LPL-798

Big Wood Lake Water Quality Study

Big Wood Lake
Grantsburg, WI

Prepared for:

Big Wood Lake Association
Grantsburg, WI

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followed and samples were taken at the same depths. According to the survey comparison, the number of species in the lake has increased since 1993 and the densities and frequency of occurrence varied throughout the species.

The lakeshore resident survey indicated that the residents are satisfied with the status of the lake and believe the quality has remained about the same. The majority of the residents support action to address a variety of problems in the lake.

Introduction

Big Wood Lake Association retained Ayres Associates to conduct a lake study on Big Wood Lake. The purpose of this study was to determine the water quality of the lake and to track any changes in the quality since the 1993 survey. The lake study included coordination with Big Wood Lake Association for water quality sampling, training of the lake association members in sampling technique and use of equipment, macrophyte (aquatic vegetation) survey, lakeshore resident survey, data collection website and lake study report.

Big Wood Lake is located in Burnett County, Wisconsin in Sections 27 & 34, T38N, R18W. It is a drainage lake that is fed by the Wood River from the north and Spirit Creek from the south. The Wood River then exits the lake at the north west corner. According to "Nonpoint Source Control Plan for the Big Wood Lake Priority Water Shed Project", the watershed feeding the lake is 6302 acres in size and the dominant land uses include: forested -39%, mixed agriculture - 29% and wetlands -16%. The lake is 520 acres and has a maximum depth of approximately 35 feet. The fishery in the lake contains large mouth bass, panfish and northern pike. The lake is classified eutrophic with fair water clarity and moderate algae blooms in the summer months. The shoreline has moderate development that has altered the natural vegetation and decreased the buffers that provide water quality protection against runoff.

To begin the project a kickoff meeting was held with the members of the lake association. The purpose of the meeting was to discuss the details of the study such as a sampling schedule, location of sample collection, macrophyte survey time and procedure, and resident survey details. The training of the members in water sampling techniques and the use of the equipment was also incorporated into this meeting for convenience and efficiency.

A variety of parameters were tested for in this study. Samples were taken from the north basin of Big Wood Lake and at the inlet and outlet of the Wood River. All of the parameters tested for in the 1993 study were again tested for in this study for comparison purposes. This study was supplemented with additional parameters to ensure an accurate assessment of water quality. Water quality samples were collected by the association and sent to the State Lab of Hygiene for analysis. Additional measurements such as dissolved oxygen, temperature, conductivity and pH were taken in the field using meters supplied by Ayres.

The macrophyte survey was conducted in July and followed the same procedure and transects as the survey conducted in 1993 to ensure an accurate comparison. Samples were collected at three sample points on each transect. The samples were collected at the same depths as the 1993 survey.

The lakeshore resident survey was created by Ayres and approved by the lake association. The purpose of the study was to assess the views the residents have of the lake and to identify any problems they may see. The survey was mailed to each household and returned to Ayres via mail. The survey was also posted on the web and the residents could choose to respond via mail or e-mail.

Methods

The sampling methods, locations, testing and data processing are the same as those used in the 1993 study to ensure an accurate comparison of data.

Water Quality Sampling

Water quality samples were collected at spring and fall turnover and in the months of June, July and August. Samples were collected at the surface (0-2 meters deep), and at the bottom (1 meter from the bottom) with a Van Dorn sampler. The sampler was cleaned with an appropriate detergent prior to the initial use. At the time of sampling, the sampler was rinsed with lake water before the sample was collected. The sample water was placed in bottles received from DNR and shipped to the Wisconsin State Lab of Hygiene in a cooler provided by DNR. The temperature and dissolved oxygen (DO) readings were taken at 3 foot intervals beginning at 33 feet deep and coming up to 3 feet from the surface. All in field data was collected using calibrated meters provided by Ayres Associates. Trained members of the association collected the samples. The following tables list the parameters tested for at turnover and during the monthly sampling.

Table 1
Spring and Fall Turnover

Lake Parameter	Stream Parameters
Total Phosphorus	Total Phosphorus
Total Kjeldahl Nitrogen	Total Kjeldahl Nitrogen
Nitrate plus Nitrite	Dissolved Reactive Phosphorus
Ammonium	Total Suspended Solids
Chlorophyll a	* pH
Color	* Conductivity
Alkalinity	** Dissolved Oxygen
* pH	
* Conductivity	
Dissolved Reactive Phosphorus	
Chloride	
Hardness	
** Dissolved Oxygen	
Total Suspended Solids	
Total Dissolved Solids	
Turbidity	
Magnesium	
Calcium	
Fecal Coliform	

* Tested for in field and lab
** Tested for in field only

Table 2
Monthly Testing

Lake Parameters	Stream Parameters
Total Phosphorus	Total Phosphorus
Total Kjeldahl Nitrogen	* pH
Nitrate plus Nitrite	* Conductivity
Ammonium	** Dissolved Oxygen
Chlorophyll a	
Color	
Alkalinity	
* pH	
* Conductivity	

* Tested for in field and lab
** Tested for in field only

The data sheets from each sample period of the water quality testing are included in Appendix A.

Macrophyte Survey

The macrophyte survey was conducted on July 7 and July 17, 2002. The procedure outlined in the 1993 study was also used for this study to ensure an accurate comparison of data. This procedure was developed from the grid sampling method of Jessen and Lound (1962). Twenty transects were sampled with three sample points in each transect. The same transects and depths were sampled as in the 1993 study. The survey transect locations were found by using a lake map and photos of landmarks included in the 1993 survey. The sample points on the transect were determined by matching the depth at the sample points from the 1993 survey. The sample point consisted of a 6 foot circle that was divided into quadrants. Each quadrant was sampled using a rake that was cast and retrieved 4 times. The following information was recorded at each point: transect number, depth, substrate, species and density. The densities were determined using the criterion from Table 3.

Table 3
Plant Species Densities

Rake Recovery of Species	Density
Rake teeth full during all four casts	5
Rake teeth partly full during all four	4
Found on rake teeth 3 of 4 casts	3
Found on rake teeth 2 of 4 casts	2
Found on rake teeth 1 of 4 casts	1

The data sheets from the survey are included in Appendix B along with photos of the lakeshore at each transect.

Results and Discussion

Water Quality Testing

The results of the water quality testing indicate the lake is eutrophic with good water quality. Eutrophic lakes are high in nutrients and support a large biomass including plants and animals. They are usually weedy or subject to algae blooms or both. These lakes can support large fish populations but are susceptible to winter kills due to oxygen depletion in the winter months. Rough fish are common in eutrophic lakes.

A variety of parameters were tested for to determine current water quality and to compare it to the water quality found in 1993. The parameters are separated into 5 categories according to the information they supply. The categories are Dissolved Oxygen (D.O.), Nutrients, Water Clarity, Buffering Capacity and Pollution Indicators. Each parameter will be discussed below and data interpretations and comparisons are included. The data sheet created for each sample period is included in Appendix A along with the rainfall and lake level records for the study period.

Dissolved Oxygen (D.O.)

Dissolved oxygen is one of the most important parameters in a lake. The DO is necessary for the survival of fish and the concentration of DO determines the form and concentration of the other chemical parameters in the lake water. The minimum water quality standard for DO in warm water lakes and streams is 5 mg/l. This is the minimum amount of oxygen fish require for survival and growth. If the concentrations dip below this level, fish kills will occur. This usually happens in the winter in shallow lakes. At the bottom of the lake, the oxygen levels decrease due to decomposition of plants. At these low levels of oxygen, nutrients and other compounds are released from the sediment. The low levels of oxygen may also occur during the summer months in stratified lakes where the water at the bottom becomes anoxic because it can not mix with surface water and replenish the oxygen supply. In stratified lakes such as Big Wood Lake, turnover in the spring and fall completely mix the lake spreading the nutrients and oxygen throughout the water column.

Turnover can be detected in the DO and temperature isopleths shown in the Figures section. At turnover the temperature and DO readings are nearly the same throughout the water column. When stratification occurs, the temperature decreases with depth and a rather large jump in temperature occurs at the thermocline. This is the layer of water that separates the top of the lake from the bottom and prevents mixing of these waters.

DO concentrations are also affected by temperature, colder water can hold more oxygen than warmer water. At 32°F water can hold 15 mg/l of oxygen and only 8 mg/l when the temperature reaches 77°F. Oxygen enters the water through the surface and is produced by the plants through photosynthesis. Oxygen is also used by the plants through respiration and by decaying plant material. The DO level is constantly changing due to the ways it is produced and consumed. The DO and temperature data collected for this study can be found in Table 4 in the Tables section of this report. Generally the DO levels from this study were higher than those found in 1993. The DO levels at the bottom of the lake did not fall below 1 mg/l as they did several times in the 1993 study.

Nutrients

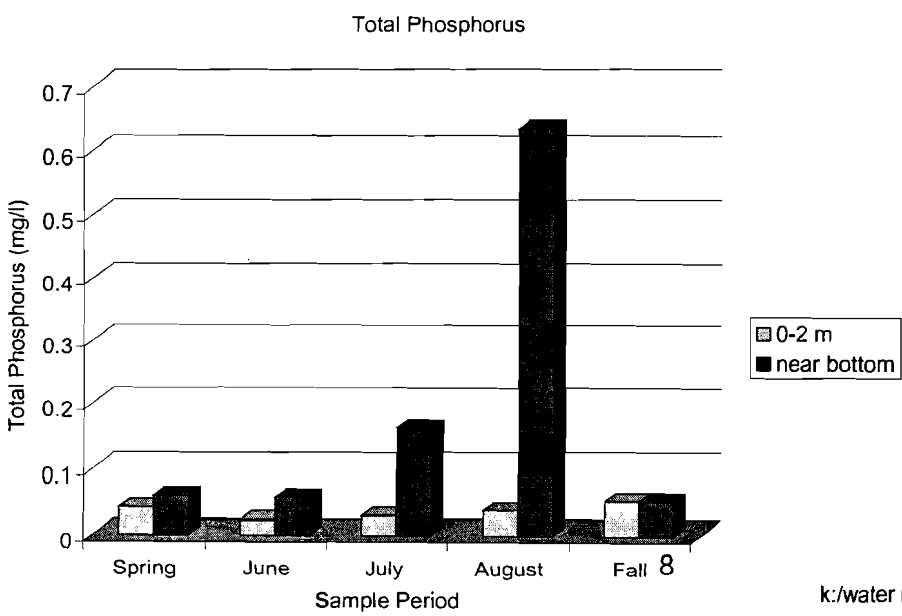
The nutrients that have the greatest impact on vegetation in a lake are phosphorus and nitrogen. Total phosphorus is used to measure the lakes nutrient status. Phosphorus promotes plant growth and is the key nutrient affecting the amount of algae and weed growth. Sources of phosphorus include human and animal wastes, fertilizers, septic systems and decaying plants. Phosphorus is measured in two forms in lake water: Total phosphorus (TP) and dissolved reactive phosphorus (DRP). TP includes DRP and the phosphorus in plants and animals in the water. DRP is the soluble form that is readily taken up by plants. Both forms were measured for this study. TP is a better indicator of the lakes nutrient status because it remains more stable than DRP. DRP is measured in the spring to determine if there are sufficient nutrients for the algae to create the nuisance blooms in the summer months. DRP concentrations vary greatly over short periods of time due to its uptake by plants.

Nitrogen is the second most important nutrient in a lake for plant and algae growth. Sources of nitrogen include fertilizer, human and animal waste and groundwater. Nitrogen exists in several forms in lakes. The analysis for this study included total Kjeldahl N, nitrate plus nitrite N and ammonium N. The forms of nitrogen are constantly interchanging in the lake water through the nitrogen cycle. Inorganic nitrogen (nitrate, nitrite, ammonium) can be used by aquatic plants. If these levels are greater than 0.3 mg/l in the spring there is enough nitrogen present to create summer algae blooms. When the plants die and decay, ammonium is released into the water. This can then be taken up by plants again and cycled through the system or it can undergo the conversions of the nitrogen cycle. If oxygen levels are depleted, the ammonium is converted to nitrate then to nitrite then to nitrogen gas, which is lost to the air.

The ratio of the amount of total nitrogen to total phosphorus is important information for lake managers. This number indicates if a lake is nitrogen limited or phosphorus limited, if there is not an ample supply of the limiting nutrient, algae blooms will not occur and plant growth will decrease. If the ratio is less than 10:1 the lake is nitrogen limited (this occurs in 10% of Wisconsin's lakes). Lakes with values between 10:1 and 15:1 are considered transitional, and lakes with values greater that 15:1 are phosphorus limited.

Total Phosphorus (TP)

The average TP measured in the lake for this study was 0.04 MG/L at the surface and 0.2 MG/L at the bottom. The 1993 study had an average measure of 0.04 MG/L at the surface.



