

Big Wood Lake Water Quality Study

**Big Wood Lake
Grantsburg, WI**

Prepared for:

**Big Wood Lake Association
Grantsburg, WI**

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**Big Wood Lake Association
Grantsburg, WI**

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Contents

	<u>Page No.</u>
Executive Summary	1
Introduction	3
Methods	4
Water Quality Sampling	4
Macrophyte Survey.....	5
Shoreline Development Assessment	6
Lakeshore Resident Survey.....	6
Results and Discussion	7
Water Quality Testing	7
Macrophyte Survey.....	19
Shoreline Development Assessment	19
Lakeshore Resident Survey.....	20
Recommendations	21
References.....	22

List of Figures

Dissolved Oxygen Isopleth
Temperature Isopleth
Map

List of Tables

	<u>Page No.</u>
Table 1 Spring and Fall Turnover	4
Table 2 Monthly Testing	5
Table 3 Plant Species Densities	5
<u>Tables 4 through 9</u>	
Table 4 Dissolved Oxygen – Temperature	
Table 5 Laboratory Lake Results	
Table 6 Laboratory Stream Results	
Table 7 In Field Lake Results	
Table 8 In Field Stream Results	
Table 9 Macrophyte Survey Results	

List of Appendices

- Appendix A Water Quality Sample Data Forms
 - Water Quality Graphs
 - Lake Levels and Rainfall Records
- Appendix B Macrophyte Survey Data
 - Transect Photos
- Appendix C Shoreline Development Data
 - Rating Example Photos
- Appendix D Lakeshore Resident Survey
 - Spreadsheet
 - Graphs

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

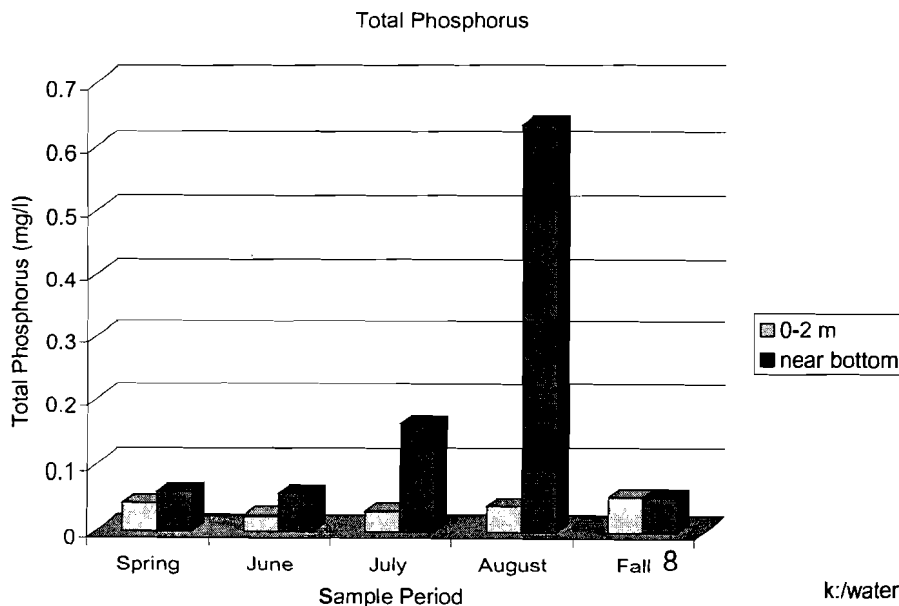
The nutrients that have the greatest impact on vegetation in a lake are phosphorus and nitrogen. Total phosphorus is used to measure the lakes nutrient status. Phosphorus promotes plant growth and is the key nutrient affecting the amount of algae and weed growth. Sources of phosphorus include human and 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 than 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.



