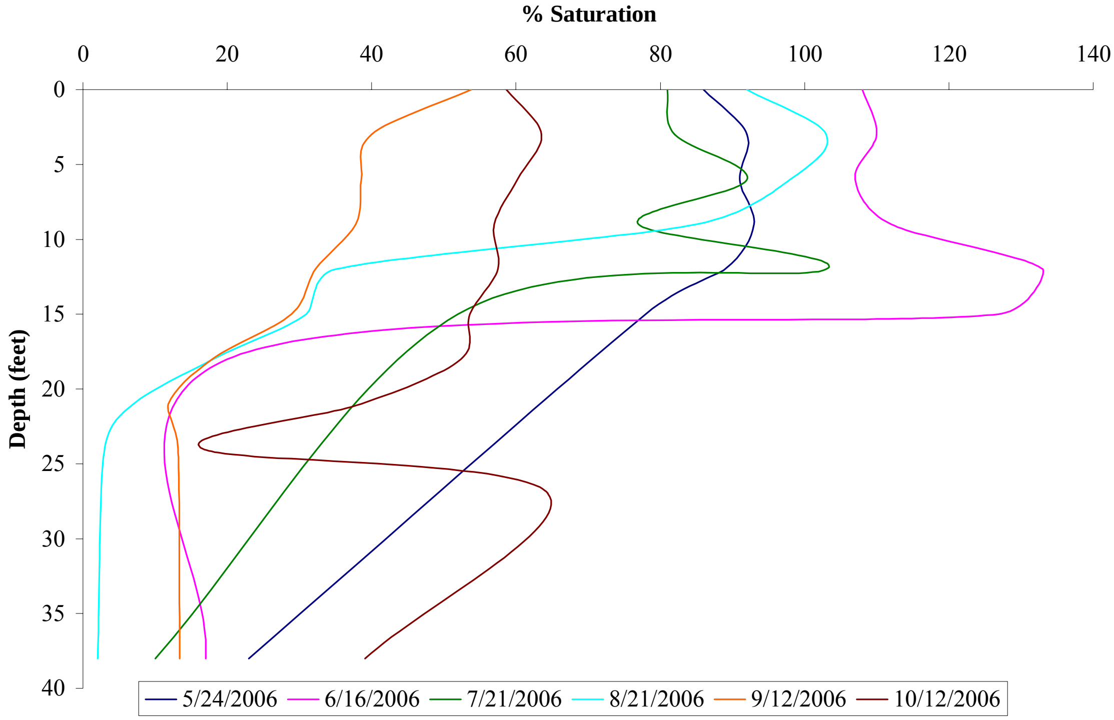

Figure 15. Dissolved oxygen profiles for the west basin of Silver Lake (Columbia County, WI) 2006.

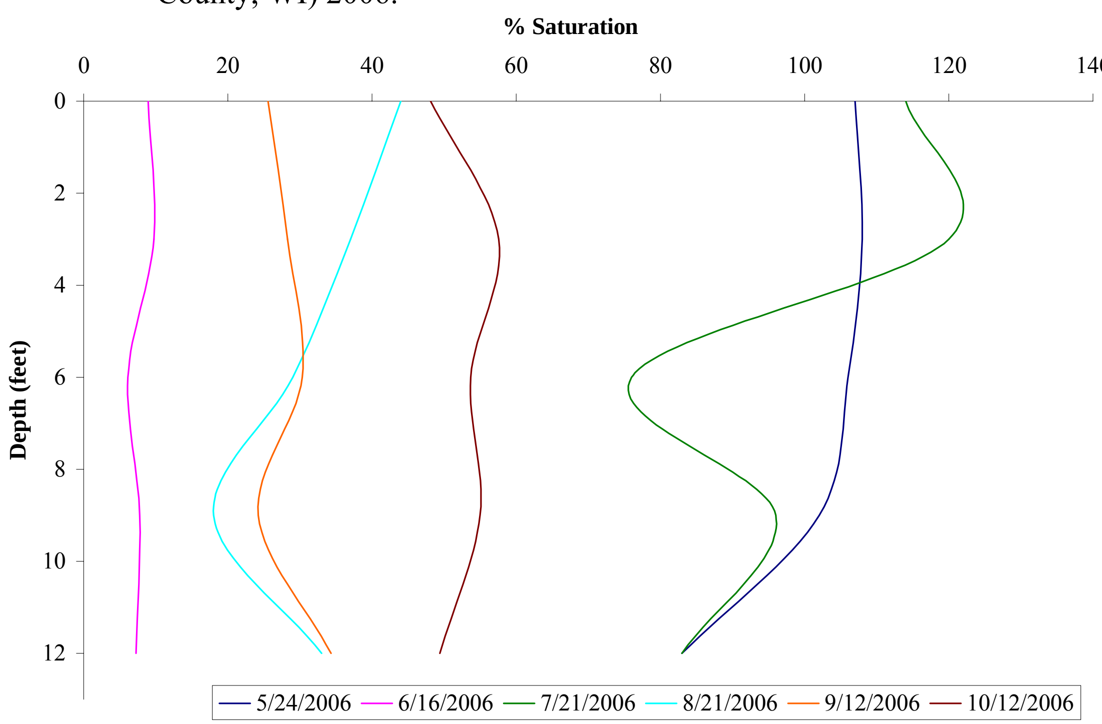

Figure 16. Dissolved oxygen profiles for the east basin of Silver Lake (Columbia County, WI) 2006.

pH

pH affects plants and fish present and has effects on the solubility of certain substances. The largest source of acidity in surface water is from the atmosphere; acidity can be increased by industrial and vehicular emissions. Elevated pH levels can also cause internal phosphorus loading. At pH levels above 9.5, phosphorus can be released from the sediments at rates similar to little or no oxygen levels (Holdren and Taggart 2001). Wisconsin lakes typically have a relatively neutral pH between 6.5 and 8.5

The pH levels in Silver Lake in 2006 were within the expected range for a spring-fed lake.

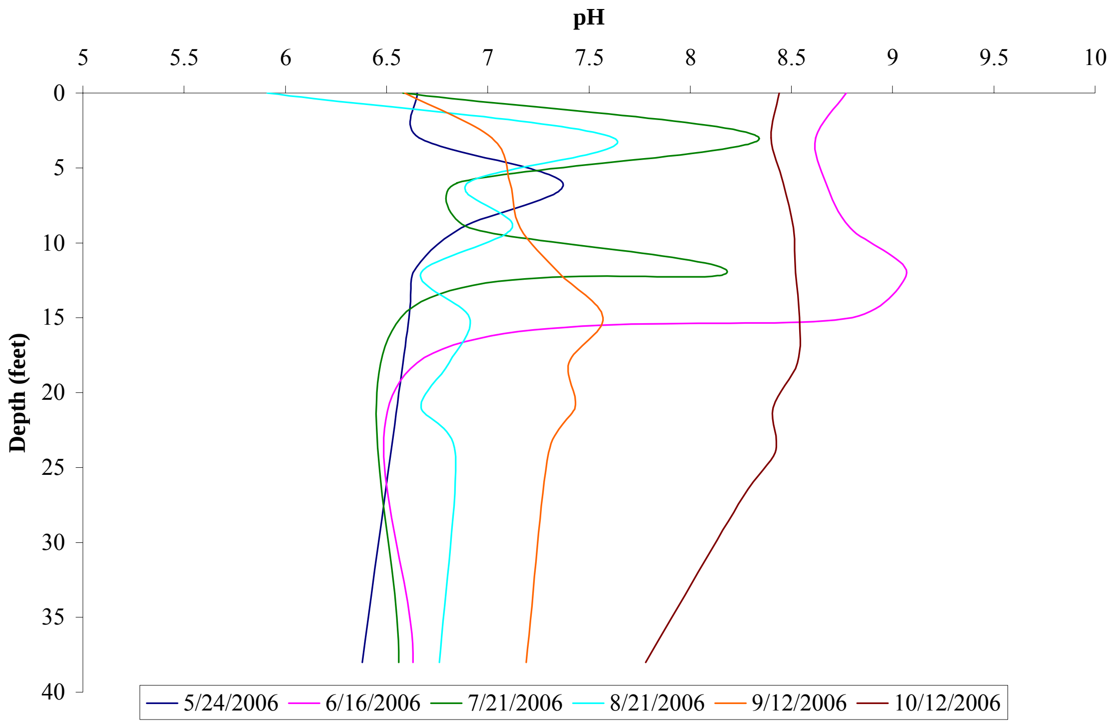

Figure 17. Profiles of pH in the west basin of Silver Lake (Columbia County, WI) 2006.