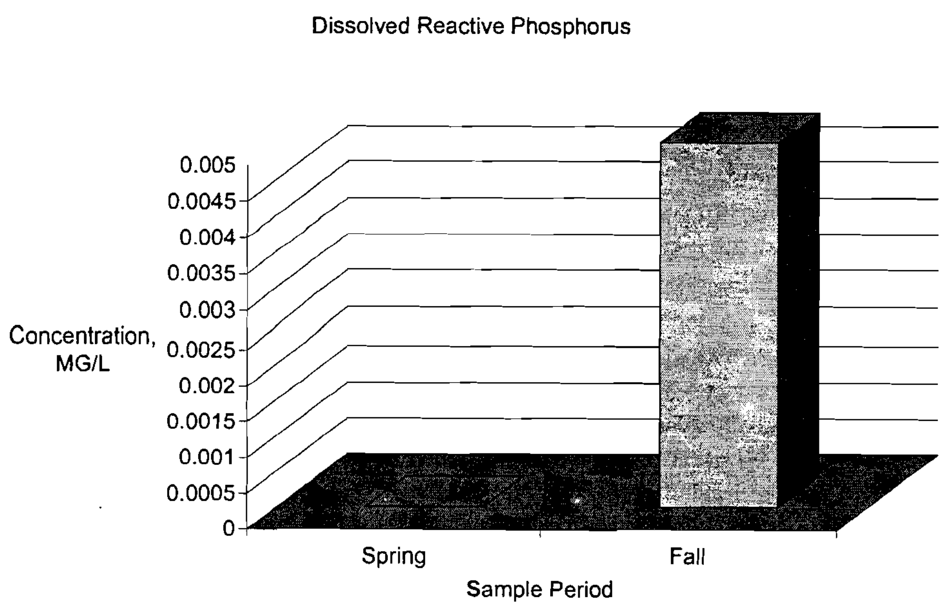
The bottom average was not calculated in the 1993 study. From the graph it can be seen that the levels at the bottom of the lake are almost always greater than near the surface.

A peak in the bottom concentrations was seen in August in both studies. This is due to the low levels of oxygen present near the bottom of the lake at this time of year. At these low oxygen levels, the sediments release phosphorus back into the water column. In the August data, a low concentration at the thermocline and at the surface with high concentrations near the bottom indicate that this is happening. The P is being released from the sediments at the bottom and is not mixing throughout the water column due to the stratification of the lake. When the oxygen levels rise again after mixing at fall turnover, the P levels go back down as seen in the data.

Dissolved Reactive Phosphorus (DRP)

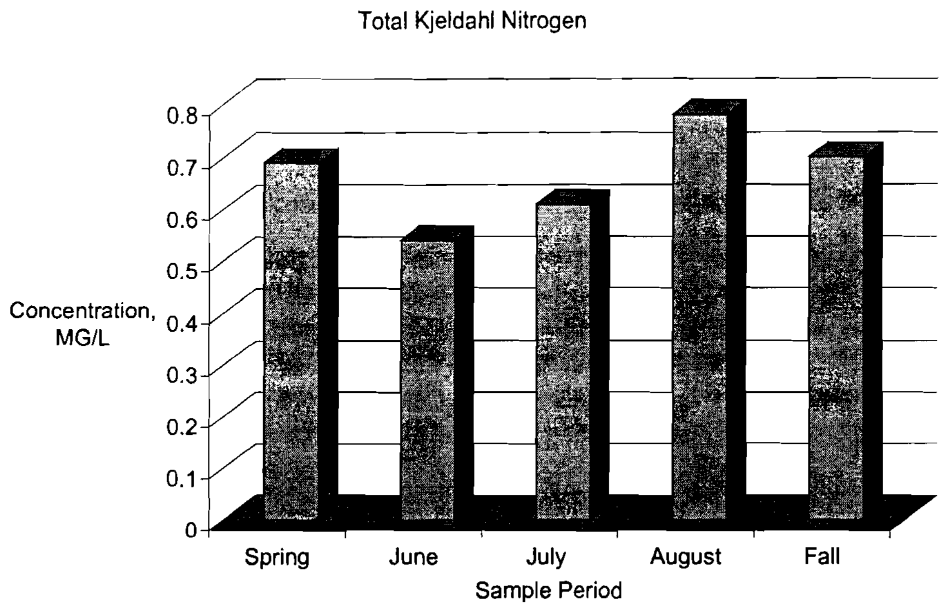
The amount of DRP was measured at spring and fall turnover to determine if the lake would have enough P to create summer algae blooms. There was not any DRP found in the spring and only 0.005 MG/L in the fall. This indicates that algae blooms should not have been a problem this year since a DRP concentration of less than 0.01 MG/L in the spring should prevent algae blooms in the summer. However, since the concentration changes rapidly a single reading in the spring may not be enough data to accurately conclude this.

According to DNR data, this lake has an average concentration of P compared to other lakes in Wisconsin. The averages for the seasons for a stratified drainage lake are 0.041, 0.035, 0.055 MG/L for spring, summer and fall respectively. The concentrations for Big Wood Lake are 0.042, 0.030, 0.053 MG/L for spring, summer and fall respectively. Lakes in the same ecoregion vary from 0.023 to 0.05 mg/l. The trophic classification of the lake according to the phosphorus levels and DNR classification is eutrophic. The following graph depicts the results of the testing.

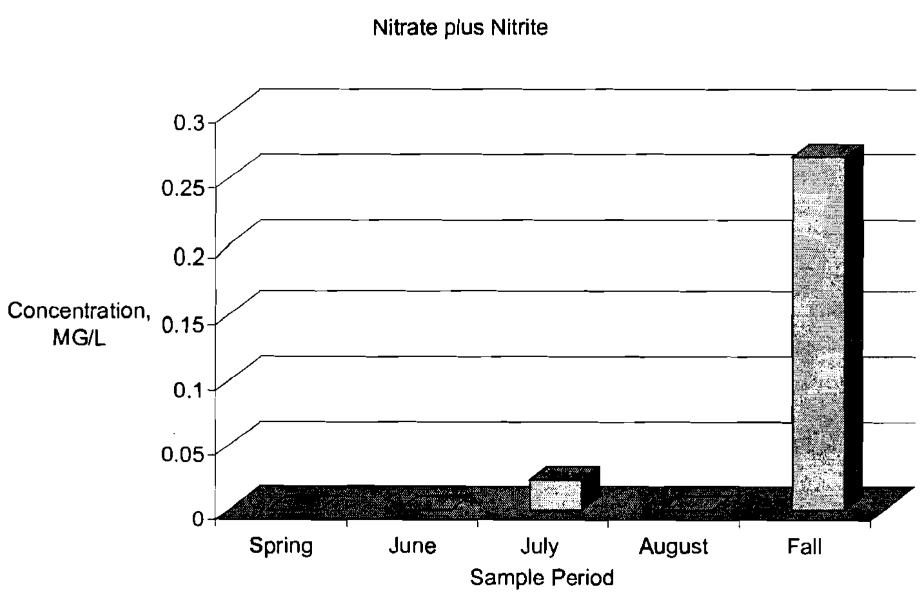


Nitrogen

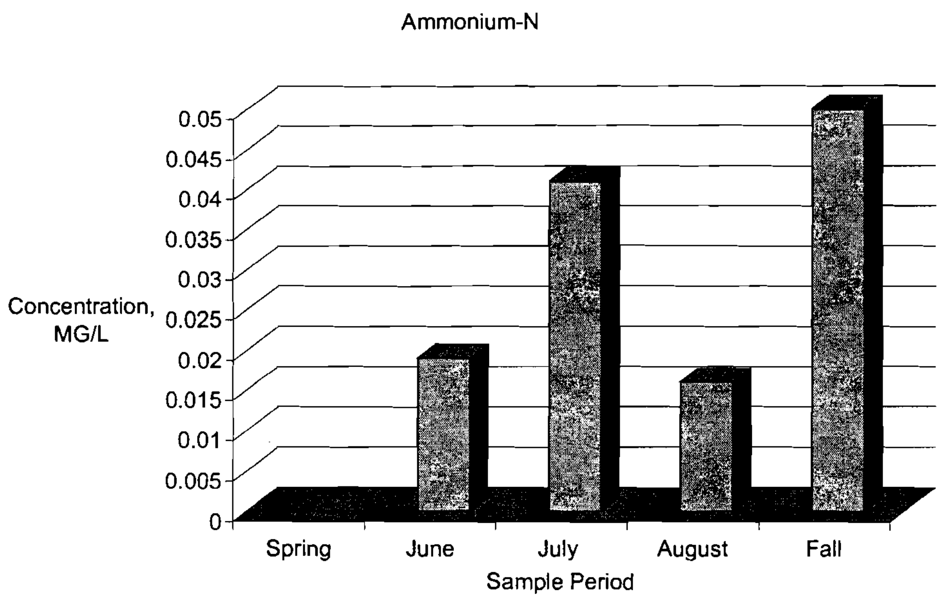
The lakes in the ecoregion range from 0.6 to 1.2 MG/L for total Kjeldahl N and <0.01 MG/L for nitrate plus nitrite for summer averages. Big Wood Lake had concentrations in this range for the summer readings. The following chart show the values of Total Kjeldahl N.



A spike in nitrate plus nitrite can be seen in the following chart at fall turnover.



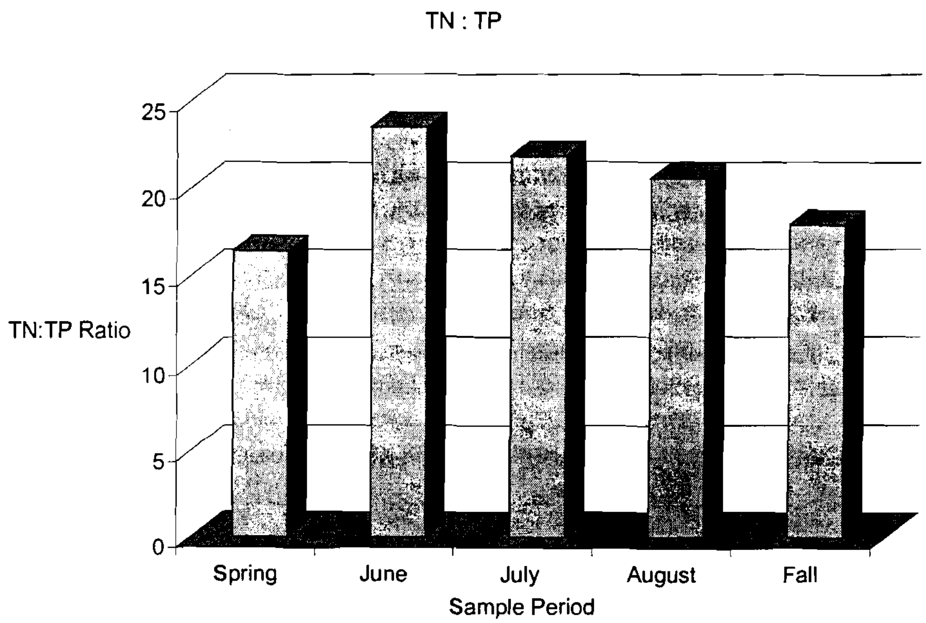
The increase in nitrate plus nitrite is due to the high concentrations of ammonium. Ammonium is released from decomposing plant material at the bottom of the lake throughout the summer when oxygen levels are low. During turnover, the water from the bottom is allowed to mix with the surface water and oxygen is spread throughout the lake. At this time the ammonium is converted to nitrate in the presence of oxygen. A smaller spike in nitrate plus nitrite and ammonium concentrations is seen in July. This follows the same logic of ammonium converting to nitrate but the source of the ammonium is more likely from agricultural runoff. Two days prior to sampling 4-in of rainfall occurred in the watershed creating high amounts of runoff into the stream that feeds Big Wood Lake. The ammonium values can be seen in the following chart.



The Kjeldahl nitrogen values are lower in this study than in the 1993 study. The mean in 1993 was 0.820 mg/l compared to 0.664 mg/l for this study. The nitrate plus nitrite values are reversed. In 1993 the average was 0.007 and in this study it was 0.058mg/l. The average for this study is higher due to the spike recorded at fall turnover, the remaining samples had levels comparable to those in 1993. The ammonia values decreased slightly from 0.029 mg/l in 1993 to 0.025 mg/l in this study. Overall the nitrogen in the lake appears to have decreased slightly since 1993 indicating an increase in water quality.

Total Nitrogen (TN) to Total Phosphorus (TP) Ratio

In the case of Big Wood Lake, the mean ratio of TN to TP was 20:1, therefore it is phosphorus limited. Phosphorus limited means algae and plant growth is limited by the amount of phosphorus present in the water. If the plant growth is to be controlled, the amount of phosphorus in the water needs to be controlled. In comparison to other lakes in the EPA ecoregion, Big Wood Lake is average. The following chart shows the data collected for this report.

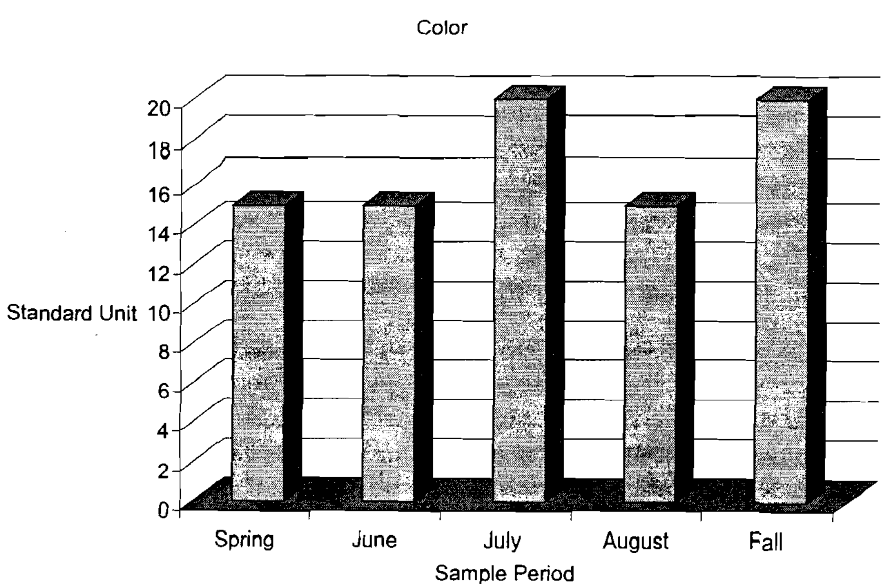


Water Clarity

Water clarity is a measure of water quality related to the chemical and physical properties of water. Water clarity has two main components: true color and turbidity. Both of these components were measured directly and indirectly in this study. The dissolved materials determine the color of the water and the suspended solids in the water determine the turbidity. To establish values for these parameters the following tests were conducted: true color, total dissolved solids, turbidity, suspended solids, chlorophyll a and secchi disk readings.