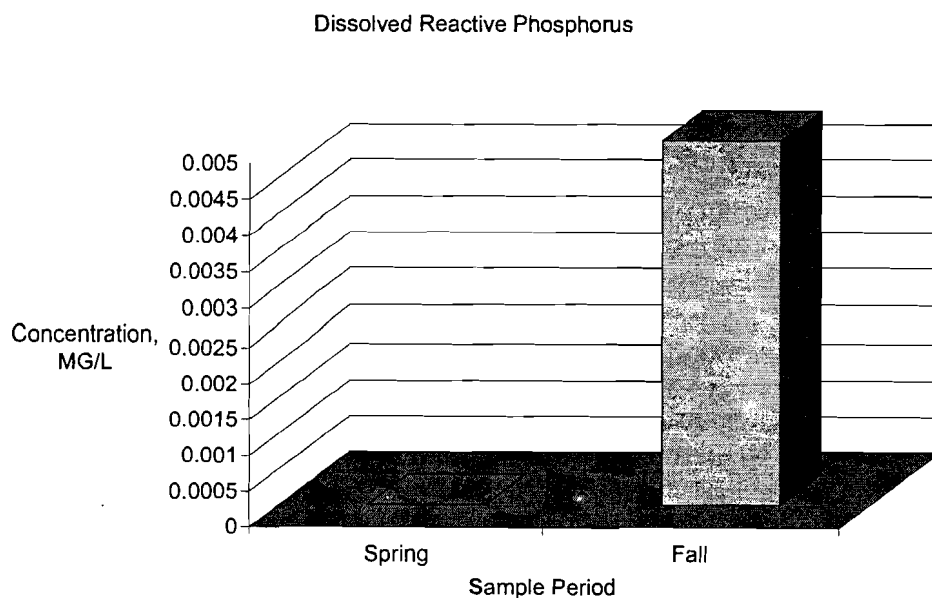
The bottom average was not calculated in the 1993 study. From the graph it can be seen that the levels at the bottom of the lake are almost always greater than near the surface.

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)

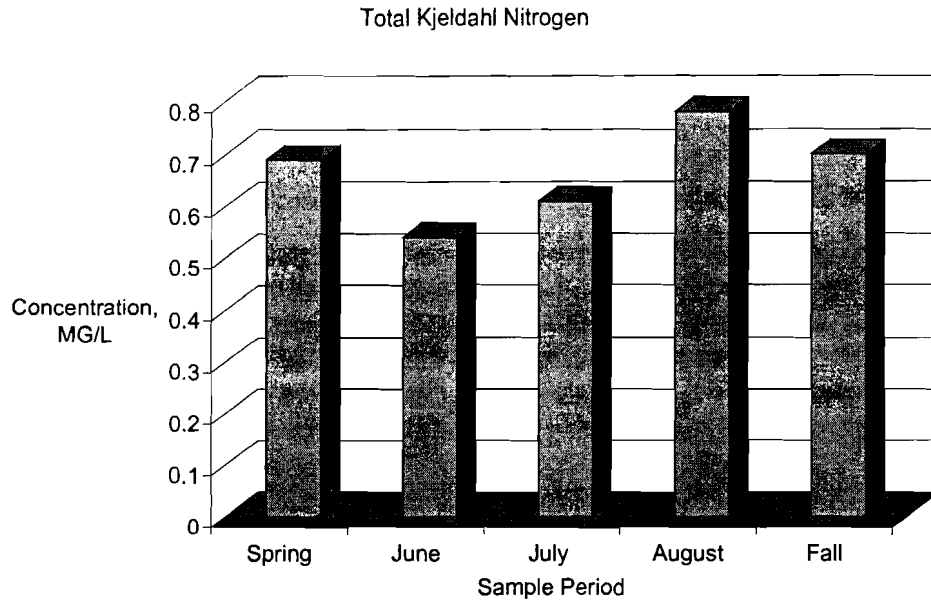
The amount of DRP was measured at spring and fall turnover to determine if the lake would have enough P to create summer algae blooms. There was not any DRP found in the spring and only 0.005 MG/L in the fall. This indicates that algae blooms should not have been a problem this year since a DRP concentration 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.