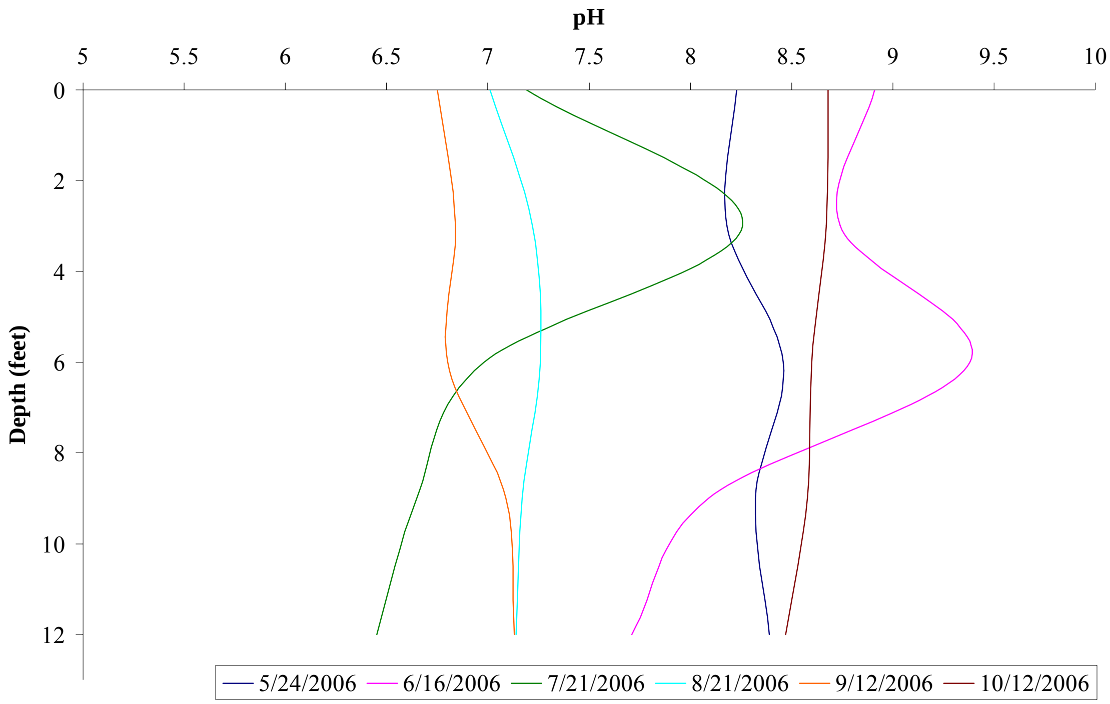

Figure 18. Profiles of pH in the east basin of Silver Lake (Columbia County, WI) 2006.

4.5 Watershed Delineation and WiLMS Analysis

The watershed delineation resulted in a 549-acre watershed (Figure 19). The watershed is dominated by urban land types, with interspersed pasture/grassland (Figure 20, Table 1). WiLMS software estimates 144.4kg of phosphorus are deposited in the lake each year through runoff.

Figure 19. Watershed delineation for Silver Lake (Columbia County, WI) 2006.

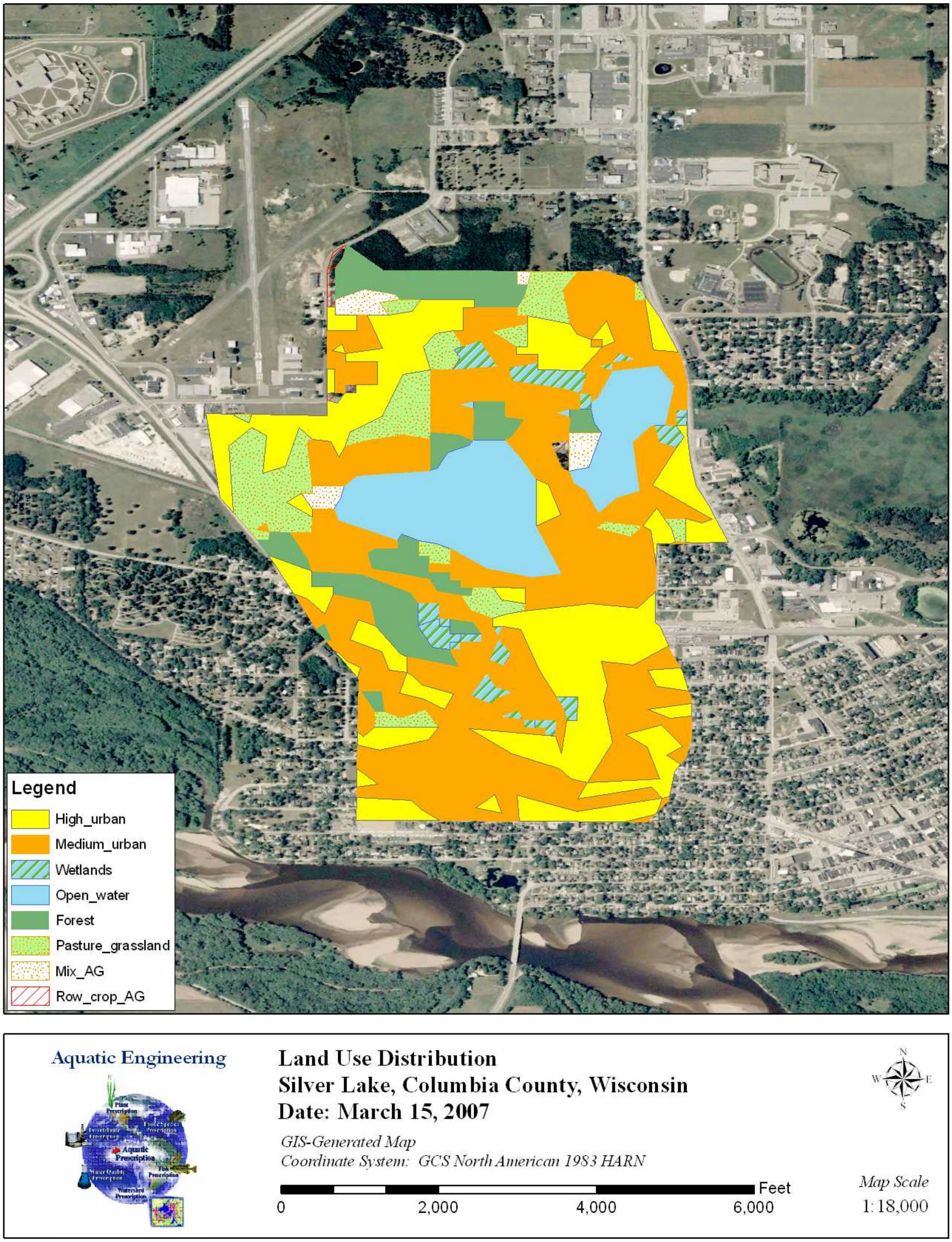

Figure 20. Watershed land use, Silver Lake (Portage County, WI) December 14, 2006.

Table 1. Land use data from watershed assessment used in WiLMS analysis.

Land Use Category	**Coverage (acres)**	**Percent of Watershed**	**Percent Phosphorus Load**
Row Crops	3	1%	1%
Wetlands	15	3%	<1%
Pasture/Grassland	46	8%	4%
Open Water	74	14%	6%
Medium-Intensity Urban	227	41%	32%
Mixed Agriculture	8	2%	2%
High-Intensity Urban	128	23%	54%
Forest	48	9%	1%
Total	**549**	**101%**	**100%**

Medium-density urban development constitutes the largest single land use type within the watershed. High-density urban land use, while approximately one quarter of the watershed, contributes the majority of phosphorus within the watershed (Figure 21 and Table 1).

