Winlsow Homer: *Boy Fishing*, 1892

Comprehensive Lake Management Plan for Big Bear Lake, Burnett County, Wisconsin

June 2003

Prepared by Steve McComas, Blue Water Science

with contributions from Wisconsin Department of Natural Resources and the Big Bear Lake Association

Funded in part by the Wisconsin Lake Management Planning Grants Program

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Big Bear Lake Management Report

Summary

prepared by Steve McComas, Blue Water Science

Big Bear Lake is a 189 acre lake located in Burnett County, Wisconsin with an average depth of 9 feet and a maximum depth of 17 feet. A comprehensive lake management study was conducted in 2002. The results and recommendations are shown below.

Goals

The goals of this project were:

* to examine existing lake conditions.
* to develop a lake management plan that protects, maintains, and enhances Big Bear Lake water quality.

Geology and Soils

Big Bear Lake is a glacial lake formed during the last retreat of the Superior glacial lobe starting about approximately 16,000 years ago. The sediments deposited by the glacier are primarily sands and subsequently, loamy sand soils have developed.

Watershed Characteristics

The lake's watershed area which is the area that drains to Big Bear is approximately 900 acres in size. Land use is primarily forest and wetlands, with developed land (urban) accounting for only about 5% of the total. The watershed is almost five times larger than the lake area. This is normal for glacial lakes. Web Lake may contribute some water to Big Bear as well.

Dissolved Oxygen and Temperature

Big Bear Lake does not strongly thermally stratify during the summer meaning the lake water is mixed through the summer and the temperature is about the same from top to bottom. Oxygen concentrations are found throughout the water column in summer.

Lake Nutrients

Phosphorus concentrations in Big Bear Lake are low (around 10 parts per billion) which is a desirable feature because low nutrients will keep the algae growth down as well. Maintaining these low lake nutrient levels should be a primary goal for the Big Bear Lake Association.

Aquatic Plants

There are fair stands of emergent vegetation in shallow water near the shoreline which is beneficial as a filter for nutrients and as well as for fish and wildlife habitat. Submerged plant distribution is good covering over 80% of the lake bottom. Low lake soil fertility may also be a factor in limiting nuisance plant growth.

Fish

A fish survey was conducted in the summer of 2002 with the help of lake association volunteers. Northern pike were found to be small and underweight. A surprise was the abundant crappie population. Sunfish numbers were fair and largemouth bass were scarce. There appears to be a lack of forage fish in Big Bear. Overall the fish community is in fair shape although the northern pike and the largemouth bass populations could be improved.

Lake Report Card

- Lake water chemistry results are comparable to and in some cases better than Ecoregion values. This is an outstanding feature of Big Bear Lake. It receives an "A" grade.
- The data base does not go back far enough to examine trends, however Big Bear Lake is in good shape at this time in regard to lake clarity.

What Will Big Bear Lake Look Like in the Future?

- Future lake water quality predictions can be made based on changes that could occur in the watershed. Often water quality in lakes decline as development occurs.
- For Big Bear Lake, the model predicted a future lake concentration of 15 ppb of phosphorus. The actual lake phosphorus level was 12 ppb in 2002. Future lake water quality is expected to remain the same assuming there is only moderate future development.

Recommended Lake Management Projects

The challenge for Big Bear Lake is to maintain the high water quality values currently experienced. Four program areas are recommended for maintaining good water quality conditions.

1. Shoreland Protection and Landscaping Projects

Controls are in place at the county level to guide new shoreland development and redevelopment. Meanwhile vegetative buffers should be maintained along the shoreline.

2. Fish Management Options

The fish management program is based on findings from the 2002 fish survey combined with results of the lake resident survey indicating fishery preferences and perceived problems.

The objective of the fish management program is to improve the quality of the northern pike population while not adversely impacting the panfish.

It appears the main factor contributing to skinny northerns is a lack of forage. Its possible that the surprisingly robust crappie population is probably competing with northerns for forage . . . and winning.

One approach is to concentrate fishing on crappies. Although stocking white suckers as an additional forage species for northern pike was considered, it probably would not be successful in Big Bear Lake.

Lastly, we recommend dissolved oxygen testing in January and February to check the possibility of a potential fish winterkill. At this time there is no indication of winterkill occurring in Big Bear Lake.

3. Aquatic Plant Management

Aquatic plants are the key to maintaining good water quality in Big Bear Lake. Coverage is currently over 80% of the lake bottom, but they do not grow to nuisance conditions. It is recommended aquatic plants should be protected, and if removal is necessary for swimming areas, remove the minimum needed.

4. Future Lake Monitoring Plans

A lake monitoring program is outlined in Table 1. It is designed to be flexible to accommodate the volunteer work force and a fluctuating budget.