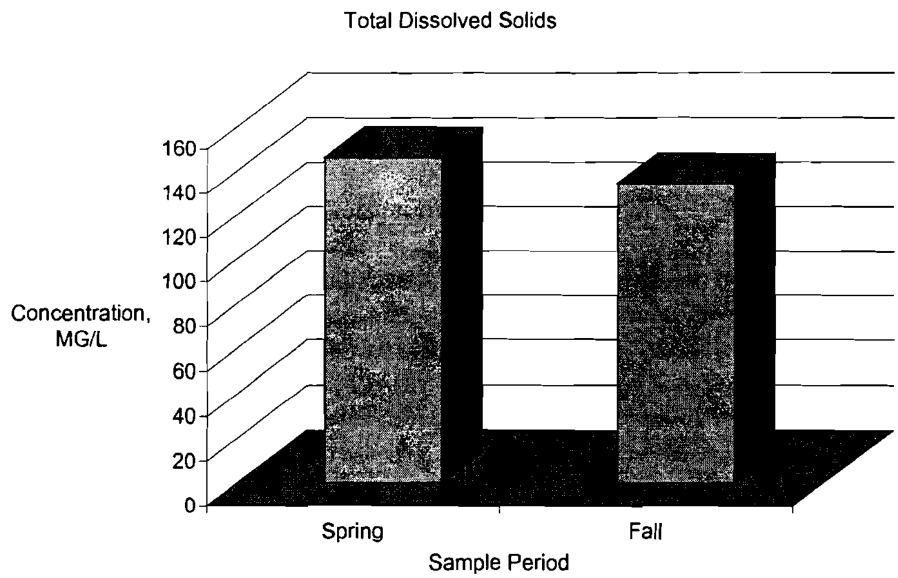
True Color

True color is a result of the type and amount of dissolved organic chemicals the water contains. The water picks up the color from the terrain it flows through or from the materials in the water. The vegetation in the lake may add color to the water during decomposition. The color of the lake had an average reading of 17 standard units (SU).



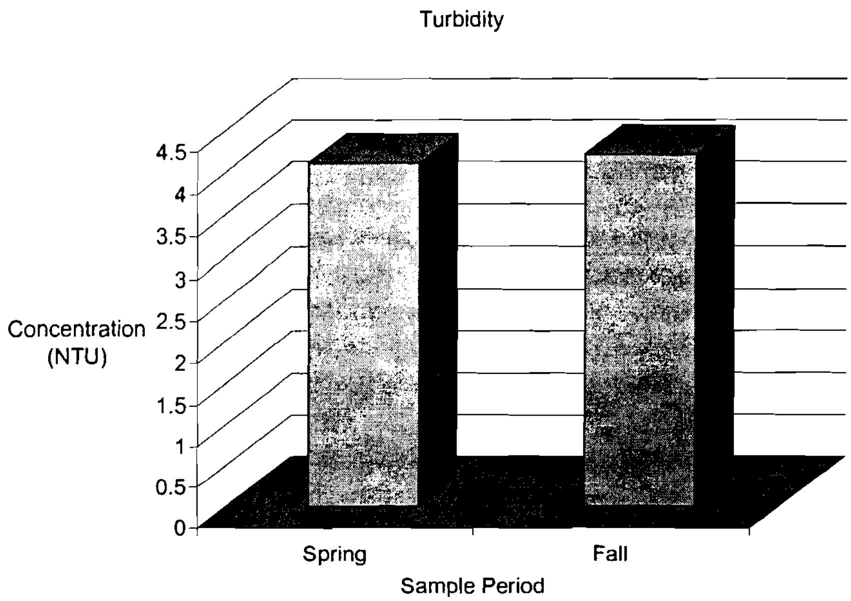
The graph above shows the readings obtained from this study. The average value from the current study is down 5 units from the 1993 true color of 22 units. The color is still categorized as Low according to DNR scale so the change is not significant. The lower reading may be a result of less dissolved solids indicating a slight increase in water quality or may depend on the time of year and the amount of decaying plants in the lake.

The color of the water is determined by the terrain the water flows through as is the amount and type of dissolved solids. The main ions that are measured for the dissolved solids test are carbonate, bicarbonate, chloride, sulfate, nitrate, sodium, potassium, calcium, and magnesium. The average concentration for total dissolved solids was 140 mg/l. The following graph shows the dissolved solids concentrations.

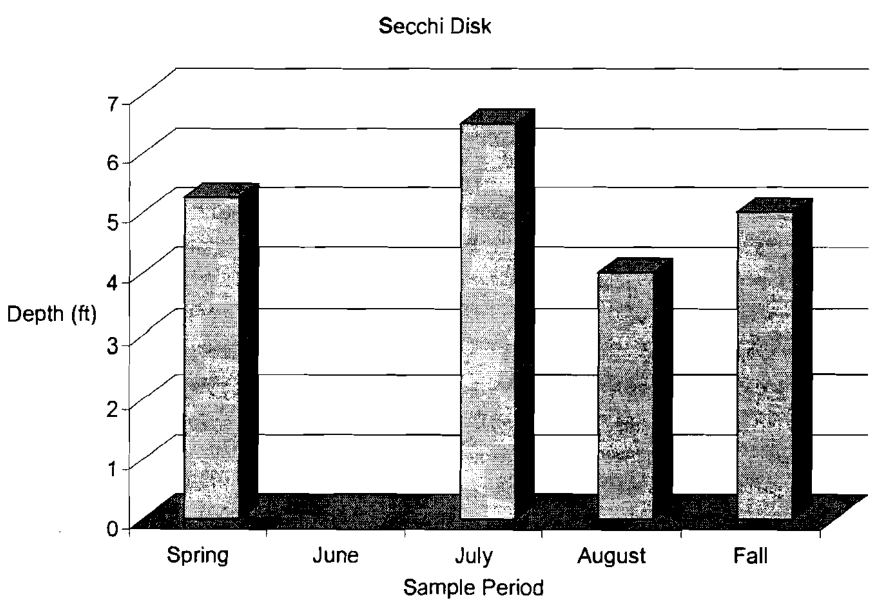


Turbidity

Turbidity is the measure of the amount of particles in the water such as suspended solids and algae. The average turbidity reading for this study was 4.2 NTU (Nephelometric Turbidity Unit), no turbidity information was recorded for the 1993 study. This reading is rather high when compared to other lakes in the ecoregion which have values of 1-2 NTU. A measurement of suspended solids indicates an average concentration of 5.3 mg/l. The amount of algae present is measured indirectly by finding the concentration of chlorophyll a in the water. The chlorophyll a is the green pigment that the algae contain. The average chlorophyll a concentration was 20.5 mg/l. This is nearly half the amount that was present in 1993 (44 mg/l). The low readings may be due to fewer or less intense algae blooms for the season. From the data, a spike in the chlorophyll a reading can be seen at fall turnover. This is due to the influx of phosphorus that was released from the bottom sediments during the summer and mixed with the surface water at turnover. It is not uncommon to see fall algae blooms at turnover in stratified lakes. The turbidity readings can be seen in the following chart.

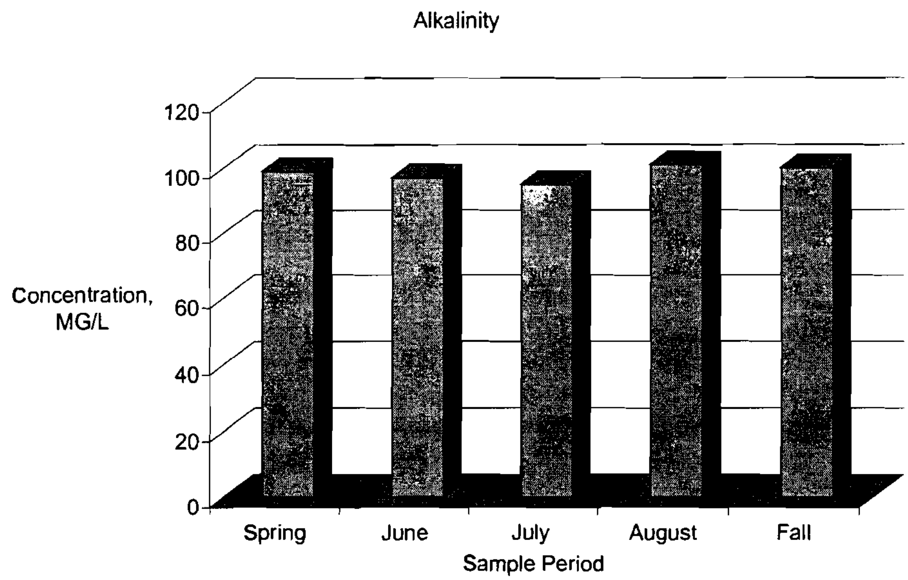


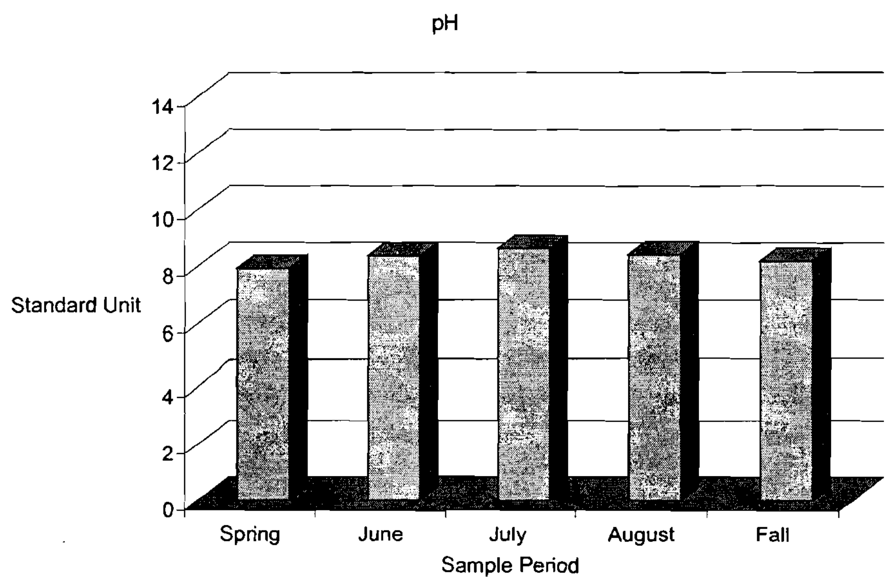
An indirect measure of turbidity is done with the Secchi disk. The readings from this study averaged 5 feet, which is approximately 1 foot deeper than the average from 1993. This indicates an increase in water clarity and is in agreement with the findings from the chlorophyll a comparison. The trophic classification according to the Secchi disk readings is eutrophic. The Secchi disk readings from this study are in the following chart. No data was available for June.



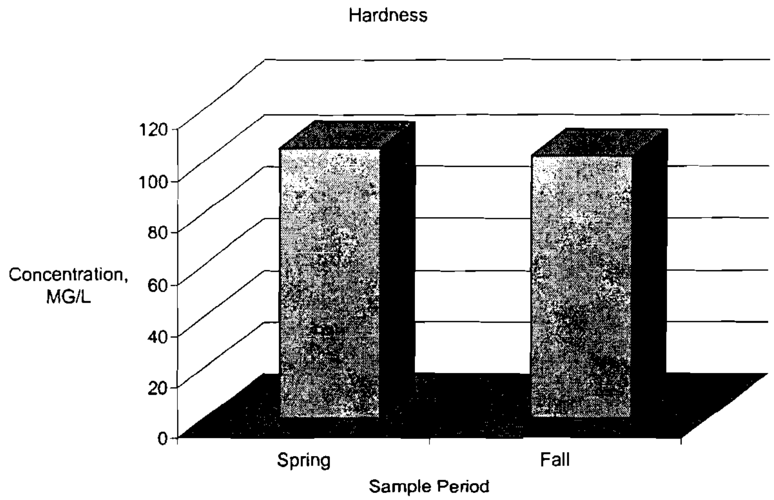
Buffering Capacity

A lakes buffering capacity is measured by the alkalinity of the water. Alkalinity is measured by the concentration of calcium carbonate in the water, the carbonate is the buffering agent. The values for this study indicate the water has a high buffering capacity, which makes it insensitive to acid rain. Alkalinity of water also determines its pH. The alkalinity values found in this study are slightly lower than that found in 1993. The pH levels are also lower, a contributing factor may be the lower alkalinity. Charts with the alkalinity and pH values follow.