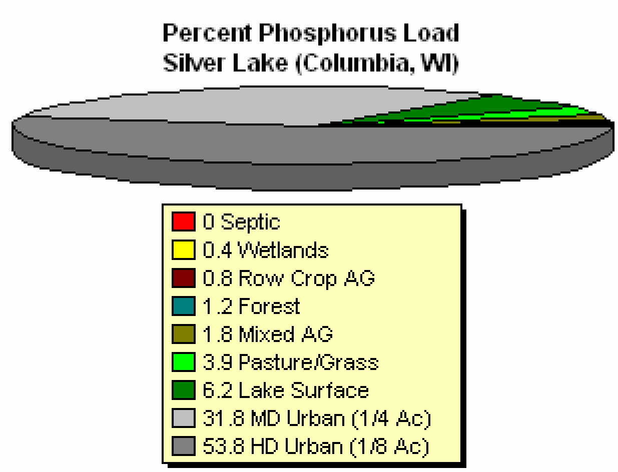

Figure 21. Phosphorus contributions within the Silver Lake watershed.

Non-point source reduction modeling shows decreasing phosphorus loads nearly identical to the percent decrease entered into the model (Table 2). This is because non-point sources were the majority contributor of all sources analyzed. If point sources were identified and entered into the model, a less direct correlation would exist.

Table 2. Annual phosphorus loads based on scenario reductions.

Percent decrease of non-point source load	Total phosphorus loading (kg/year)
Zero	144.4
25	110.5
50	76.7

5.0 Discussion

5.1 Trophic State Index

The TSI values for Silver Lake in 2006 show that chlorophyll α and Secchi levels were eutrophic, and phosphorus levels were at the upper end of mesotrophic (Table 3). Overall, the west basin is eutrophic. In the east basin, all TSI values were mesotrophic. Silver Lake has qualities expected of the eutrophic/mesotrophic status, with phosphorus and chlorophyll α concentrations peaking during mid summer and being inversely proportional to water clarity.

Table 3. Comparison of TSI values for the west and east basins of Silver Lake.

Parameter	**Chl a**		**TP**		**Secchi**	
	TSI	**Trophic status**	**TSI**	**Trophic status**	**TSI**	**Trophic status**
West Basin	60.5	eutrophic	49.4	mesotrophic	57.1	eutrophic
East Basin	46.7	mesotrophic	47.1	mesotrophic	47.2	mesotrophic

The values realized in the east basin are most likely artificially low due to extremely high aquatic vegetation biomass. In the east basin, plants are taking up nutrients at such a high rate that total phosphorus readings are low because of it. Abundant plants are also lowering chlorophyll-a readings (chlorophyll is contained in algae cells) and increasing water transparency (fewer algae present raises transparency). These three factors are what we use to calculate TSI. When plants artificially lower these values, you don't get a good estimate of the total biological production occurring in that area.

The water clarity of Silver Lake is moderate in the spring and fall. The elevated water quality results from basin to basin can be due to erosion from rain/wind events, algal blooms and/or recreational use. However, both of the basins have distinctly different morphological characteristics that acutely affect water quality. The west basin becomes tinted in the summer due to planktonic algae growth, which is confirmed further by the nutrient availability, Secchi readings and chlorophyll a values that occurred during the same sampling period.

There is no evidence that planktonic blooms have affected recreation or perceived value of the lake. The City has control of activities within Silver Lake's relatively small watershed and should implement watershed best management practices (BMPs) to prevent further degradation of water quality.

As part of a future monitoring strategy, the TSI values can be calculated and compared to historical data and will indicate whether the eutrophication process is increasing, decreasing, or remaining constant. The TSI value of a lake can change dramatically from year to year when environmental conditions are significantly different, so strong baseline data are required to determine actual trends. Monitoring water quality will also help determine the success of implemented BMPs.

5.2 Nutrients

There is evidence of internal loading of phosphorus in Silver Lake supported by the increased hypolimnetic concentrations. Dissolved oxygen decreased in the west basin to levels we can assume are promoting internal loading of phosphorus. As discussed earlier, pH values greater than 9.5 can also promote internal loading. However, the pH levels measured during this study were not high enough to suggest that internal loading is a result of the pH levels.

There is not enough known regarding the hydrology of the lake to determine what groundwater interactions contribute to the water column. Ground water is usually low in phosphorus and could be diluting the hypolimnetic water samples.

When the two basins are compared for phosphorus, it is clear that internal loading is a problem associated with the west basin and not the east. The east basin may contribute phosphorus through internal loading even though dissolved oxygen and pH readings would suggest otherwise. The reason this could happen is because decomposition occurring at the water-sediment interface can cause a locally decreased oxygen concentration (bacteria consume oxygen as they decompose plant and other organic matter in the sediment) to an extent necessary to make phosphorus soluble.

Oxygen depletion and phosphorus concentrations are going to be misleading in the east basin because of the amount of plant material present. The plants will be producing oxygen during the day and consuming it at night. Plants and algae will also take up phosphorus while they are growing and reproducing. The shear amount of plant and algae biomass in the east basin makes it difficult to generalize the results of measured chemical parameters.

The lake is clearly phosphorus limited (driven), which means plants and algae are limited in growth by the amount of phosphorus in the lake. Additions of phosphorus will correlate to increased plant and algae growth. Residents can limit phosphorus inputs by maintaining their septic systems, implementing watershed BMPs, and using phosphorus-free fertilizers.

5.3 Watershed Delineation and WiLMS Analysis

The land use data used to perform the WiLMS analysis does not contain current information regarding land use coverage. The data give a good indication of historical conditions for the area and show that urban development has been the predominant land use type. Grassland/pasture was also identified as a large portion of the watershed.

It is clear that the watershed of Silver Lake has been significantly impacted by urban development. Residential and commercial land uses are common within the watershed. Runoff from human influenced land types is almost always higher in pollutants, nutrients, and solids than runoff from naturally vegetated areas such as forests. Before the city can make goals for nutrient or sediment reductions they must understand natural background levels. That is to say, the city must find a similar but undeveloped watershed and quantify the typical load in the absence of human influence. This natural background level can be subtracted from the observed level within Silver Lake's watershed. The difference between observed values and natural values indicates the realistic room for improvement within the Silver Lake watershed.

The nutrient loading by land use type was estimated using historical data. A more exact nutrient model can be constructed if the land use information is updated. The State and County are best equipped to perform and update land use classifications. Planning efforts and partnering should be investigated if an updated nutrient budget is desired.

In addition to land use contributions, the WiLMS analysis did not consider nutrients originating from ground water interactions, point sources, or internal loading. A complete hydrologic budget and well monitoring is necessary for determining ground water contributions. A more detailed water quality sampling protocol is necessary to determine the extent of internal loading. Performing a hydrologic budget and monitoring for internal loading would be significant investments for managing water quality. The City should begin planning for these activities in the event water quality conditions continue to decline.

6.0 Recommendations

The water quality of Silver Lake is impacted by two main components – surface runoff and internal loading. Point source pollution may also contribute to nutrient inputs, but the amount of contribution is unknown as no point sources were obvious during our investigation.

The City of Portage should take the following steps to improve the quality of water within Silver Lake.

Short-term

- Public education and implementation of buffer strips and shoreline restoration
- Take semi-monthly surface and bottom water samples from May to October one year out of every three and have them analyzed for TP, Chl *a*, and TKN
- Continue WDNR's Citizen Lake Monitroing Network (CLMN) Secchi depth monitoring. Secchi depth should be recorded every other week from May to October

Mid-Term

- Initiate WDNR Advanced CLMN monitoring
- Install, maintain, and improve stormwater BMP's
- Investigate re-routing storm sewer for major roadway east of the eastern basin

Long-term

- Work with the County and local townships while they update and create land use and zoning regulations to help minimize effects of current and future development.
- Consider allocation of tax dollars for future management activities.
- Enforce existing erosion control ordinances. In particular, enforce construction site regulations.

- A street sweeping regimen may be necessary if the City applies salt and/or sand to roadways during winter months.