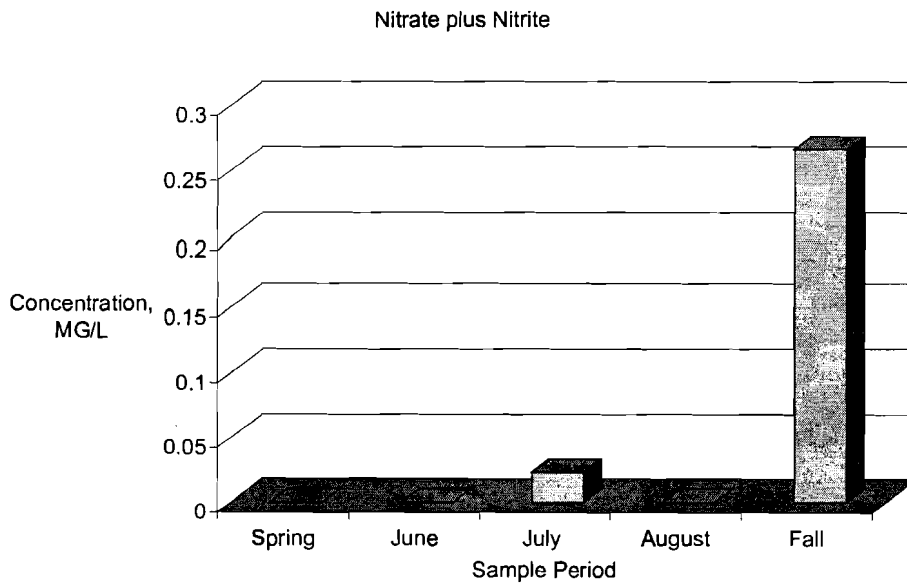


Nitrogen

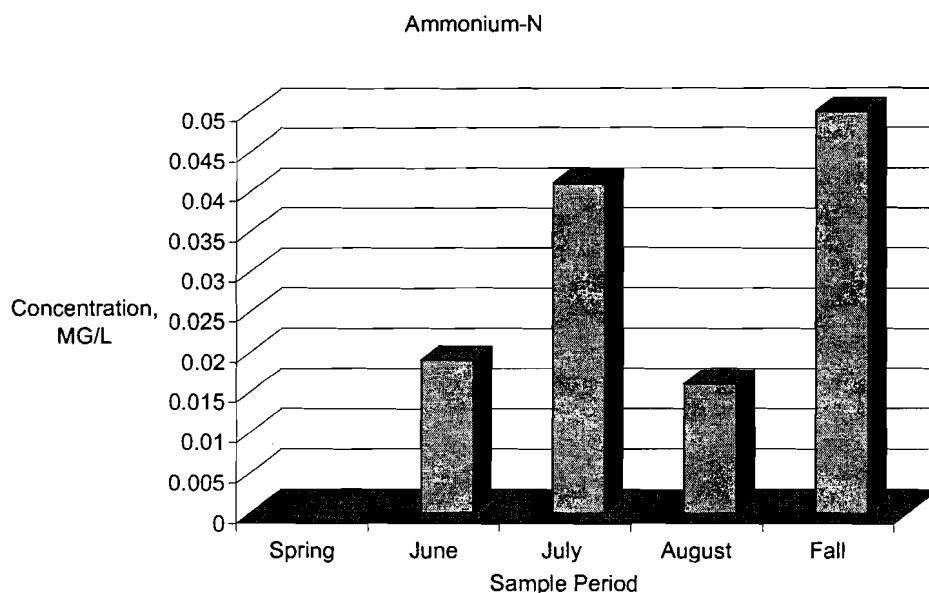
The lakes in the ecoregion range from 0.6 to 1.2 MG/L for total Kjeldahl N and <0.01 MG/L for nitrate plus nitrite for summer averages. Big Wood Lake had concentrations in this range for the summer readings. The following chart show the values of Total Kjeldahl N.



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



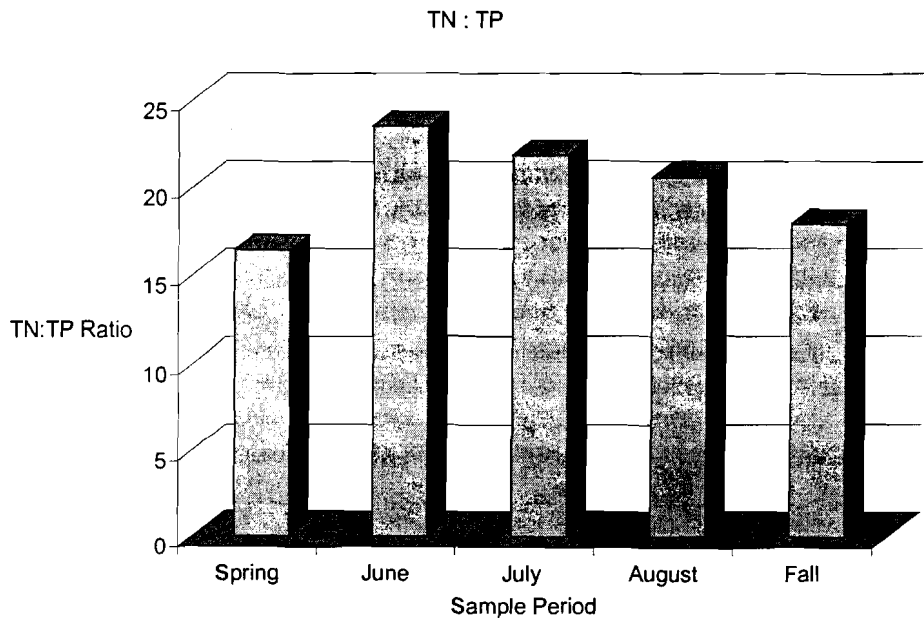
The increase in nitrate plus nitrite is due to the high concentrations of ammonium. Ammonium is released from decomposing plant material at the bottom of the lake throughout the summer when oxygen levels are low. During turnover, the water from the bottom is allowed to mix with the surface water and 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.