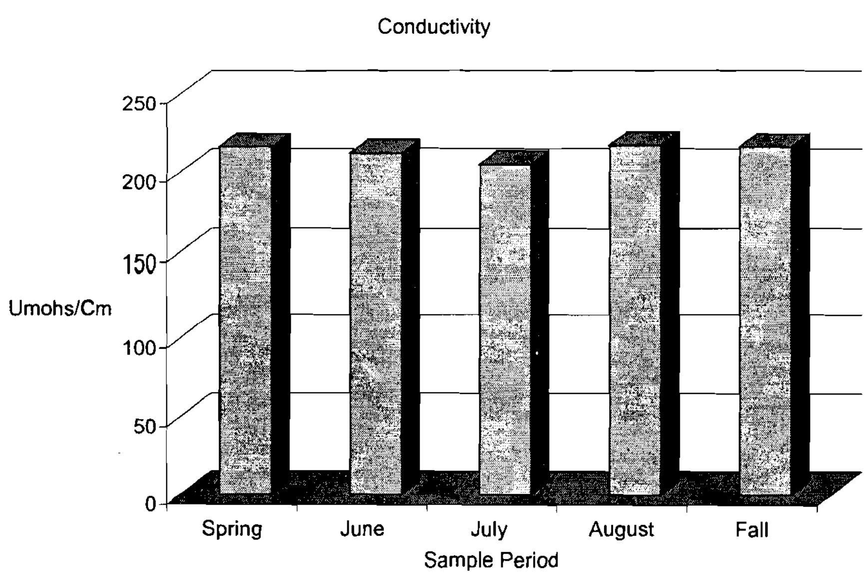




Hardness is also measured by the amount of calcium carbonate in the water. The calcium and magnesium ions cause hardness in water. Hard water is beneficial to health but can cause problems with scaling in pipes. Since hardness and alkalinity are a measure of the same compound, the values should be close. If the alkalinity value is high the sodium concentrations in the water may be high. If the alkalinity is much lower than the hardness the chloride, nitrate or sulfate concentrations may be high. The following chart shows the values of hardness for the sample periods.

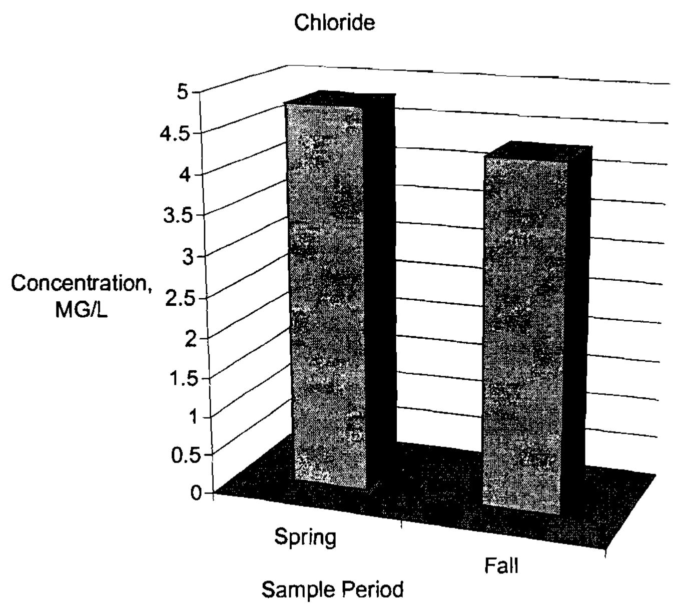


Another parameter that is measured relative to hardness is conductivity. The conductivity is a measure of the water's ability to conduct an electrical current and it gives an indication of the amount of dissolved substances in the water. The conductivity in an uncontaminated lake should be about twice the hardness. If it is much higher it may indicate the presence of contaminants such as chloride, sodium, nitrate or sulfate. The values of the alkalinity and hardness were found to be 114 and 104 mg/l respectively and conductivity was 213 mg/l, which indicates that the lake is not contaminated. The conductivity value is lower that the 1993 average of 229 mg/l indicating less dissolved substances in the water. The values for this study are shown in the chart below.



Pollution Indicators

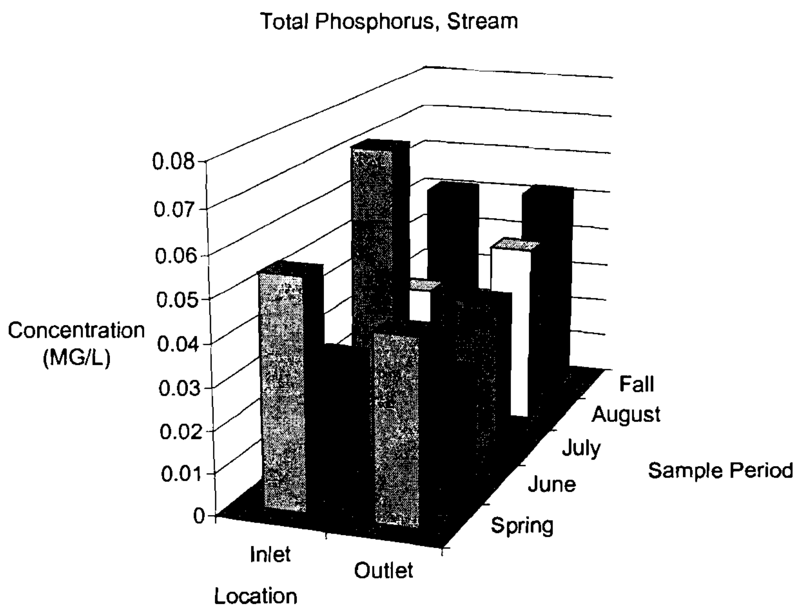
Two of the parameters tested for in this study are used as pollution indicators, chloride and coliform bacteria. The presence of chloride in lake water, where it does not naturally occur, may be an indication of pollution. The natural chloride level in lake water in the northern section of the state is less than 3 mg/l. The concentration found in Big Wood Lake was 4.6 mg/l. This may indicate pollution from leaking septic systems, fertilizers, animal waste or road salt. Chloride concentrations tend to vary naturally in lakes, for this reason it is important to have background data to draw accurate conclusions. The value obtained in this survey should be used as background data for future studies since this is the first reading taken on the lake. The data for this study can be found in the chart below.

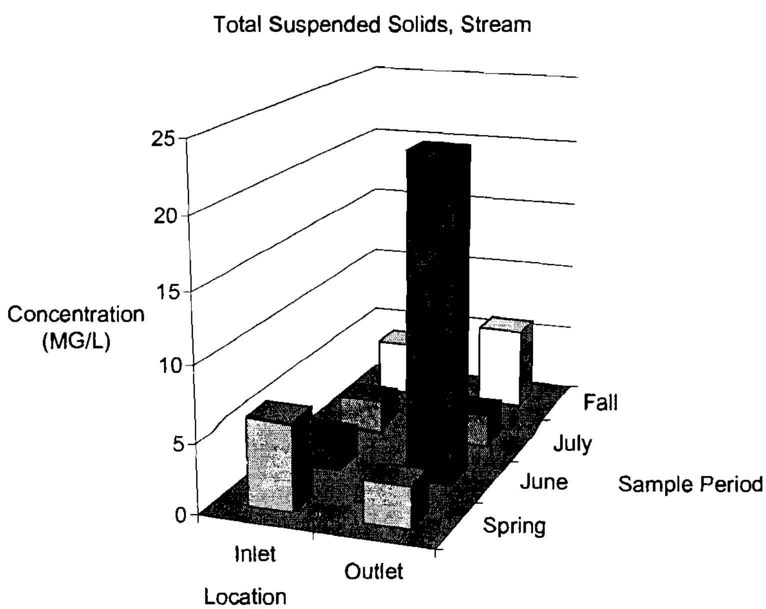


The second pollution indicator used for this study, coliform bacteria, was not found in the lake. The presence of coliform bacteria indicates pollution from animal or human wastes. Coliform bacteria does not usually cause disease but is an indicator that harmful pathogens may be present. If coliform bacteria is found in a sample, a second should be taken to confirm the results.

Stream Testing

A lake that is primarily fed by a stream is often higher in nutrients that seepage lakes. In order to assess the affects of the stream water on the lake the Wood River was sampled at the inlet and outlet of Big Wood Lake. The following parameters were tested for: total phosphorus, dissolved reactive phosphorus, total Kjeldahl nitrogen and total suspended solids. The data collected helped in assessing the source of the phosphorus in the lake. The values at the inlet and the outlet were relatively close to each other except for the July sample. At this time the inlet concentration was nearly twice the outlet. The cause of this is likely the 4-in of rain that was received the 2 days prior to testing. The runoff from the rain carried the nutrients from the landscape into the stream. The nitrogen and suspended solids results support this conclusion, the inlet values are higher than the outlet and the lake values fall in between. This indicates the source of the parameters is likely the stream. The following graphs show the phosphorus and total suspended solids concentrations found in the stream.





In August, the data indicated higher P concentrations at the outlet. The source of this P is from the bottom sediments. In reviewing the graphs, it can be seen that the concentrations of P at the bottom are very high compared to the surface or to the inlet and outlet. This indicates phosphorus loading from the sediments. In the fall sample the effects of both the stream input and the sediment loading are seen in the elevated concentrations at the inlet, outlet and the lake.

The effects of the watershed on this lake are very important and continued study is recommended. The priority watershed project that is currently being conducted could yield valuable information pertaining to the lake and the source of the parameters that have been tested for in this study. Controlling the input from the watershed will have a great impact on the water quality of the lake.

Results of Water Quality Testing

The results from the tests discussed above are included at end of this report in table format. Table 4 lists the DO and temperature readings from the lake, Table 5 lists the laboratory results from the lake samples including values for each sample period, seasonal averages and averages from the 1993 study, Table 6 lists laboratory results from the stream samples at the inlet and outlet and Tables 7 and 8 lists the in-field results from the lake samples and stream samples respectively.

Macrophyte Survey

The macrophyte survey was conducted on July 7 and 17, 2002. The purpose of the survey was to inventory the species present in the lake and their relative densities. 24 species were identified in this survey compared to 15 species identified in 1993. The new species included duckweeds, lilies, pickerelweed, rushes and cattail. The frequency of occurrence increased from the 1993 survey for a number of species. These species include coontail, muskgrass and all of the pondweeds, except floating leaf pondweed. All of these species increased in density also except largeleaf pondweed, sago pondweed and claspingleaf pondweed. The frequency of occurrence of the following plants saw a decrease: canada waterweed, common water milfoil, najas sp., and water celery. All of the densities saw a decrease also except the common water milfoil. The stands of this plant are fewer but the ones that remain have a greater density.

From the data, it appears that the vegetation in the lake is increasing. Of the species that have increased in mean density, four of them may form nuisance colonies according to WDNR. These are coontail, common water milfoil, curlyleaf pondweed and flatstem pondweed. If the stands of these plants are considered a nuisance by the users of the lake, control measures may be considered. Table 9, found at the Tables section of the report, lists the species found in the survey along with a Species Mean Density and Frequency of Occurrence for the 2002 survey and averages of the two surveys conducted in 1993. The data sheets and photos of each transect are included in Appendix B and a map with the transects is included in the Figures section.

Shoreline Development Assessment

At the time the macrophyte survey was conducted the lakeshore inventory was also being carried out. The inventory indicated that one-third of the lakeshore is heavily developed and nearly one-third has no development and is left natural. The other third of the shore is split between light and moderate development with light development taking a slight lead. The shoreline seems to have a good mix of development, but the one-third of shoreline with the heavy development delivers much more than one-third of the runoff and pollution to the lake. With out a buffer, all of the fertilizer and lawn clippings on a lawn runs directly to the lake dumping a load of nutrients into the water. Maintaining natural buffers will decrease the load to the lake from the shoreland and may greatly decrease the overall load of nutrients to the lake. The results of the inventory are listed below. The percent of lakeshore for each development rating is listed in the following table. A map indicating the areas assessed is located in the Figures section. The data sheets along with example photos are included in Appendix C.

Percent of Shoreline for Each Development Rating

Rating	% of Shoreline
Heavy	32
Moderate	16
Light	23
None	29

Lakeshore Resident Survey

The lakeshore resident survey was created to assess the views the residents have of the lake. Questions were taken from various surveys and tailored to fit this survey. The results of the survey indicate that people are quite satisfied with the quality of the lake and have noticed little change in it over the years. The majority of the landowners has a shoreline stabilized with rock or vegetation, various watercraft and use their land for peace and tranquility on the weekends. Most of the respondents believe the shoreline has light to moderate development. The residents believe that all aspects of the lake are about right including vegetation, fish numbers and habitat, diversity of birds and wildlife, number of loons, and watercraft and housing. They also believe that these aspects have remained the same over the years except for housing, watercraft and algae, which have increased. The people think that items that have the greatest impact on water quality are septic systems and lawn fertilizers and chemicals on the lakeshore and agricultural land uses in the watershed. The scenic beauty of the lake is most disrupted by shoreline structures such as docks and trampolines. The people have an opinion on ways to solve the problems they see with the lake and support a number of actions to address these problems. These opinions and actions can be viewed in the attached copy of the survey. The responses to the survey are included in Appendix D along with a spreadsheet tabulating the responses, graphs for interpretation and a copy of the survey. 191 surveys were mailed and 92 or 57% were returned. The number of responses was up from the 1993 survey when 43% were returned. Eight of the 92 surveys received were filled out on the website and electronically submitted.

Recommendations

This 2002 study covers a number of factors that influence the quality of the lake including the water quality, lake vegetation, condition and use of lakeshore and views of lakeshore residents. By comparing the results from the 1993 study and the 2002 study, the lake has remained relatively stable for the past 9 years. With the information gathered in the 1993 and 2002 studies, a great resource of background information is being built. This information can be used to track long term changes in the water quality. The variety and amount of information gathered so far should help in determining the cause of any changes the lake may go through in the future. We recommend continuing to conduct these studies in the future years. The information being collected is very valuable to the management of the lake. With these studies small changes can be detected and investigated further, possibly discovering a problem before it is too late to correct.