7.0 References

Holdren, C., W. Jones, and J. Taggart. 2001. Managing Lakes and Reservoirs. N. Am. Lake Mange. Soc. And Terrene Inst. In coop. with Off. Water Assess. Watershed Prot. Div. U.S. Environ. Prot. Agency, Madison, WI.

Lillie, R. A. and J. W. Mason. 1983. Limnological Characteristics of Wisconsin Lakes. Wisconsin Department of Natural Resources Technical Bulletin 138, Madison, WI.

Tippecanoe Environmental Lake and Watershed Foundation. Website accessed on February 2, 2006 http://www.telwf.org/watertesting/watertesting.htm

WDNR 2006. Website http://www.dnr.wi.gov/org/water/fhp/lakes/under/trophics.htm accessed on 12/15/06. Table 4 information used in reference.

Appendix A – Profile Data (collected on site)

	West Basin					
	Depth (ft)	pH	DO (mg/L)	% sat	temp (^oC)	Secchi (ft)
5/24/2006	0	6.65	7.41	86	20.1	4.25
	3	6.66	8.11	92	19.1	
	6	7.37	8.03	91	19.5	
	9	6.87	8.45	93	17.8	
	12	6.63	8.52	89	15.9	
	15	6.61	7.57	78	14.9	
	38	6.38	2.32	23	8.7	
6/16/2006	0	8.77	6.88	108	24.4	5
	3	8.62	8.92	110	24.3	
	6	8.67	8.83	107	23.9	
	9	8.79	9.5	112	22.5	
	12	9.07	11.16	133	23.4	
	15	8.8	11.98	127	17.3	
	18	6.65	1.88	20	17.1	
	38	6.63	1.7	17	14.6	
7/21/2006	0	6.58	6.81	81	25.4	4
	3	8.34	6.86	82	25.9	
	6	6.85	7.46	92	25.5	
	9	6.91	6.14	77	25	
	12	8.18	8.58	103	22.4	
	15	6.57	4.61	52	20	
	38	6.56	1.06	10	13.2	
8/21/2006	0	5.91	7.41	92	25.5	3
	3	7.62	8.07	103	26.5	
	6	6.9	7.83	98	25.4	
	9	7.12	6.9	85	24.7	
	12	6.67	2.85	35	24.3	
	15	6.91	2.61	31	22.8	
	18	6.81	1.63	18	19.5	
	21	6.67	0.73	7	13.5	
	24	6.84	0.31	3	10.2	
	38	6.76	0.24	2	10.2	
9/12/2006	0	6.59	4.89	53.8	18.4	4.5
	3	7.02	3.7	40	18.5	
	6	7.11	3.5	38.6	18.5	
	9	7.16	3.43	37.8	18.5	
	12	7.35	2.92	32.2	18.4	
	15	7.57	2.64	28.9	18.1	
	18	7.4	1.71	17.9	16.1	
	21	7.43	1.24	11.8	11.6	
	24	7.3	1.43	13.2	10.3	
	38	7.19	1.54	13.4	7.7	

	Depth (ft)	pH	DO (mg/L)	% sat	temp (^oC)	Secchi (ft)
10/12/2006	0	8.44	6.38	58.7	9.5	7
	3	8.4	6.42	63.5	12.7	
	6	8.46	6.28	60.2	11.3	
	9	8.51	5.89	57	11.7	
	12	8.52	6.03	57.5	11.1	
	15	8.54	5.53	53.6	11.8	
	18	8.53	5.28	52.4	12.8	
	21	8.41	3.91	38.5	12.5	
	24	8.42	1.81	16.6	9.4	
	27	8.26	7.03	64.4	9.3	
	38	7.78	4.65	39.1	5.8	

	East Basin					
	Depth (ft)	pH	DO (mg/L)	% sat	temp (°C)	Secchi (ft)
5/24/2006	0	8.23	9.33	107	20.2	6.5
	3	8.18	9.62	108	19.5	
	6	8.46	9.43	106	19.2	
	9	8.32	9.08	102	17	
	12	8.39	7.63	83	16.8	
6/16/2006	0	8.91	8.97	114	26.1	9
	3	8.74	9.74	120	26.3	
	6	9.38	6.12	76	28	
	9	8.09	7.78	96	25.1	
	12	7.71	7.25	83	21.8	
7/21/2006	0	7.19	5.23	64	23.9	7
	3	8.26	5.45	66	23.5	
	6	6.98	3.35	41	23.7	
	9	6.65	3.18	38	23.4	
	12	6.45	1.84	22	22.3	
8/21/2006	0	7.01	3.55	44	25.3	8
	3	7.22	3.07	37	24	
	6	7.26	2.41	29	23.5	
	9	7.17	1.49	18	22.7	
	12	7.14	2.67	33	24	
9/12/2006	0	6.75	2.42	25.6	16.4	8
	3	6.84	2.65	28.3	16.7	
	6	6.8	2.86	30.3	16.6	
	9	7.09	2.74	24.2	16.7	
	12	7.13	3.24	34.3	16.4	
10/12/2006	0	8.68	5.21	48.1	9.6	7
	3	8.67	6.18	57.6	10	
	6	8.6	5.65	53.7	10.9	
	9	8.58	5.72	55	11.3	
	12	8.47	5.19	49.4	10.9	

Appendix B – WSLOH Water Quality Reports

Parameter Description	Sample Location	Sample Depth	Sample Collected	Result Value	Units
ALKALINITY TOTAL CACO3	SILVER LAKE – WEST BASIN	F1	5/24/2006	105	MG/L
ALKALINITY TOTAL CACO3	SILVER LAKE – WEST BASIN	F1	6/16/2006	98.6	MG/L
ALKALINITY TOTAL CACO3	SILVER LAKE – WEST BASIN	F2	7/21/2006	92.2	MG/L
ALKALINITY TOTAL CACO3	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	92.6	MG/L
ALKALINITY TOTAL CACO3	SILVER LAKE – WEST BASIN	F1	9/12/2006	95.5	MG/L
ALKALINITY TOTAL CACO3	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	104	MG/L
ALKALINITY TOTAL CACO1	SILVER LAKE – EAST BASIN	F1	5/24/2006	74.4	MG/L
ALKALINITY TOTAL CACO2	SILVER LAKE – EAST BASIN	F1	6/16/2006	59.6	MG/L
ALKALINITY TOTAL CACO3	SILVER LAKE – EAST BASIN	F2	7/21/2006	57.1	MG/L
ALKALINITY TOTAL CACO3	SILVER LAKE – EAST BASIN	F1	8/21/2006	69.3	MG/L
ALKALINITY TOTAL CACO3	SILVER LAKE – EAST BASIN	F1	9/12/2006	75.6	MG/L
ALKALINITY TOTAL CACO3	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	78.1	MG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – WEST BASIN	F1.0	5/24/2006	5.73	UG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – WEST BASIN	F1.0	6/16/2006	9.1	UG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – WEST BASIN	F2	7/21/2006	12	UG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	42	UG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – WEST BASIN	F1	9/12/2006	20.7	UG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	10.5	UG/L

Parameter Description	Sample Location	Sample Depth	Sample Collected	Result Value	Units
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – EAST BASIN	F1	5/24/2006	4.19	UG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – EAST BASIN	F1	6/16/2006	4.02	UG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – EAST BASIN	F2	7/21/2006	4.99	UG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – EAST BASIN	F1	8/21/2006	6.52	UG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – EAST BASIN	F1	9/12/2006	4.66	UG/L
CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	8.58	UG/L
CONDUCTIVITY AT 25C	SILVER LAKE – WEST BASIN		5/24/2006	355	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – WEST BASIN		6/14/2006	341	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – WEST BASIN	F2	7/21/2006	329	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	328	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – WEST BASIN	F1	9/12/2006	333	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	352	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – EAST BASIN	F1	5/24/2006	286	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – EAST BASIN	F1	6/14/2006	256	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – EAST BASIN	F2	7/21/2006	251	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – EAST BASIN	F1	8/21/2006	272	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – EAST BASIN	F1	9/12/2006	280	US/CM
CONDUCTIVITY AT 25C	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	286	US/CM
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F1	9/12/2006	1.13	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F1.0	5/24/2006	1.07	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F1.0	6/16/2006	0.95	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	1.5	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	1.07	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F2	7/21/2006	0.89	MG/L