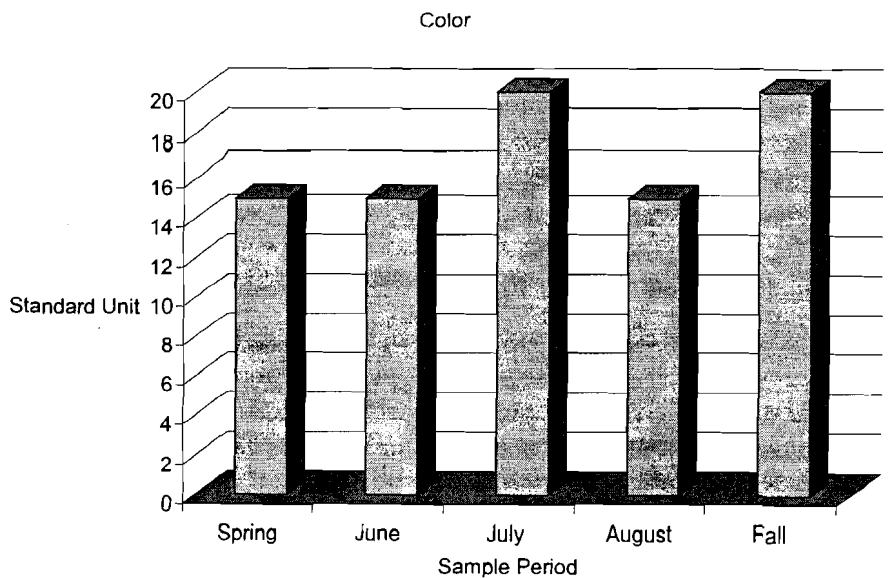


Water Clarity

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.

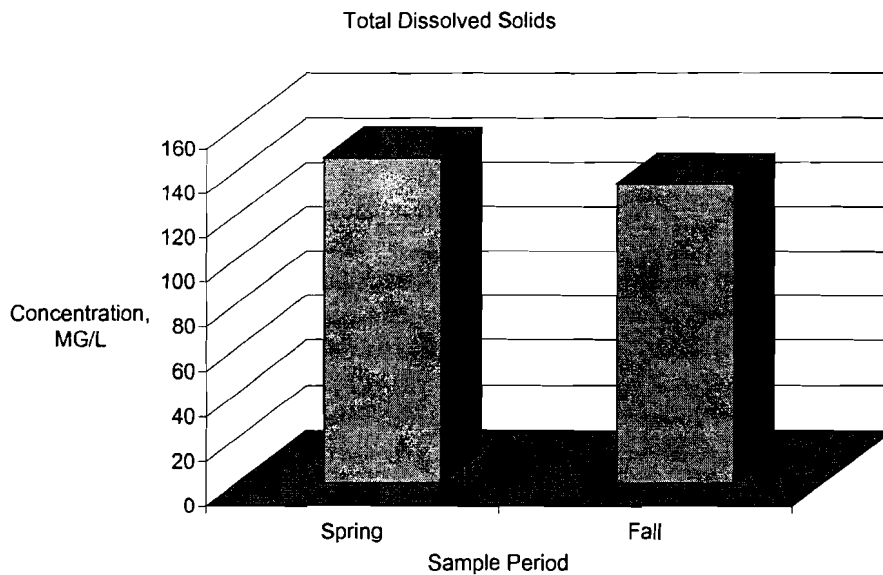
True Color

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.