In order to maintain the quality of the lake, or perhaps improve it, there are few things that can be done. Buffer strips should be maintained on the shorelands surrounding the lake. The buffer strip should be of native vegetation that will trap nutrients and sediments and prevent them from entering the lake. The vegetation in the lake should be maintained as much as possible. The vegetation protects the shoreland from the forces of the waves and wind and reduces erosion. It also provides habitat for the fish and wildlife of the lake. If vegetation is too thick and interferes with activities, a carefully crafted management plan may be implemented to reduce the vegetation. Burnett County offers financial and technical assistance for preserving and restoring natural shorelines. Contact the Burnett County Land and Water Conservation Department for more information on these programs. You may also visit their website at www.mwd.com/burnett/lwcd.

To protect the lake from influences in the watershed, the "Nonpoint Source Control Plan for the Big Wood Lake Priority Watershed Project" has been designed and implemented. Funding for the program became available in fall of 2000. Since then, the county has provided technical and financial assistance to landowners for a number of projects including shoreland restoration, barnyard diversion, a fencing project to restrict cattle movement through a wetland and various programs and seminars providing information and education on conservation topics. Future projects include nutrient management plans for farmers in the watershed, a project restoring an area with severe gully erosion and the continued educational and informational projects. The Priority Watershed Project is scheduled to run through 2010. To obtain more information or track the progress of the project contact the Burnett County Land and Water Conservation Department.

The information contained in this report and the 1993 report should be used to assess the changes occurring in the lake. The extensive information provided should also provide clues to the causes of the changes. Future studies should be conducted to track the water quality of the lake and to assess the effects of the Priority Watershed Project on Big Wood Lake. Other studies may be done to assess the fisheries and the habitat for fish and wildlife.

References

Barr Engineering Company, Burnett County Land Conservation Department, Wisconsin Department of Natural Resources. January 1994. Big Wood Lake Planning Grant Report.

Jessen, R. and R. Lound. 1962. An evaluation of a Survey Technique for Submerged Aquatic Plants. Minnesota Department of Conservation Game Investigational Report No. 6.

Wisconsin Department of Natural Resources, Wisconsin Department of Agriculture, Trade and Consumer Protection, and the Burnett County Land Conservation Department. May 2001. Nonpoint Source Control Plan for the Big Wood Lake Priority Watershed Project.

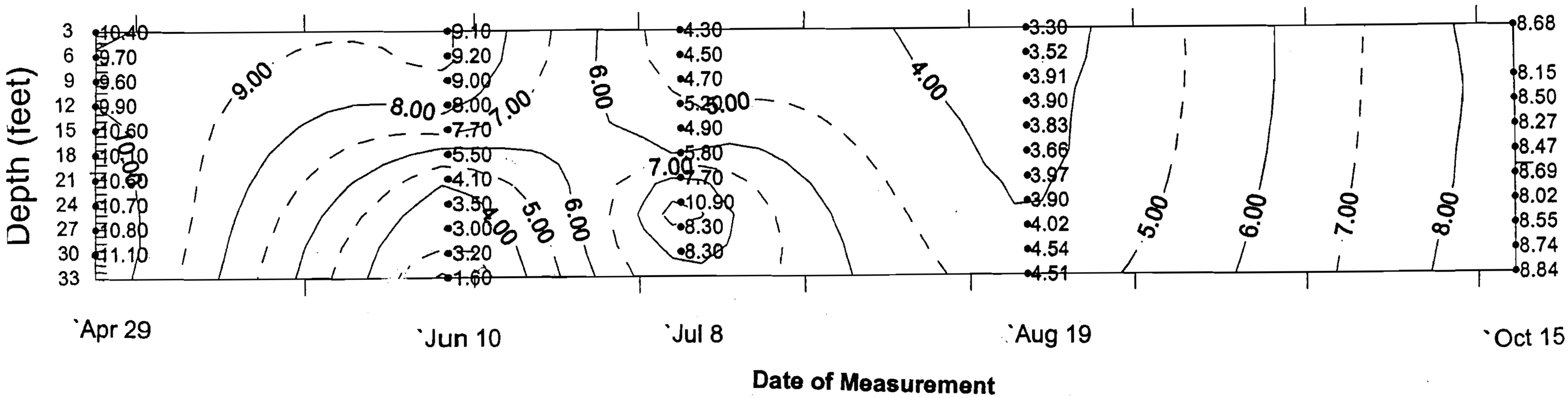
Figures

Dissolved Oxygen Isopleth

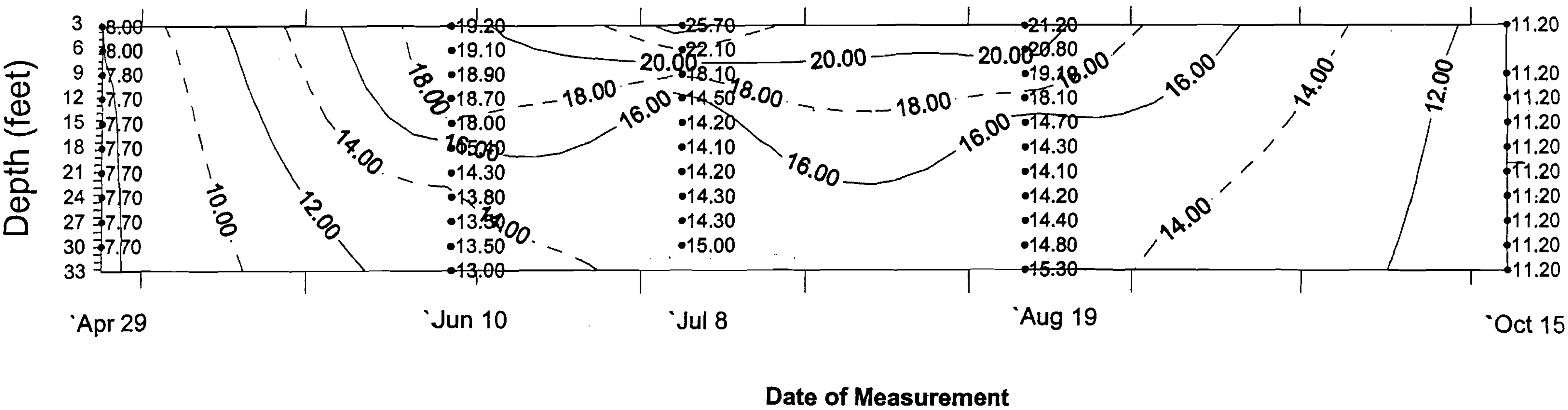
Temperature Isopleth

Map

Big Wood Lake
Dissolved Oxygen Isopleth
DO (mg/l) Measurements Vs Depth at Water Quality Sample Point



Big Wood Lake
Temperature Isopleth
Temperature (°C) Measurements Vs Depth at Water Quality Sample Point



Tables

Big Wood Lake Management Plan Water Quality Results
April thru October 2002
SUMMARY

Table 4

Dissolved Oxygen - Temperature

Depth	Spring		June		July		August		Fall	
	D.O. mg/L	Temp °C	D.O. mg/L	Temp °C	D.O. mg/L	Temp °C	D.O. mg/L	Temp °C	D.O. mg/L	Temp °C
33			1.6	13.0			4.5	15.3	8.8	11.2
30	11.1	7.7	3.2	13.5	8.3	15.0	4.5	14.8	8.7	11.2
27	10.8	7.7	3.0	13.5	8.3	14.3	4.0	14.4	8.6	11.2
24	10.7	7.7	3.5	13.8	10.9	14.3	3.9	14.2	8.0	11.2
21	10.6	7.7	4.1	14.3	7.7	14.2	4.0	14.1	8.7	11.2
18	10.1	7.7	5.5	15.4	5.8	14.1	3.7	14.3	8.5	11.2
15	10.6	7.7	7.7	18.0	4.9	14.2	3.8	14.7	8.3	11.2
12	9.9	7.7	8.0	18.7	5.2	14.5	3.9	18.1	8.5	11.2
9	9.6	7.8	9.0	18.9	4.7	18.1	3.9	19.1	8.2	11.2
6	9.7	8.0	9.2	19.1	4.5	22.1	3.5	20.8	8.7	11.2
3	10.4	8.0	9.1	19.2	4.3	25.7	3.3	21.2	8.7	11.2

Table 9

Big Wood Lake
Macrophyte Survey
July 7 & 17, 2002

* May be considered nusiance

Plant Species Scientific Name	Plant Species Common Name	2002 Survey Species Mean Density Rating (1-5) *	2002 Survey Frequency Of Occurrence (%) **	1993 Average Species Mean Density Rating (1-5) *	1993 Average Frequency Of Occurrence (%) **
Algae Sp	Filamentous Algae	3.0	20.0		
Algae Sp	Slimy Algae	4.0	3.3		
**Ceratophyllum demersum*	Coontail	4.0	81.7	3.6	66.6
Chara sp	Muskgrass	5.0	25.0	2.6	16.7
**Elodia canadensis*	Canada Waterweed	1.0	18.3	2.2	27.5
Lemna minor	Lesser Duckweed	3.0	1.7		
**Myrrophyllum exalbescens*	Common Water Milfoil	4.0	40.0	2.5	43.3
Najas sp	Najas sp	2.0	18.3	2.7	31.7
Nuphar advena	Yellow Water Lily	4.0	3.3		
Nymphaea odorata	White Water Lily	1.0	18.3		
Pontedaria cordata	Pickerelweed	4.0	1.7		
Potamogeton amplifolius	Largeleaf Pondweed	1.0	16.7	2.0	3.4
**Potamogeton crispus*	Curlyleaf Pondweed	3.0	50.0	2.1	30.0
Potamogeton natans	Floatingleaf Pondweed	1.0	5.0	1.4	6.7
Potamogeton nodosus	Long-leaf Pondweed	2.0	10.0	1.5	3.3
**Potamogeton pectinatus*	Sago Pondweed	1.0	21.7	1.4	15.0
Potamogeton richardsonii	Claspingleaf Pondweed	1.0	36.7	1.6	15.0
**Potamogeton zosteriformis*	Flatstem Pondweed	4.0	65.0	1.9	40.0
Scirpus americanus	Three-square Bulrush	4.0	3.3		
Scirpus validus	Softstem Bulrush	4.0	21.7		
Spirodela polyrhiza Schleiden	Big Duckweed	3.0	10.0		
Typha angustifolia	Narrow-leaved Cattail	1.0	3.3		
Vallisneria americana	Water Celery	1.0	25.0	2.5	31.7
Wolffia columbiana Karsten	Watermeal	4.0	3.3		

Appendix A

Water Quality Sample Data Forms

Water Quality Graphs

Lake Levels and Rainfall Records

Big Wood Lake Management Plan Water Quality Results

Date of Sampling: Monday April 29, 2002 Spring Turnover

Weather: Sunny $50^{0}F$ Windy

High winds and snow previous week

Laboratory Testing

Lake Results

Parameter	Depth	Results	Units
Total Phosphorus	0-2 m	0.042	MG/L
Total Phosphorus	near bottom	0.061	MG/L
Total Kjeldahl Nitrogen	0-2 m	0.69	MG/L
Nitrate plus Nitrite – N	0-2 m	ND	MG/L
Ammonia – N	0-2 m	ND	MG/L
Chlorophyll a	0-2 m	24	UG/L
Color	0-2 m	15	SU
Alkalinity	0-2 m	99	MG/L
pH	0-2 m	7.91	SU
Conductivity	0-2 m	216	UMHOS/CM
Dissolved Reactive Phos.	0-2 m	ND	MG/L
Chloride	0-2 m	4.8	MG/L
Hardness	0-2 m	105	MG/L
Suspended Solids	0-2 m	4	MG/L
Total Dissolved Solids	0-2 m	146	MG/L
Turbidity	0-2 m	4.1	NTU
Magnesium	0-2m	8.9	MG/L
Calcium	0-2m	27.6	MG/L
Fecal Coliform`	0-2 m	ND	

Stream Results

Parameter	Depth	Results		Units
		Inlet	Outlet	
Total Phosphorus	1 foot	0.055	0.044	MG/L
Dissolved Reactive Phos	1 foot	ND	ND	MG/L
Total Kjeldahl Nitrogen	1 foot	0.87	0.45	MG/L
Total Suspeded Solids	1 foot	6	3	MG/L

In-Field Testing

Lake Results

Parameter	Depth	Results	Units
Conductivity	0-2 m	145	UMHOS/CM
	Near bottom	140	UMHOS/CM
Temperature	0-2 m	9	^{0}C
	Near bottom	9	^{0}C
pH	0-2 m	6.9	SU
	Near bottom	6.9	SU
Secchi Disk		5'4"	

Dissolved Oxygen - Temperature Isopleth

Depth	D.O. (mg/L)	Temperature (^{0}C)
30	11.1	7.7
27	10.8	7.7
24	10.7	7.7
21	10.6	7.7
18	10.1	7.7
15	10.6	7.7
12	9.9	7.7
9	9.6	7.8
6	9.7	8
3	10.4	8

Stream Results

		Results		
Parameter	Depth	Inlet	Outlet	Units
Conductivity	1 foot	122	145	UMHOS/CM
Temperature	1 foot	9.2	8.4	^{0}C
pH	1 foot	7.3	7.3	SU
D.O.	1 foot	11	10.6	MG/L

MG/L	milligrams per liter
UG/L	micrograms per liter
SU	standard units
UMHOS/CM	micromhos per centimeter
^{0}C	degress celsius
ND	not detected

Big Wood Lake Management Plan Water Quality Results

Date of Sampling: Monday June 10, 2002 June Sample
Weather:

Laboratory Testing

Lake Results

Parameter	Depth	Results	Units
Total Phosphorus	0-2 m	0.023	MG/L
Total Phosphorus	near bottom	0.058	MG/L
Total Kjeldahl Nitrogen	0-2 m	0.54	MG/L
Nitrate plus Nitrite – N	0-2 m	ND	MG/L
Ammonia – N	0-2 m	0.019	MG/L
Chlorophyll a	0-2 m	2	UG/L
Color	0-2 m	15	SU
Alkalinity	0-2 m	97	MG/L
pH	0-2 m	8.35	SU
Conductivity	0-2 m	212	UMHOS/CM
Dissolved Reactive Phos.	0-2 m		
Chloride	0-2 m		
Hardness	0-2 m		
Suspended Solids	0-2 m		
Total Dissolved Solids	0-2 m		
Turbidity	0-2 m		
Fecal Coliform`	0-2 m		

Stream Results

Parameter	Depth	Results Inlet	Results Outlet	Units
Total Phosphorus	1 foot	0.028	0.027	ug/l
Dissolved Reactive Phos	1 foot			
Total Kjeldahl Nitrogen	1 foot			mg/l
Total Suspeded Solids	1 foot	2	23	mg/l

In-Field Testing

Lake Results

Parameter	Depth	Results	Units
Conductivity	0-2 m		umhos/cm
	Near bottom	188	umhos/cm
Temperature	0-2 m	21	^{0}C
	Near bottom	15.5	^{0}C
pH	0-2 m		
	Near bottom		
Secchi Disk		5'4"	

Dissolved Oxygen - Temperature Isopleth

Depth	D.O. (mg/L)	Temperature (^{0}C)
33	1.6	13
30	3.2	13.5
27	3	13.5
24	3.5	13.8
21	4.1	14.3
18	5.5	15.4
15	7.7	18
12	8	18.7
9	9	18.9
6	9.2	19.1
3	9.1	19.2

Stream Results

Parameter	Depth	Results Inlet	Outlet	Units
Conductivity	1 foot			umhos/cm
Temperature	1 foot			^{0}C
pH	1 foot			
D.O.	1 foot			mg/L

MG/L	milligrams per liter
UG/L	micrograms per liter
SU	standard units
UMHOS/CI	micromhos per centimeter
^{0}C	degress celsius
ND	not detected

Big Wood Lake Management Plan Water Quality Results

Date of Sampling: Monday July 8, 2002 July Sample
Weather: 4-in of rain in prior 2 days

Laboratory Testing

Lake Results

Parameter	Depth	Results	Units
Total Phosphorus	0-2 m	0.029	MG/L
Total Phosphorus	near bottom	0.159	MG/L
Total Kjeldahl Nitrogen	0-2 m	0.61	MG/L
Nitrate plus Nitrite – N	0-2 m	0.023	MG/L
Ammonia – N	0-2 m	0.041	MG/L
Chlorophyll a	0-2 m	7.52	UG/L
Color	0-2 m	20	SU
Alkalinity	0-2 m	95	MG/L
pH	0-2 m	8.62	SU
Conductivity	0-2 m	205	UMHOS/CM
Dissolved Reactive Phos.	0-2 m		
Chloride	0-2 m		MG/L
Hardness	0-2 m		MG/L
Suspended Solids	0-2 m		MG/L
Total Dissolved Solids	0-2 m		MG/L
Turbidity	0-2 m		NTU
Magnesium	0-2m		MG/L
Calcium	0-2m		MG/L
Fecal Coliform`	0-2 m		

Stream Results

Parameter	Depth	Results		Units
		Inlet	Outlet	
Total Phosphorus	1 foot	0.072	0.037	MG/L
Dissolved Reactive Phos	1 foot			
Total Kjeldahl Nitrogen	1 foot			MG/L
Total Suspeded Solids	1 foot	2	2	MG/L

In-Field Testing

Lake Results

Parameter	Depth	Results	Units
Conductivity	0-2 m	109	UMHOS/CM
	Near bottom	112	UMHOS/CM
Temperature	0-2 m	25.7	^{0}C
	Near bottom	15	^{0}C
pH	0-2 m		SU
	Near bottom		SU
Secchi Disk		6'6"	FT

Dissolved Oxygen - Temperature Isopleth

Depth	D.O. (mg/L)	Temperature (^{0}C)
30	8.3	15
27	8.3	14.3
24	10.9	14.3
21	7.7	14.2
18	5.8	14.1
15	4.9	14.2
12	5.2	14.5
9	4.7	18.1
6	4.5	22.1
3	4.3	25.7

Stream Results

Parameter	Depth	Results Inlet	Outlet	Units
Conductivity	1 foot			UMHOS/CM
Temperature	1 foot			^{0}C
pH	1 foot			SU
D.O.	1 foot			MG/L

MG/L	milligrams per liter
UG/L	micrograms per liter
SU	standard units
UMHOS/CM	micromhos per centimeter
^{0}C	degress celsius
ND	not detected

Big Wood Lake Management Plan Water Quality Results

Date of Sampling: Monday August 19, 2002 August Sample

Weather: Sunny, 65^0 F, 0.5" rain on 8/17/02

Laboratory Testing

Lake Results

Parameter	Depth	Results	Units
Total Phosphorus	0-2 m	0.038	MG/L
Total Phosphorus	near bottom	0.635	MG/L
Total Phosphorus	thermocline	0.045	MG/L
Total Kjeldahl Nitrogen	0-2 m	0.78	MG/L
Nitrate plus Nitrite – N	0-2 m	ND	MG/L
Ammonia – N	0-2 m	0.016	MG/L
Chlorophyll a	0-2 m	32.4	UG/L
Color	0-2 m	15	SU
Alkalinity	0-2 m	101	MG/L
pH	0-2 m	8.41	SU
Conductivity	0-2 m	217	UMHOS/CM
Dissolved Reactive Phos.	0-2 m		
Chloride	0-2 m		MG/L
Hardness	0-2 m		MG/L
Suspended Solids	0-2 m		MG/L
Total Dissolved Solids	0-2 m		MG/L
Turbidity	0-2 m		NTU
Magnesium	0-2m		MG/L
Calcium	0-2m		MG/L
Fecal Coliform`	0-2 m		

Stream Results

Parameter	Depth	Results Inlet	Results Outlet	Units
Total Phosphorus	1 foot	0.031	0.044	MG/L
Dissolved Reactive Phos	1 foot			
Total Kjeldahl Nitrogen	1 foot			MG/L
Total Suspeded Solids	1 foot			MG/L

In-Field Testing

Lake Results

Parameter	Depth	Results	Units
Conductivity	0-2 m	200	UMHOS/CM
	Near bottom	250	UMHOS/CM
Temperature	0-2 m	21.2	^0C
	Near bottom	15.3	^0C
pH	0-2 m	8.2	SU
	Near bottom	7.2	SU
Secchi Disk		4'	FT

Dissolved Oxygen - Temperature Isopleth

Depth	D.O. (mg/L)	Temperature (^0C)
33	4.51	15.3
30	4.54	14.8
27	4.02	14.4
24	3.9	14.2
21	3.97	14.1
18	3.66	14.3
15	3.83	14.7
12	3.9	18.1
9	3.91	19.1
6	3.52	20.8
3	3.3	21.2

Stream Results

Parameter	Depth	Results Inlet	Outlet	Units
Conductivity	1 foot			UMHOS/CM
Temperature	1 foot			^0C
pH	1 foot			SU
D.O.	1 foot			MG/L

MG/L	milligrams per liter
UG/L	micrograms per liter
SU	standard units
UMHOS/CM	micromhos per centimeter
^0C	degress celsius
ND	not detected

Big Wood Lake Management Plan Water Quality Results

Date of Sampling: Tuesday Oct. 15, 2002 Fall Turnover
Weather: Cold/ Windy 40°F

Laboratory Testing:

Lake Results

Parameter	Depth	Results	Units
Total Phosphorus	0-2 m	0.054	MG/L
Total Phosphorus	near bottom	0.053	MG/L
Total Kjeldahl Nitrogen	0-2 m	0.7	MG/L
Nitrate plus Nitrite – N	0-2 m	0.266	MG/L
Ammonia – N	0-2 m	0.05	MG/L
Chlorophyll a	0-2 m	36.5	UG/L
Color	0-2 m	20	SU
Alkalinity	0-2 m	100	MG/L
pH	0-2 m	8.17	SU
pH	near bottom	7.2	SU
Conductivity	0-2 m	216	UMHOS/CM
Dissolved Reactive Phos.	0-2 m	0.005	MG/L
Chloride	0-2 m	4.3	MG/L
Hardness	0-2 m	102	MG/L
Suspended Solids	0-2 m	6.6	MG/L
Total Dissolved Solids	0-2 m	134	MG/L
Turbidity	0-2 m	4.2	NTU
Magnesium	0-2m	8.4	MG/L
Calcium	0-2m	27.2	MG/L
Fecal Coliform`	0-2 m	<100	/100ml

Stream Results

Parameter	Depth	Results Inlet	Results Outlet	Units
Total Phosphorus	1 foot	0.051	0.052	MG/L
Dissolved Reactive Phos	1 foot	0.005	ND	MG/L
Total Kjeldahl Nitrogen	1 foot			MG/L
Total Suspeded Solids	1 foot	4	6	MG/L

[redacted]

Lake Results

Parameter	Depth	Results	Units
Conductivity	0-2 m	150	UMHOS/CM
	Near bottom	150	UMHOS/CM
Temperature	0-2 m	11	^{0}C
	Near bottom	11.2	^{0}C
pH	0-2 m	7.6	SU
	Near bottom	7.2	SU
Secchi Disk		5	FT

Dissolved Oxygen - Temperature Isopleth

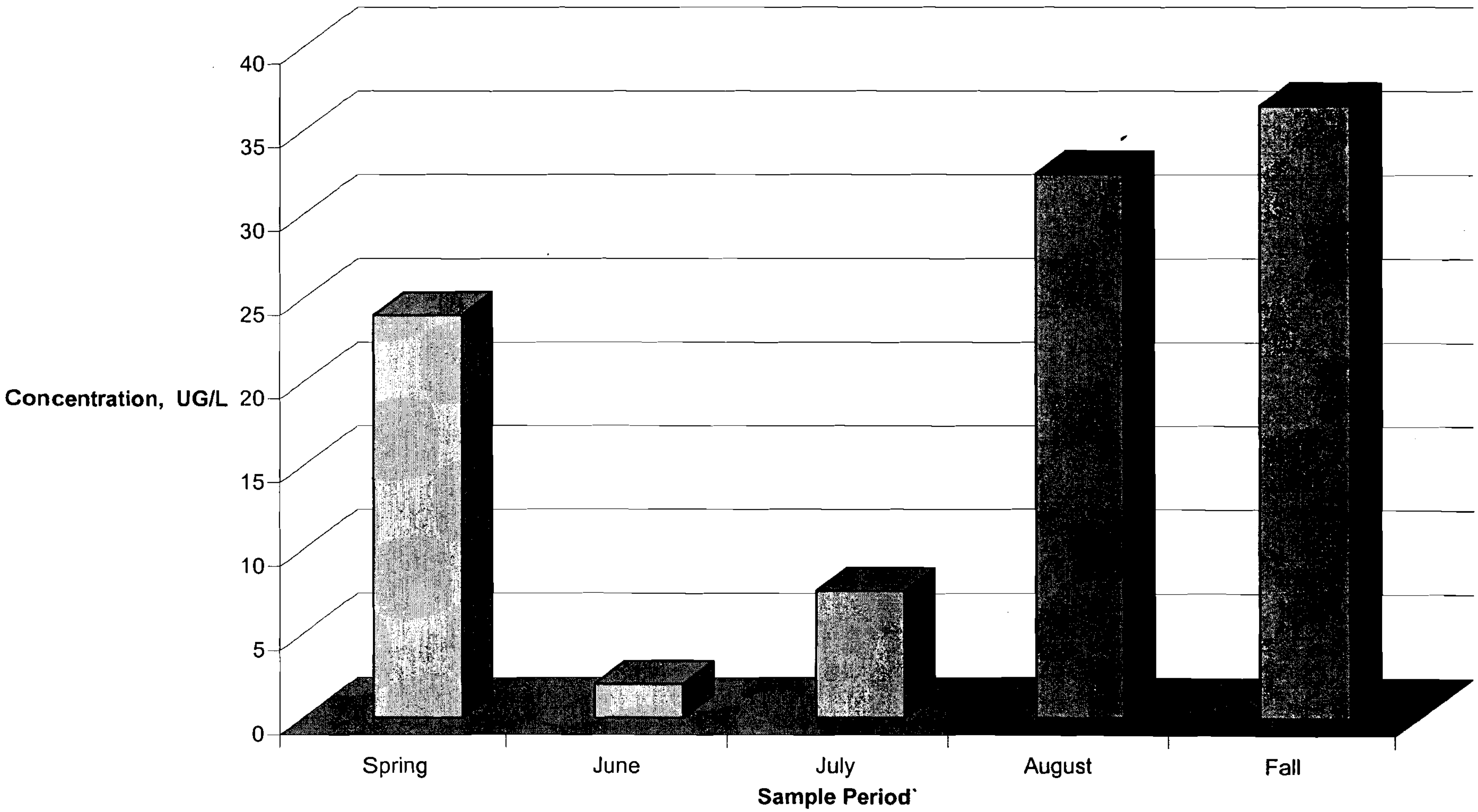
Depth	D.O. (mg/L)	Temperature (^{0}C)
33	8.84	11.2
30	8.74	11.2
27	8.55	11.2
24	8.02	11.2
21	8.69	11.2
18	8.47	11.2
15	8.27	11.2
12	8.5	11.2
9	8.15	11.2
6	8.7	11.2
3	8.68	11.2