Parameter Description	Sample Location	Sample Depth	Sample Collected	Result Value		Units
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F38	5/24/2006		9.38	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F38	6/16/2006		3.73	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F38	7/21/2006		3.34	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F38	8/21/2006		8.04	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F38	9/12/2006		6.06	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – WEST BASIN	F39	10/12/2006		6.18	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F1	5/24/2006		0.85	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F1	6/16/2006		0.88	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F2	7/21/2006		0.88	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F1	8/21/2006		0.86	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F1	9/12/2006		0.79	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F1.0	10/12/2006		0.84	MG/L
					0.85	
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F10	5/24/2006		2.36	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F10	6/16/2006		7.2	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F11	7/21/2006		1.66	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F11	8/21/2006		0.96	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F11	9/12/2006		24.6	MG/L
NITROGEN KJELDAHL TOTAL	SILVER LAKE – EAST BASIN	F11	10/12/2006		4.22	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – WEST BASIN	F38	7/21/2006		2.19	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – WEST BASIN	F2	7/21/2006	ND		MG/L
NITROGEN NH3-N DISS	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	ND		MG/L
NITROGEN NH3-N DISS	SILVER LAKE – WEST BASIN	F38	8/21/2006		4.88	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – WEST BASIN	F38	9/12/2006		4.84	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – WEST BASIN	F1	9/12/2006		0.026	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – WEST BASIN	F1.0	10/12/2006		0.02	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – WEST BASIN	F39	10/12/2006		4.64	MG/L

Parameter Description	Sample Location	Sample Depth	Sample Collected	Result Value	Units
NITROGEN NH3-N DISS	SILVER LAKE – EAST BASIN	F11	7/21/2006	0.024	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – EAST BASIN	F2	7/21/2006	0.03	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – EAST BASIN	F1	8/21/2006	0.021	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – EAST BASIN	F11	8/21/2006	0.144	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – EAST BASIN	F11	9/12/2006	0.134	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – EAST BASIN	F1	9/12/2006	0.046	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	ND	MG/L
NITROGEN NH3-N DISS	SILVER LAKE – EAST BASIN	F11	10/12/2006	0.017	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – WEST BASIN	F38	7/21/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – WEST BASIN	F2	7/21/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – WEST BASIN	F38	8/21/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – WEST BASIN	F38	9/12/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – WEST BASIN	F1	9/12/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – WEST BASIN	F39	10/12/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – EAST BASIN	F11	7/21/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – EAST BASIN	F2	7/21/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – EAST BASIN	F1	8/21/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – EAST BASIN	F11	8/21/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – EAST BASIN	F11	9/12/2006	*ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – EAST BASIN	F1	9/12/2006	*ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	ND	MG/L
NITROGEN NO3+NO2 DISS (AS N)	SILVER LAKE – EAST BASIN	F11	10/12/2006	ND	MG/L

Parameter Description	Sample Location	Sample Depth	Sample Collected	Result Value	Units
PH LAB	SILVER LAKE – WEST BASIN	F1.0	5/24/2006	8.69	
PH LAB	SILVER LAKE – WEST BASIN	F1.0	6/16/2006	8.58	
PH LAB	SILVER LAKE – WEST BASIN	F2	7/21/2006	8.37	SU
PH LAB	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	8.79	SU
PH LAB	SILVER LAKE – WEST BASIN	F1	9/12/2006	8.14	SU
PH LAB	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	8.09	SU
PH LAB	SILVER LAKE – EAST BASIN	F1.0	5/24/2006	9.41	
PH LAB	SILVER LAKE – EAST BASIN	F1.0	6/16/2006	9.54	
PH LAB	SILVER LAKE – EAST BASIN	F2	7/21/2006	8.71	SU
PH LAB	SILVER LAKE – EAST BASIN	F1	8/21/2006	8.01	SU
PH LAB	SILVER LAKE – EAST BASIN	F1	9/12/2006	7.72	SU
PH LAB	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	7.98	SU
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F1	5/24/2006		MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F38	5/24/2006	0.412	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F1	6/16/2006	0.018	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F38	6/16/2006	0.276	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F38	7/21/2006	0.257	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F2	7/21/2006	0.022	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	0.029	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F38	8/21/2006	0.721	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F38	9/12/2006	0.554	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F1	9/12/2006	0.024	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	0.019	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – WEST BASIN	F39	10/12/2006	0.487	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F1	5/24/2006		MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F11	5/24/2006	0.05	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F1	6/16/2006	0.019	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F11	6/16/2006	0.382	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F11	7/21/2006	0.073	MG/L

Parameter Description	Sample Location	Sample Depth	Sample Collected	Result Value	Units
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F2	7/21/2006	0.02	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F1	8/21/2006	0.02	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F11	8/21/2006	0.025	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F11	9/12/2006	1.12	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F1	9/12/2006	0.022	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	0.018	MG/L
PHOSPHORUS TOTAL	SILVER LAKE – EAST BASIN	F11	10/12/2006	0.162	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – WEST BASIN	F1	6/14/2006	0.02	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – WEST BASIN	F38	6/14/2006	0.233	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – WEST BASIN	F38	7/21/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – WEST BASIN	F2	7/21/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – WEST BASIN	F38	8/21/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – WEST BASIN	F38	9/12/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – WEST BASIN	F1	9/12/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	0.02	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – WEST BASIN	F39	10/12/2006	0.513	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – EAST BASIN	F1	6/14/2006	0.017	
PHOSPHORUS TOTAL DISS	SILVER LAKE – EAST BASIN	F10	6/14/2006	0.266	
PHOSPHORUS TOTAL DISS	SILVER LAKE – EAST BASIN	F11	7/21/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – EAST BASIN	F2	7/21/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – EAST BASIN	F1	8/21/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – EAST BASIN	F11	8/21/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – EAST BASIN	F11	9/12/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – EAST BASIN	F1	9/12/2006	**	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	0.019	MG/L
PHOSPHORUS TOTAL DISS	SILVER LAKE – EAST BASIN	F11	10/12/2006	0.059	MG/L

Parameter Description	Sample Location	Sample Depth	Sample Collected	Result Value	Units
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F1	9/12/2006	6	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F1.0	5/24/2006	3	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F1.0	6/16/2006		MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	7	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	2	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F2	7/21/2006	3	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F38	5/24/2006	42	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F38	6/16/2006	12	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F38	7/21/2006	8	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F38	8/21/2006	13	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F38	9/12/2006	16	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – WEST BASIN	F39	10/12/2006	12	MG/L

Parameter Description	Sample Location	Sample Depth	Sample Collected	Result Value	Units
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F1	5/24/2006		
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F1	6/16/2006		
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F1	8/21/2006	ND	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F1	9/12/2006	ND	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	ND	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F2	7/21/2006	ND	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F11	5/24/2006	48	
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F11	6/16/2006	145	
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F11	7/21/2006	41	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F11	8/21/2006	2	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F11	9/12/2006	258	MG/L
RESIDUE TOTAL NFLT (TOTAL SUSPENDED SOLIDS)	SILVER LAKE – EAST BASIN	F11	10/12/2006	136	MG/L
SAMPLE SIZE LITERS	SILVER LAKE – WEST BASIN	F2	7/21/2006	200	ML
SAMPLE SIZE LITERS	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	200	ML
SAMPLE SIZE LITERS	SILVER LAKE – WEST BASIN	F1	9/12/2006	100	ML
SAMPLE SIZE LITERS	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	200	ML

Parameter Description	Sample Location	Sample Depth	Sample Collected	Result Value	Units
SAMPLE SIZE LITERS	SILVER LAKE – EAST BASIN	F2	7/21/2006	200	ML
SAMPLE SIZE LITERS	SILVER LAKE – EAST BASIN	F1	8/21/2006	200	ML
SAMPLE SIZE LITERS	SILVER LAKE – EAST BASIN	F1	9/12/2006	100	ML
SAMPLE SIZE LITERS	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	200	ML
TEMPERATURE AT LAB	SILVER LAKE – WEST BASIN	F38	7/21/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – WEST BASIN	F2	7/21/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – WEST BASIN	F1.0	8/21/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – WEST BASIN	F38	8/21/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – WEST BASIN	F38	9/12/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – WEST BASIN	F1	9/12/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – WEST BASIN	F1.0	10/12/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – WEST BASIN	F39	10/12/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – EAST BASIN	F11	7/21/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – EAST BASIN	F2	7/21/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – EAST BASIN	F1	8/21/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – EAST BASIN	F11	8/21/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – EAST BASIN	F11	9/12/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – EAST BASIN	F1	9/12/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – EAST BASIN	F1.0	10/12/2006	ICED	C
TEMPERATURE AT LAB	SILVER LAKE – EAST BASIN	F11	10/12/2006	ICED	C

Appendix C – Glossary

This Glossary defines commonly used terms and important processes and concepts relating to lakes and lake management. To provide further detail, items have been cross-referenced.

Acid neutralizing capacity (ANC): the equivalent capacity of a solution to neutralize strong acids. The components of ANC include weak bases (carbonate species$_1$ dissociated organic acids, alumino-hydroxides, borates, and silicates) and strong bases (primarily, OH). In the National Surface Water Survey, as well as in most other recent studies of acid-base chemistry of surface waters, ANC was measured by the Gran titration procedure.

Acid rain: rainfall that contains acidic chemicals, such as nitric acid from automobile emissions and sulfuric acid that have escaped into the air from burning fossil fuels.

Acidic deposition: transfer of acids and acidifying compounds from the atmosphere to terrestrial and aquatic environments via rain, snow, sleet, hail, cloud droplets, particles, and gas exchange.

Adsorption: the adhesion of one substance to the surface of another; clays, for example, can adsorb phosphorus and organic molecules.

Aerobic: describes life or processes that require the presence of molecular oxygen.

Algae: small aquatic plants that occur as single cells, colonies, or filaments. They contain chlorophyll but lack special water-carrying tissues. Through the process of photosynthesis, algae produce most of the food and oxygen in water environments.

Algal: of or related to algae.

Allochthonous: materials (e.g., organic matter and sediment) that enter a lake from atmosphere or drainage basin. See Autochthonous.

Anaerobic: describes processes that occur in the absence of molecular oxygen.

Anoxia: a condition of no oxygen in the water. Often occurs near the bottom of fertile, stratified lakes in the summer and under ice In late winter.

Aphotic zone: that area of the lake too dark to support photosynthesis. Aquatic life: organisms that live and grow in, or frequent, water.

Aquifer: an underground, water-bearing bed of permeable rock, sand, or gravel. Aquifers contain large amounts of groundwater that feed into wells and springs.

Autochthonous: materials produced within a lake; e.g., autochthonous organic matter from plankton versus allochthonous organic matter from terrestrial vegetation.

Bacteria: a large group of microscopic organisms of many different shapes, generally without chlorophyll. Some bacteria are helpful (as in a fermentation process), but certain species can cause diseases such as swimmer's itch, pneumonia, or typhoid fever, among others.

Bareground banks: river or stream banks that have no vegetation (no plant covering) to hold the soil against erosive action.

Bathymetric map: a map showing the bottom contours and depth of a lake; can be used to calculate lake volume.

Benthic: refers to life or things found on the bottom of a lake. Examples: benthic animals, benthic sediments.

Benthos: macroscopic (seen without aid of a microscope) organisms living in and on the bottom sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the substrate.

Berm: a narrow shelf, ledge, or barricade, typically at the top or bottom of a slope; a mound or wall of earth; for example, small dams or ridges.

Best management practices (BMPs): systems, activities, and structures that human beings can construct or practice to prevent nonpoint source pollution.

Biochemical oxygen demand (BOD): the rate of oxygen consumption by organisms during the decomposition (see Respiration) of organic matter, expressed as grams oxygen per cubic meter of water per hour.

Biodiversity: a multiplicity of different, mutually dependent living things characteristic of a particular region or habitat.

Biomass: the weight of biological matter. Standing crop is the amount of biomass (e.g.. fish or algae) in a body of water at a given time. Often measured in terms of grams per square meter of surface.

Biota: all plant and animal species occurring in a specified area.

Cadmium: bluish-white toxic metal or metallic element used especially in protective plating and in bearing metals.

Chemical oxygen demand (COD): nonbiological uptake of molecular oxygen by organic and inorganic compounds in water.

Chlorophyll a: A type of chlorophyll present in all types of algae, sometimes in direct proportion to the biomass of algae.

Chlorophyll: a green pigment in algae and other green plants that is essential for the conversion of sunlight, carbon dioxide, and water to sugar (see Photosynthesis). Sugar is then converted to starch, proteins, fats, and other organic molecules.

Clarifier tanks: holding tanks associated with wastewater and sewage treatment centers. Wastewater in these tanks is treated to remove harmful substances before being released into a watershed.

Clean Water Act: the federal Clean Water Act of 1972 (formerly referred to as the Federal Water Pollution Control Act): requires the development of comprehensive programs for preventing, reducing, or eliminating the pollution and improving the condition of the nation's navigable, surface, and groundwaters.

Cluster development: placement of housing and other buildings of a development In groups to provide larger areas of open space.

Coliform: a bacteria carried in human and animal wastes.

Combined sewer overflow (CSO): what happens when too much stormwater flows into drainage systems that also contain wastewater effluent The combined flow from the stormwater and wastewater may result in releases of untreated wastewater directly into lakes, rivers, or streams This is most common in older systems since most modern drainage systems separate stormwater and wastewater flows (CSOs refer to overflows before the water reaches the treatment plant)

Comparability: this is often very important for citizen monitoring programs because it represents how well data from one lake compare to data from another For example, state and regional agencies and local monitors should work together to establish standard sampling methods and procedures for volunteer monitoring programs.

Compliance officer: one who plans, manages, or oversees a company's submission to laws, regulations, and practices; a person delegated to ensure a company's conformity with the law.

Compliance: the act of fulfilling an official requirement; submission to operative laws, regulations, practices, terms, or conditions.

Compost: a mixture of soil and decayed organic matter (food, vegetative, and animal wastes) used for fertilizing and conditioning land.

Conservation easement: (also known as conservation restrictions) are legal agreements between a landowner and a qualified government agency or nongovernmental organization (most commonly a land trust) that permanently limit a property's uses; they remain with it if it is sold. A conservation easement does not transfer title to the property or open it to the public. The landowner continues to own the property, and may live on it, sell it, or pass it on to heirs.

Conservation tillage: a practice or method of plowing in which crop residue is left on the field as protective mulch or cover instead of being plowed under.

Consumers: animals that cannot produce their own food through photosynthesis and must consume plants or animals for energy. See Producers.

Decomposition: the transformation of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and non-biological processes.

Delphi: a technique that solicits potential solutions to a problem situation from a group of experts and then asks the experts to rank the full list of alternatives.

Denitrification: the process by which nitrate in water or sediments is converted to nitrogen gas, which is then lost to the atmosphere.

Density flows: a flow of water of one density (determined by temperature or salinity) over or under water of another density (e.g., flow of cold river water under warm reservoir surface water).

Detritus: organic material composed of dead plants or animals, or parts thereof (e.g., leaves, grass clippings) that settle to the bottom of a lake. Bacteria and fungi slowly decompose detritus, thus recycling it back into the lake's ecosystem.

Drainage basin: land area from which water flows into a stream or lake. See Watershed.

Drainage lakes: lakes having a defined surface inlet and outlet

Ecology: a branch of science concerned with the interrelationship of organisms with their environment

Ecoregion: Comprised of relatively homogenous ecological systems delineated by geology, soils, climate, vegetation, and landform, and involving interrelationships among organisms and their environment

Ecosystem: a system of interrelated organisms and their physical-chemical environment. In this manual, the ecosystem is usually defined to include the lake and its watershed.

Effluent: liquid wastes from sewage treatment, septic systems, or industrial sources that are released to a surface water.

Environment: the complex of one's surroundings; the climatic, soil-related, and life-related factors that act on organisms or ecological communities and ultimately determine their form and survival.

Environmental movement: an organized or grass roots, public, or private movement or group acting to preserve the quality and continuity of life through the conservation of natural resources and the prevention and/or reduction of pollution.