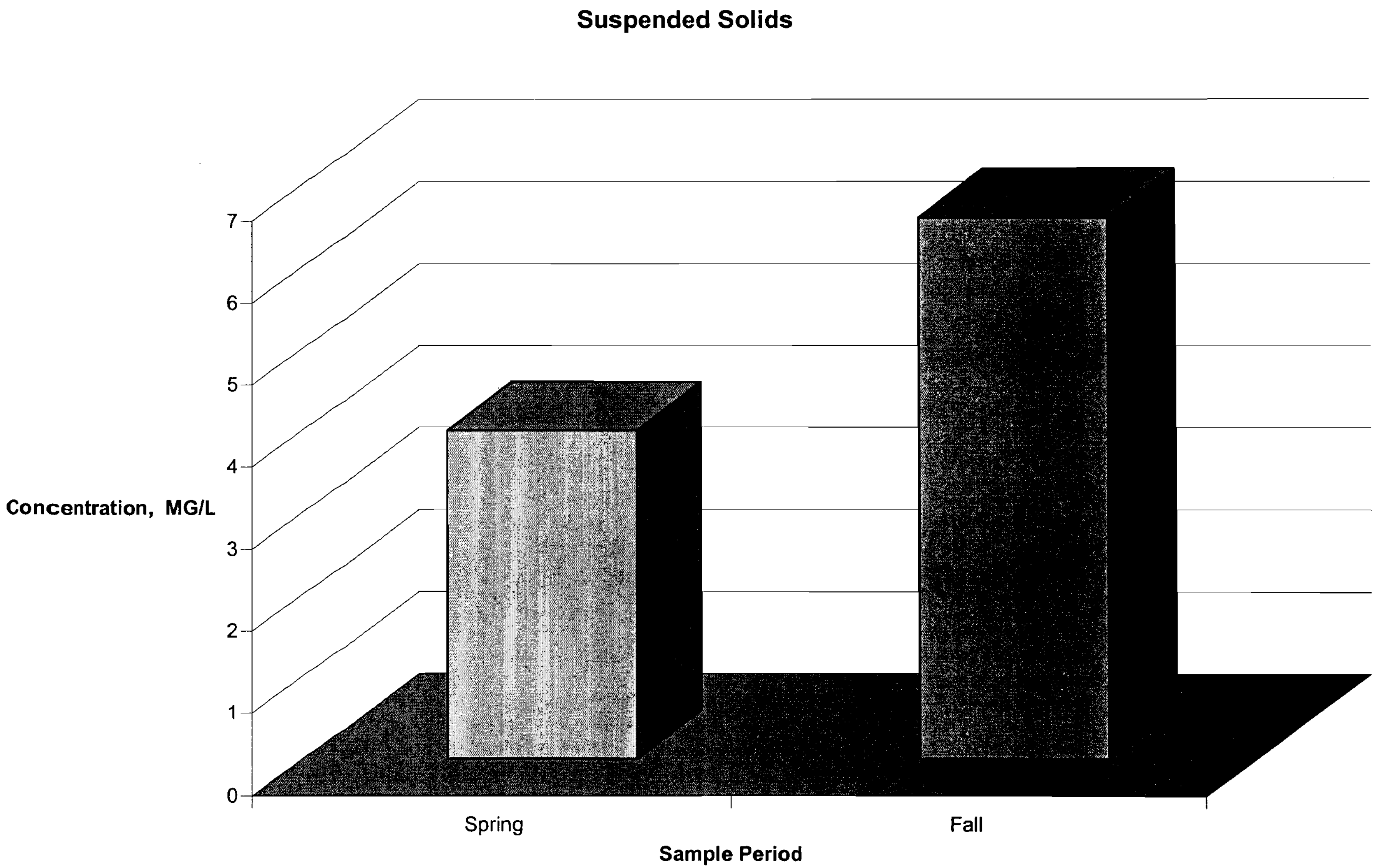
Stream Results

		Results		
Parameter	Depth	Inlet	Outlet	Units
Conductivity	1 foot	130	150	UMHOS/CM
Temperature	1 foot	11.2	11.2	^{0}C
pH	1 foot	7	7.5	SU
D.O.	1 foot	8.68	8.68	MG/L

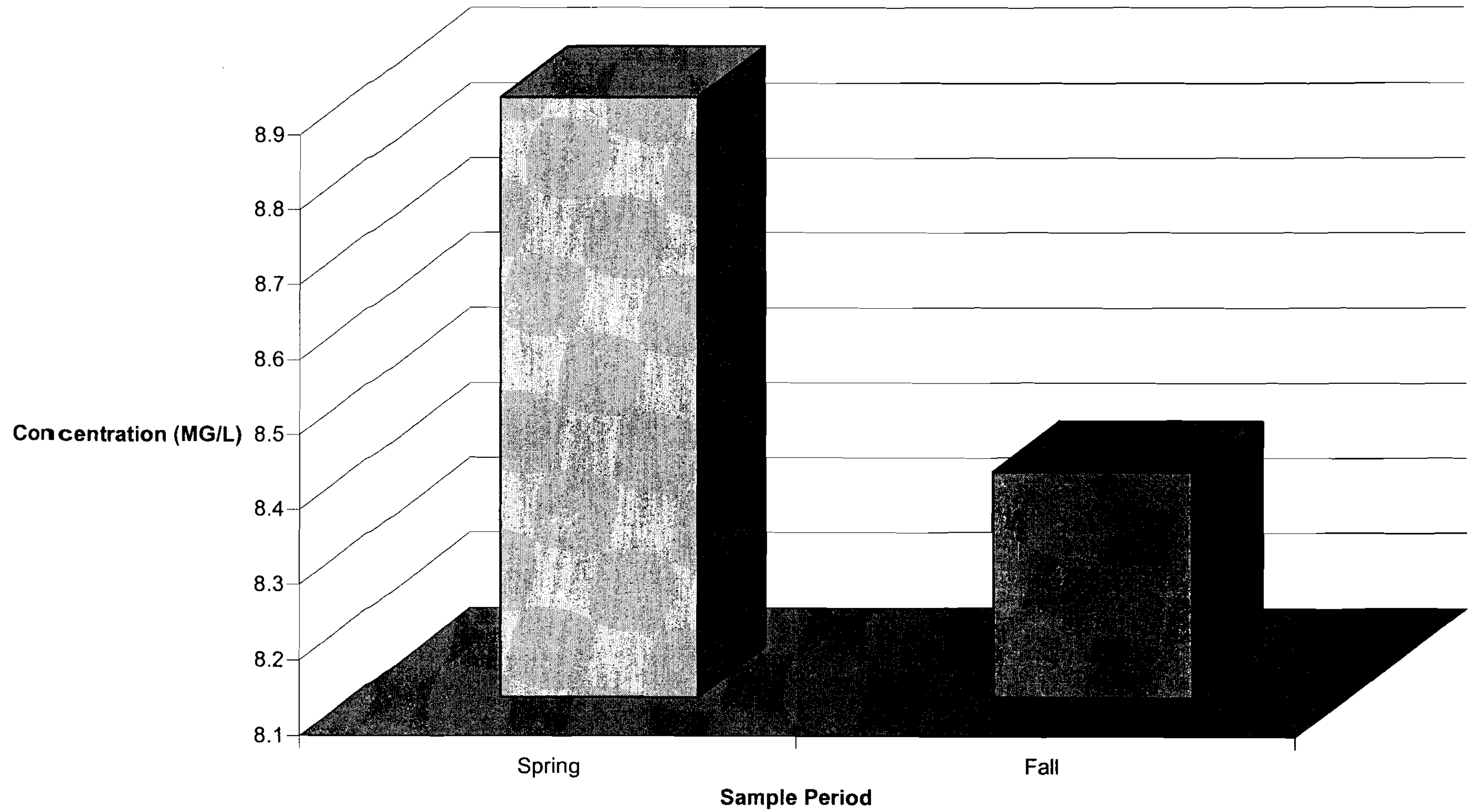
MG/L	milligrams per liter
UG/L	micrograms per liter
SU	standard units
UMHOS/CM	micromhos per centimeter
^{0}C	degress celsius
ND	not detected