Environmental Protection Agency (EPA): a division or office of government, either federal or state, responsible for safeguarding and managing a region's natural resources and quality of life. The U.S. EPA is an agency of the federal government; the names of state EPAs vary.

Epilimnion: uppermost, warmest, well-mixed layer of a lake during summertime thermal stratification. The epilimnion extends from the surface to the thermocline. See Stratification.

Epiphytes: small plants or animals that grow attached to larger plants.

Erosion: the gradual wearing down of land by water, wind, or melting snow. Soil losses, for example, from streambanks and forests, hilly ground, lawns, and farm fields.

Eutrophic: from Greek for "well-nourished": describes a lake of high photosynthetic activity and low transparency. See Trophic State.

Eutrophication: the process of physical, chemical, and biological changes associated with nutrient, organic matter, and silt enrichment and sedimentation of a lake or reservoir that cause a water body to age. If the process is accelerated by human influences, it Is termed cultural eutrophication.

Eutrophication cultural: human activities, such as discharge of sewage and storm-water, and nonpoint source pollutants, can dramatically hasten the process of eutrophication.

Fall overturn: the autumn mixing, top to bottom, of lake water caused by cooling and wind-derived energy.

Fecal coliform test: most common test for the presence of fecal material from warm-blooded animals. Fecal coliforms are measured because of convenience; they are not necessarily harmful but indicate the potential presence of other disease-causing organisms.

Floodplain: land adjacent to lakes or rivers that is covered as water levels rise and overflow the normal water channels.

Flushing rate: the rate at which water enters and leaves a lake relative to lake volume, usually expressed as time needed to replace the lake volume with inflowing water.

Flux: the rate at which a measurable amount of a material flows past a designated point in a given amount of time.

Food chain: the general progression of feeding levels from primary producers, to herbivores, to planktivores, to the larger predators.

Food web: the complex of feeding interactions existing among the lake's organisms.

Forage fish: Fish, including a variety of panfish and minnows, that are prey for game fish.

Forest Service (FS): an agency of the federal government located within the Department of Agriculture that manages and protects our forests, wooded areas, and timber resources.

Groundwater: the supply of fresh water found beneath the earth's surface (usually in aquifers); often used to supply drinking water to wells and springs; may be connected to lakes.

Habitat: the physical environment or typical place within which a plant or animal naturally or normally lives and grows.

Hydrographic map: a map showing the location of areas or objects within a lake.

Hydrologic cycle: the circular flow or cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Runoff, surface water, groundwater, and water infiltrated in soils are all part of the hydrologic cycle.

Hypolimnion: lower, cooler layer of a lake during summertime thermal stratification. See Stratification.

Influent: a tributary stream.

Internal nutrient cycling: transformation of nutrients such as nitrogen or phosphorus from biological to inorganic forms through decomposition, occurring within the lake itself.

Isothermal: the same temperature throughout the lake.

Lake: a considerable inland body of standing water, either naturally formed or built by humans.

Lake district: a special purpose unit of government with authority to manage a lake(s) and with financial powers to raise funds through mill levy, user charge, special assessment, bonding, and borrowing. May or may not have police power to inspect septic systems, regulate surface water use, or zone land.

Lake management: the practice of keeping lake quality in a state such that attainable uses can be achieved.

Lake protection: the act of preventing degradation or deterioration of attainable lake uses.

Lake restoration: the act of bringing a lake back to its attainable uses.

Lentic: relating to standing water (versus lotic, running water).

Limnetic zone: also called Epilimnion. See Stratification.

Limnology: the scientific study of the physical, chemical, geological, and biological factors that affect aquatic productivity and water quality in freshwater ecosystems — lakes, reservoirs, rivers, and streams.

Limnologist: one who practices limnology.

Littoral zone: the shallow zone along the shore of a lake; that portion of a water body extending from the shoreline lakeward to the greatest depth occupied by rooted plants. Plants growing here support a rich biological community.

Loading: the total amount of material (sediment, nutrients, oxygen-demanding material) brought into the lake by inflowing streams, runoff, direct discharge through pipes, groundwater, the air, and other sources over a specific period of time (often annually).

Macroinvertebrates: aquatic insects, worms, clams, snails, and other animals visible without aid of a microscope, that may be associated with or live on substrates such as sediments and macrophytes. They supply a major portion of fish diets and consume detritus and algae.

Macrophytes: plants large enough to be seen without magnification. Some forms, such as duckweed and coontail *(Ceratophyllum),* are free-floating forms without roots in the sediment

Mandatory property owners association: organization of property owners in a subdivision or development with membership and annual fee required by covenants on the property deed. Association will often enforce deed restrictions on members' property and may have common facilities such as bathhouse, clubhouse, golf course, etc.

Marginal zone: area where land and water meet at the perimeter of a lake. Includes plant species, insects, and animals that thrive in this narrow, specialized ecological system.

Meaningful indicators: link objectives to management objectives; are meaningful to stakeholders; are measurable, or ranked subjectively; and can be predicted.

Mercury: a heavy silver-white poisonous metallic element sometimes found as a contaminant in rainfall.

Mesotrophic: the medium range of eutrophication. See Trophic State.

Metalimnion: layer of rapid temperature and density change in a thermally stratified lake; lies between epilimnion and hypolimnion. Resistance to mixing is high in the region. See Stratification.

Minimum tillage: a practice of plowing or turning the soil only enough to plant new crops, while leaving plant residue on the surface as compost

Morphometry: relating to a lake's physical structure (e.g., depth, shoreline length).

Mulch: a protective covering (as of sawdust, compost, or paper) spread or left on the ground. Mulch prevents evaporation, maintains even soil temperature, prevents erosion, controls weeds, and enriches the soil.

National Pollutant Discharge Elimination System (NPDES): federal operating permits Issued by EPA to industrial and municipal facilities to help these facilities comply with the Clean Water Act.

Natural Resources Conservation Service (NRCS): a federal agency responsible for safeguarding and managing soil and water resources. NRCS operates within the Department of Agriculture and maintains local offices throughout the country.

Nekton: large aquatic and marine organisms whose mobility is not determined by water movement—for example, fish and amphibians.

NEPA: The National Environmental Policy Act of 1969 that established a national policy for the environment, created the Council on Environmental Quality, and directed that every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment include a detailed statement on the environmental Impact of the proposed action. For the complete act, see Council on Environmental Quality, I 991.

NOAA: National Oceanic and Atmospheric Administration

Nominal group process: a process of soliciting concerns/issues/ideas from members of a group and ranking the resulting list to ascertain group priorities. Designed to neutralize dominant personalities.

Noncompliance: a condition of not submitting to applicable laws, regulations, terms, or conditions.

Nonpoint source (NPS): pollution that cannot be traced to a specific origin or starting point, but seems to flow from many different sources. NPS pollutants are generally carried off the land by stormwater (or melting snow) runoff. The commonly used categories for nonpoint sources are agriculture, forestry, urban, mining, construction, dams and channels, land disposal, and saltwater intrusion.

Nutrient: an element or chemical essential to life, such as carbon, oxygen, nitrogen, and phosphorus.

Nutrient budget: quantitative assessment of nutrients (e.g., nitrogen or phosphorus) moving into, being retained in, and moving out of an ecosystem; commonly constructed for phosphorus because of its tendency to control lake trophic state.

Nutrient cycling: the flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).

Nutrients: substances or ingredients that nourish or promote growth and repair the natural destruction of organic life.

Oligotrophic: "poorly nourished;' from the Greek. Describes a lake of low plant productivity and high transparency. See Trophic State.

Ooze: lake bottom accumulation of inorganic sediments and the partially decomposed remains of algae, weeds, fish, and aquatic insects. Sometimes called muck. See Sediment.

Ordinary high water mark: physical demarcation line, indicating the highest point that water level reaches and maintains for some time. Line is visible on rocks, or shoreline, and by the location of certain types of vegetation.

Organic: of, relating to, or derived from living things; relating to, produced with or based on the use of plant and animal fertilizers rather than chemically formulated fertilizers or pesticides.

Organic matter: molecules manufactured by plants and animals and containing linked carbon atoms and elements such as hydrogen, oxygen, nitrogen, sulfur, and phosphorus.

Paleolimnology: the study of lake sediments and the relics preserved In them.

Pathogen: a microorganism capable of producing disease. They are of great concern to human health relative to drinking water and swimming beaches.

Pelagic zone: the open area of a lake, from the edge of the littoral zone to the center of the lake.

Perched: a condition where the lake water is isolated from the groundwater table by impermeable material such as clay.

Permeable: a surface or material that has pores or openings that allow liquids to penetrate or pass through.

Pesticide: an agent used to destroy insects and other pests.

pH: a measure of the concentration of hydrogen ions of a substance, which ranges from very acid (pH = I) to very alkaline (pH = 14). pH 7 Is neutral and most lake waters range between 6 and 9. pH values less than 6 are considered acidic, and most life forms cannot survive at pH of 4.0 or lower.

Photic zone: the lighted region of a lake where photosynthesis takes place. Extends down to a depth where plant growth and respiration are balanced by the amount of light available.

Photosynthesis: a chemical reaction that occurs only in plants. Plants use a green pigment called chlorophyll to convert water and carbon dioxide into cellular material and oxygen in the presence of light. Hence, photosynthesis occurs only during daylight hours.

Phytoplankton: microscopic algae and microbes that float freely in open water of lakes and oceans. In some lakes, they provide the primary base of the food chain for all animals. They also produce oxygen by a process called photosynthesis.

Phytoremediation: plants are used to clean up certain types of heavily contaminated soils by absorbing the contaminants from the soil.

Plankton: small, mostly microscopic plants and animals that are too small to outswim most currents, so the movement of water tends to move them from place to place. Plankton consists of phytoplankton (planktonic plants) and zooplanlcton (plank-tonic animals).

Plankton rain: the almost constant settling of plankton, live and dead, through the water to the bottom sediments.

Plantivores: fish and invertebrate that collectively prey on zooplankton.

Point source (PS): pollution discharged into water bodies from specific, identifiable pipes or points, such as an industrial facility or municipal sewage treatment plant

Pollutants: solid, liquid, or gaseous substances that contaminate the local or general environment

Pollution: the condition of being polluted. A generic word for any type of contamination of water, land, or air.

Precipitation: a water deposit on earth in the form of hail, rain, sleet, and snow.

Primary productivity: the rate at which algae and macrophytes fix or convert light, water, and carbon dioxide to sugar in plant cells. Commonly measured as milligrams of carbon per square meter per hour.

Producers: green plants that manufacture their own food through photosynthesis.

Profundal zone: mass of lake water and sediment occurring on the lake bottom below the depth of light penetration. Also called Hypolimnion. See Stratification.

Reservoir: lake created by artificially damming a stream or river where water is collected and kept in quantity for a variety of uses, including flood control, water supply, recreation, and hydroelectric power.

Residence time: commonly called the hydraulic residence time — the amount of time required to completely replace the lake's current volume of water with an equal volume of "new" water.

Respiration: process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process releases energy, carbon dioxide, and water.

Runoff: that portion of precipitation that flows over the land carrying with it such substances as soil, oil, trash, and other materials until it ultimately reaches streams, rivers, lakes, or other water bodies.

Secchi depth: a measure of transparency of water (the ability of light to penetrate water) obtained by lowering a black and white, or all white, disk (Secchi disk, 20 cm in diameter) into water until it is no longer visible. Measured in units of meters or feet.

Secchi disk: a white or black and white disk used to measure transparency of water. See Secchi depth.

Sediment: bottom material in a lake that has been deposited after the formation of a lake basin. It originates from remains of aquatic organisms, chemical precipitation of dissolved minerals, and erosion of surrounding lands. See Ooze.

Sediment oxygen demand (SOD): after a long time, plant and algal cells that die can sink to low places in a lake where they begin to decompose, eventually accumulating as a thick layer of soft, highly organic sediments. This decomposition by bacteria uses oxygen from the overlying water, and thus, can drain a lake's dissolved oxygen. If accidentally resuspended (as in a storm or by power boats), these sediments can kill fish and other animals. When bottom dissolved oxygen falls too low, millions of small invertebrates (animals without backbones) living in and on the bottom may also be reduced or even eliminated.

Seepage lakes: lakes having either an inlet or outlet (but not both) and generally obtaining their water from groundwater and rain or snow.

Septic tank: a holding tank for collecting residential wastewaters. Used as an alternative to municipal sewer systems in some areas. Wastewater collected in septic tanks disperses into the soil through a septic drainfield.

Sewage treatment plant: a facility (usually municipal) that treats sewer waste to remove harmful substances before discharge.

Soil retention capacity: the ability of a given soil type to adsorb substances such as phosphorus, thus retarding their movement to the water.

Spawning: the production and deposit of eggs by fish within their aquatic habitat

Standing crop: the amount of biomass (e.g., fish or algae) in a body of water at a given time.

Stratification: process in which several horizontal water layers of different density may form in some lakes. During stratification, the bottom mass (hypolimnion or profundal zone) is cool, high in nutrients, low in light, low in productivity, and low in dissolved oxygen. The top mass (epilimnion or limnetic zone) is warm, higher in dissolved oxygen, light, and production, but lower (normally) in nutrients. The sharp boundary between the two masses is called a thermocline. The metalimnion exists in this area.

Swimmer's itch: a rash caused by penetration into the skin of the immature stage (cercaria) of a flatworm (not easily controlled due to complex life cycle). A shower or alcohol rubdown should minimize penetration.

Thermal stratification: lake stratification caused by temperature-created differences in water density.

Thermocline: a horizontal plane across a lake at the depth of the most rapid vertical change in temperature and density in a stratified lake. See Metalimnlon and Stratification.

Tillage: the operation of plowing or cultivating land.

Topographic map: a map showing the elevation of the landscape at fixed contour intervals, usually 2, 5, 10, or 20 feet. This information can be used to delineate a watershed.

Toxic: poisonous substances harmful to living things. Of, relating to, or caused by poison.

Trophic state: the degree of eutrophication of a lake. Transparency, chlorophyll *a* levels, phosphorus concentrations, amount of macrophytes, and quantity of dissolved oxygen in the hypolimnion can be used to assess trophic state.

Trophic state index: a number used to categorize lakes as oligo-, meso-, or eutrophic, on a scale generally from I to I 00: the higher the number, the more eutrophic. It can be calculated a variety of ways, using chlorophyll (a measure of algae abundance), Secchi depth (an indirect measure of algae abundance by measuring water clarity), or nutrients. Lakes with TSI of 60 or more are considered eutrophic.

Turbid: thick or cloudy with sediment

Turbidity: cloudiness; characterized by obscurity.

Upset: a waste/sewage treatment plant malfunction. In an upset, untreated or incompletely treated wastewater enters the watershed.

USDA: U.S. Department of Agriculture

USFS: U.S. Forest Service, a USDA agency

USGS: U.S. Geological Survey

Vegetative/vegetation filter strips: plantings used to trap water (and the substances it carries) to prevent it from running off the land; a BMP that helps prevent nonpoint source pollution.

Voluntary lake property owners association: organization of property owners in an area around a lake that members join at their option.

Wastewater treatment plant: sometimes synonymous with sewage treatment plant, but often an industrial treatment facility that processes the water to remove toxic and hazardous wastes.

Water body: a land basin filled with water. Any river, lake, stream, or ocean that receives runoff waters from a watershed.

Water column: water In the lake between the interface with the atmosphere at the surface and the Interface with the sediment layer at the bottom. Idea derives from vertical series of measurements (oxygen, temperature, phosphorus) used to characterize lake water.

Water hardness: originally defined as the capacity of water to preciptate soap, water hardness is now defined as the sum of the calcium and magnesium concentrations, both expressed as calcium carbonate, in mg/L.

Water table: the upper surface of groundwater; below this point, the soil is saturated with water.

Watershed: a drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Wetlands: lands or areas, such as tidal flats or swamps, that are often or periodically saturated with water. Wetlands contain much soil moisture and plants that grow well in that condition.

Zooplankton: microscopic animals that float freely in lake water, graze on detritus particles, bacteria, and algae, and may be consumed by fish.