Chlorophyll a

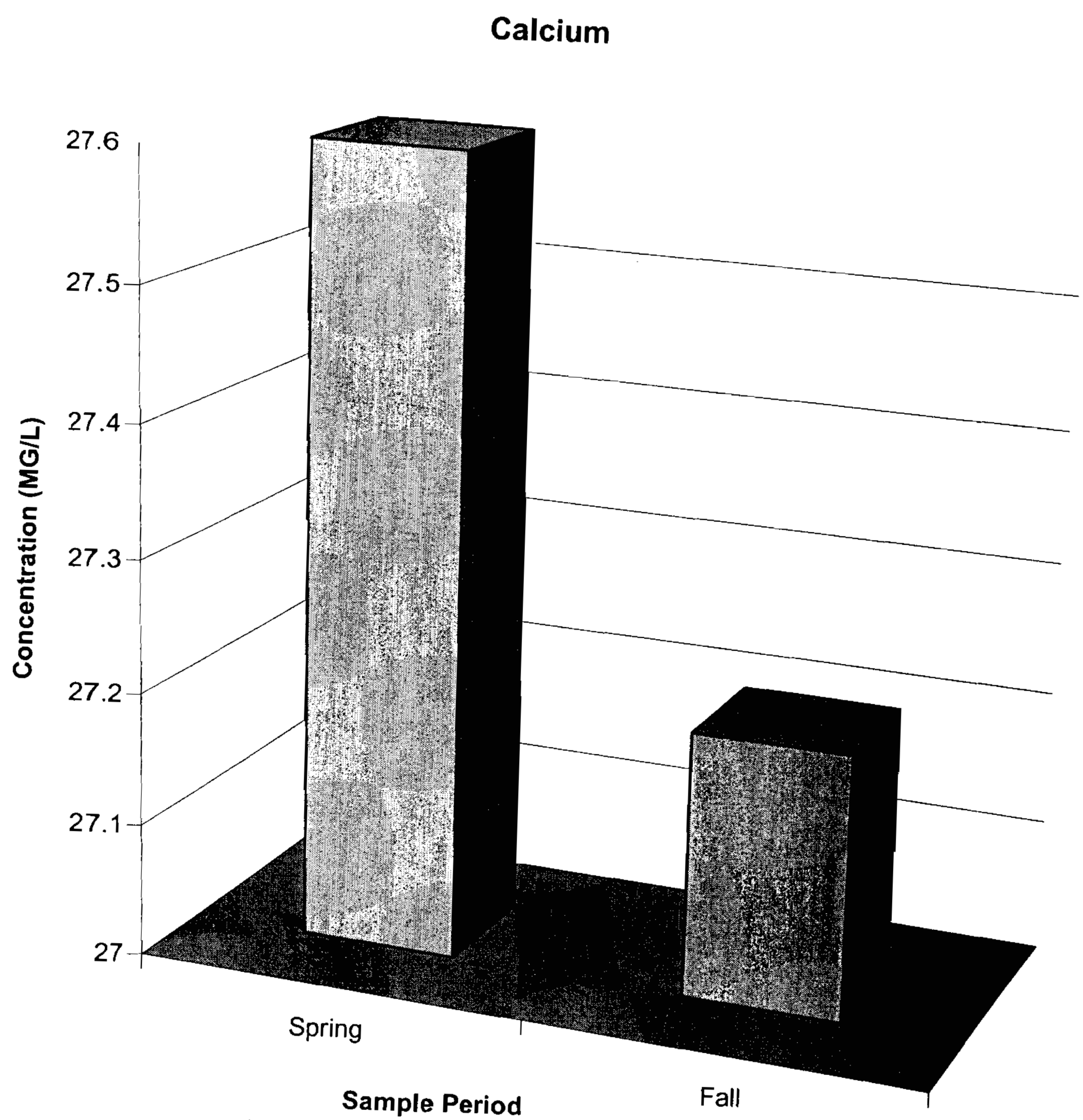



Suspended Solids
Concentration, MG/L
7
6
5
4
3
2
1
0
Spring
Fall
Sample Period

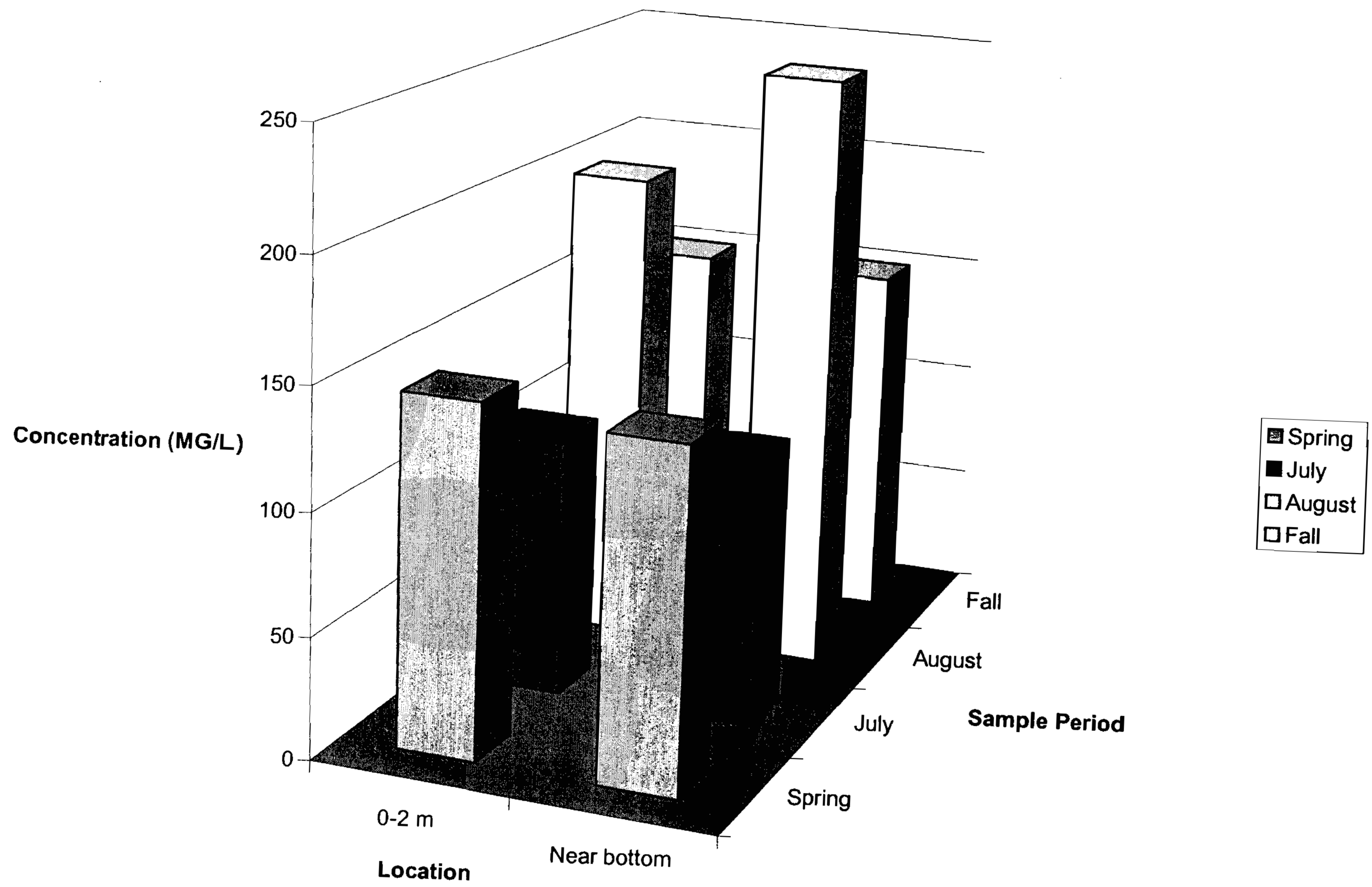
Magnesium

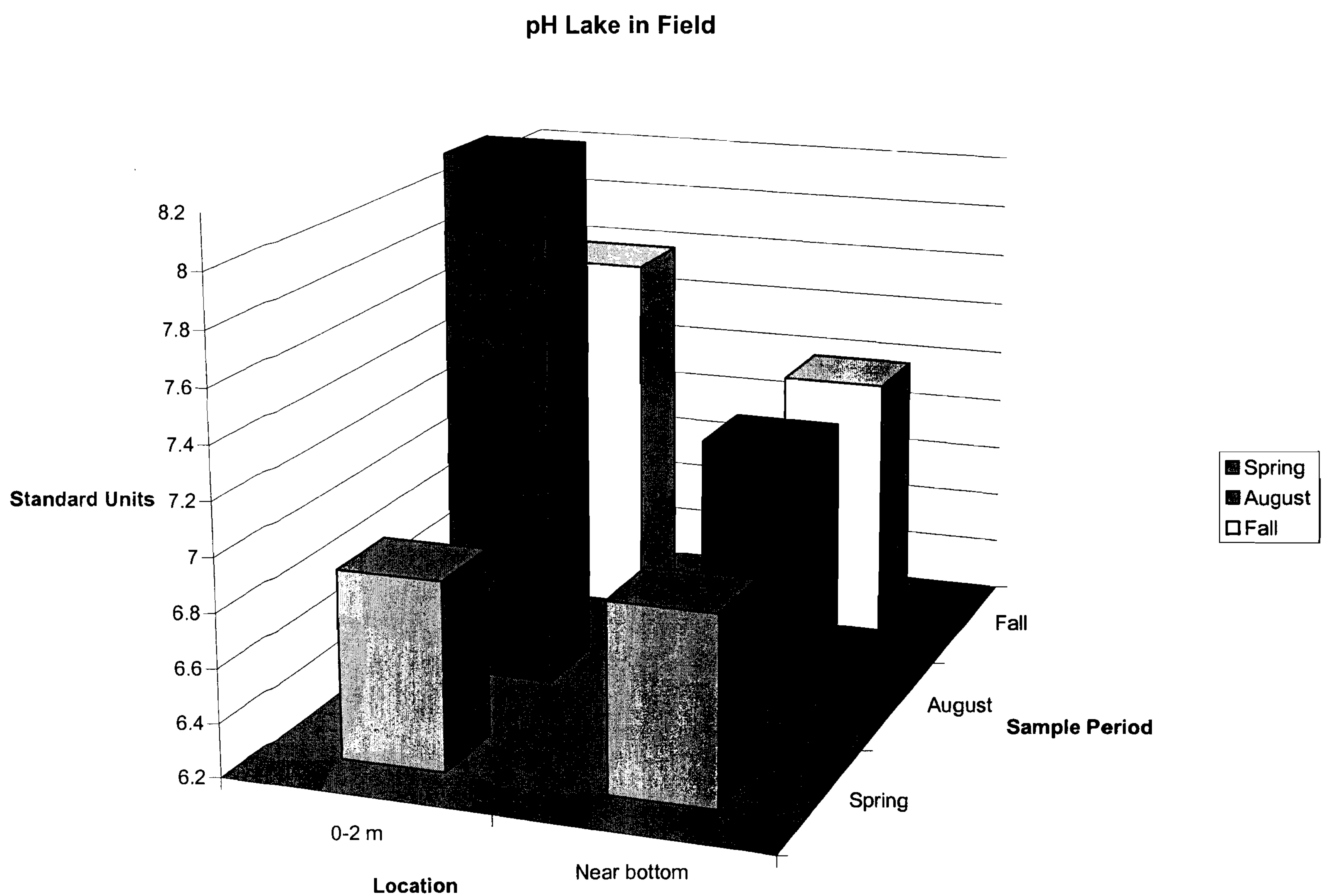


Concentration (MG/L)
8.9
8.8
8.7
8.6
8.5
8.4
8.3
8.2
8.1
Spring
Fall
Sample Period

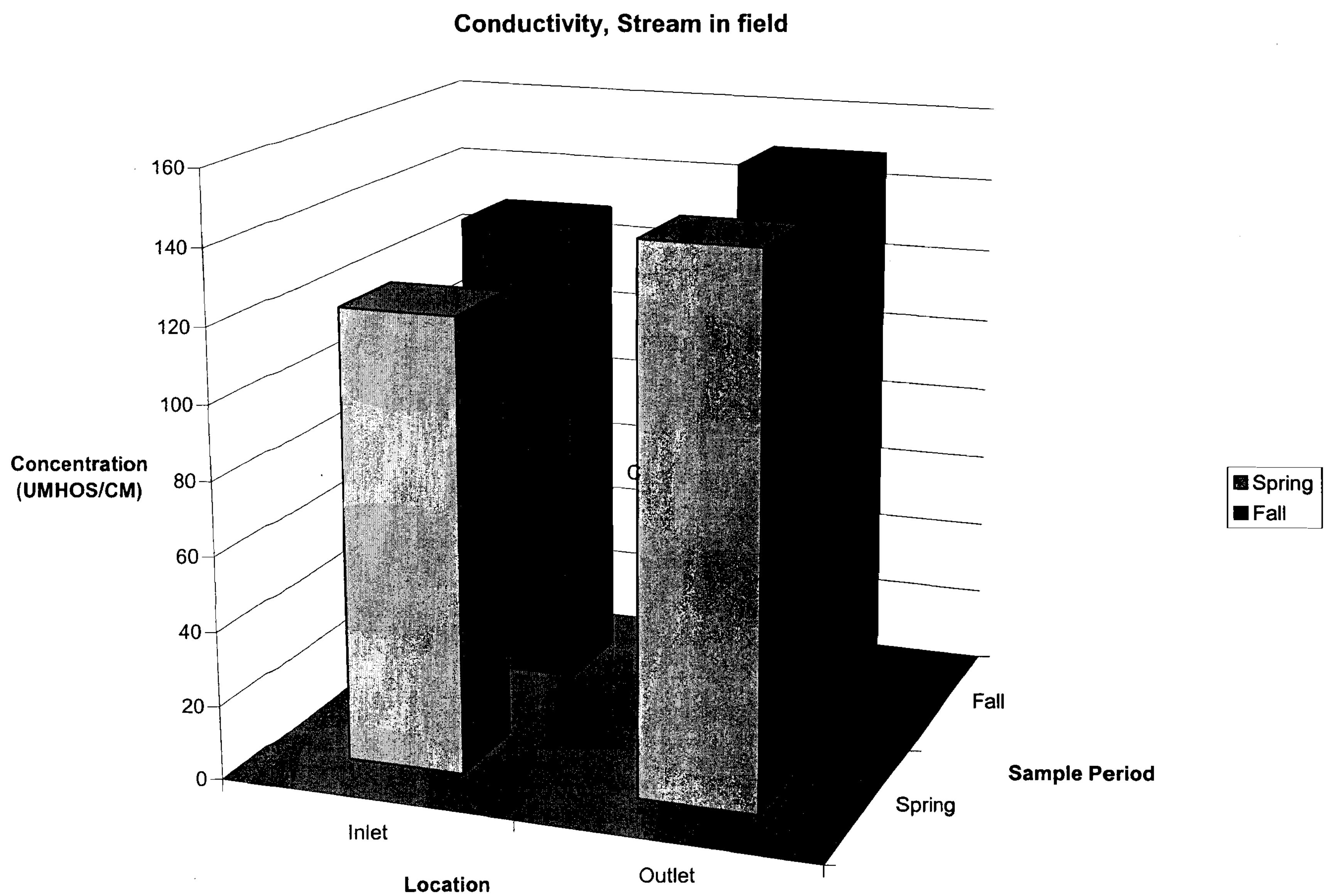

Calcium
Concentration (MG/L)
27.6
27.5
27.4
27.3
27.2
27.1
27
Spring
Fall
Sample Period

Conductivity, Lake in Field





pH Lake in Field
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
Standard Units
0-2 m
Near bottom
Location
Spring
August
Fall
Sample Period
Spring
August
Fall


Conductivity, Stream in field
Concentration
(UMHOS/CM)
160
140
120
100
80
60
40
20
0
Inlet
Outlet
Location
Spring
Fall
Sample Period
Spring
Fall

Big Wood Lake
Lake Levels and Rainfall
Lake Study 2002

Date	Lake Level * feet	Rainfall inches	Temperature °F
4/29/2002	2.02		
4/30/2002		trace	
5/4/2002		trace	
5/5/2002		0.4	
5/6/2002	1.72	0.1	
5/7/2002		0.9	
5/8/2002		0.9	
5/11/2002		0.2	
5/12/2002	2.00	0.3	
5/15/2002		trace	
5/20/2002	2.04		
5/22/2002		trace	
5/27/2002	1.54		
6/2/2002		0.4	
6/3/2002	1.30	trace	
6/4/2002		0.3	
6/7/2002		0.3	
6/10/2002	1.20		
6/11/2002		0.4	
6/16/2002		0.3	
6/17/2002	1.16		
6/20/2002		0.7	
6/21/2002		trace	
6/23/2002		0.8	
6/24/2002	1.32		
7/1/2002	1.20		
7/7/2002		2.0	
7/8/2002	1.36	2.3	
7/10/2002		0.2	
7/15/2002	1.32		
7/21/2002		0.8	
7/22/2002	1.30		
7/24/2002		0.2	
7/25/2002		0.3	
7/27/2002		1.5	
7/28/2002		0.3	
7/29/2002	1.36		
7/31/2002		0.1	
8/3/2002		1.8	
8/5/2002	1.52		
8/12/2002	1.52	0.5	
8/15/2002		0.2	
8/17/2002		0.8	
8/19/2002	1.56		

Date	Lake Level * feet	Rainfall inches	Temperature °F
8/20/2002			
8/21/2002		1.2	
8/23/2002		trace	
8/26/2002	1.54		
9/1/2002		3.2	
9/2/2002	1.74		
9/3/2002		0.2	
9/5/2002			
9/6/2002		3.8	
9/9/2002	2.50		
9/10/2002		0.6	
9/14/2002		0.5	
9/16/2002	2.10		
9/18/2002	1.73	trace	
9/19/2002	1.72	0.4	
9/20/2002	1.68	0.3	
9/22/2002	1.56	0.1	
9/24/2002	1.50		64
9/25/2002	1.46	0.2	61
9/26/2002	1.48	1.0	60
9/30/2002	1.40	0.2	60
10/1/2002	1.38		60
10/3/2002	1.34		59
10/4/2002	1.36	2.0	59
10/5/2002	1.78	1.0	57
10/6/2002	2.20	0.8	55
10/8/2002	2.30		54
10/9/2002	2.36		53
10/10/2002	2.48	0.1	53
10/11/2002	2.40	0.3	53
10/13/2002	2.40		52
10/15/2002	2.34		50

* Lake levels were recorded from a staff gage in the lake. The levels recorded are arbitrary and the gage is not tied to a datum.