Table 1. Big Bear Lake Water Quality Monitoring Program

Category	Level	Alternative	Labor Needed	Cost/Year
A. Dissolved oxygen	1	Check dissolved oxygen in Big Bear Lake every two weeks in January, February, and March depending on winter conditions.	Moderate	$0
	2	Check dissolved oxygen in Big Bear Lake every one to two weeks in December, January, February, and March, depending on winter conditions.	Moderate	$0
B. Water clarity	1	Secchi disc taken at spring and fall turnover.	Low	$0
	2	Secchi disc monitoring once per month May - October.	Low-moderate	$0
	3	Secchi disc monitoring twice per month, May - October.	Moderate	$0
C. Water chemistry	1	Spring and fall turnover samples are collected and sent to UW-Stevens Point. Selected parameters for analysis include: TP and chlorophyll.	Low	$200
	2	Spring and fall turnover samples are collected and sent to UW-Steven Point. Standard package of parameters is analyzed.	Low	$600
	3	Sample for phosphorus and chlorophyll once per month from May - September (surface water only).	Low-moderate	$300
	4	Sample for phosphorus and chlorophyll twice per month from May - October.	Moderate	$600
	5	Sample for phosphorus, chlorophyll, Kjeldahl-N, nitrate-nitrite-N, and ammonia-N once per month (May-October)	Moderate	$960
	6	Sample for phosphorus, chlorophyll, Kjeldahl-N, nitrate-nitrite-N, and ammonia-N twice per month (May-October).	Moderate	$1,920
D. Special samples or surveys	1	Special samples: suspended solids, BOD, chloride, turbidity, sampling bottom water, and other parameters as appropriate. Aquatic plant surveys, etc.	--	$50+

For 2004, a recommended program consists of Level A1 every three years, Level B2 annually, Level C1 annually and an aquatic plant survey (Level D1) every three years.

1. Introduction and Project Setting

Big Bear Lake is located in Burnett County, Wisconsin (Figure 1) and is 189 acres in size. Big Bear Lake characteristics are shown in Table 1.

The objectives of this study were to characterize existing lake conditions and to make recommendations to protect and improve the lake environment where feasible.

Table 1. Lake statistics.

	Big Bear Lake
Size (acres)	189
Mean depth (ft)	9
Maximum depth (ft)	17

Figure 1. Big Bear Lake is located in Burnett County, Wisconsin.

2. Glaciers and Soils

Big Bear Lake was formed approximately 10,000 years ago during the last glacial retreat of the Superior Lobe (Figure 2). The soils deposited by the Superior Lobe glacier were primarily sands and loamy-sands (Figure 3). Beneath these soils, at depths of about 50-350 feet, is Precambrian bedrock that is over one billion years old. The bedrock is referred to as the North American shield.

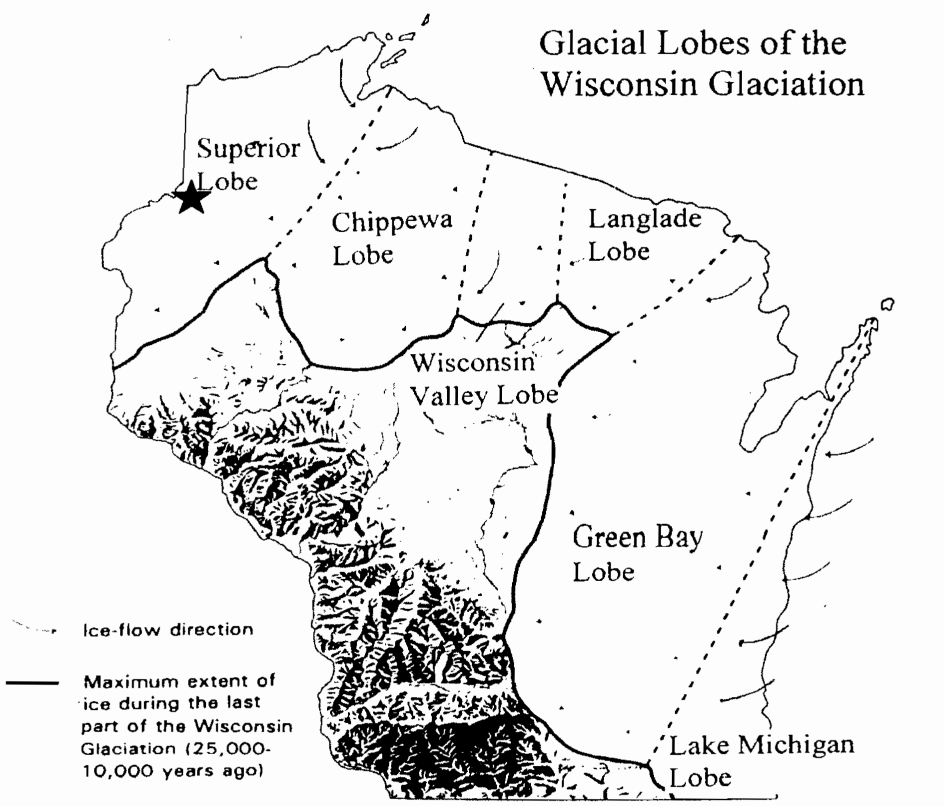


Figure 2. Glacial lobes of the Wisconsin glaciation. Big Bear Lake is located in the Superior lobe.

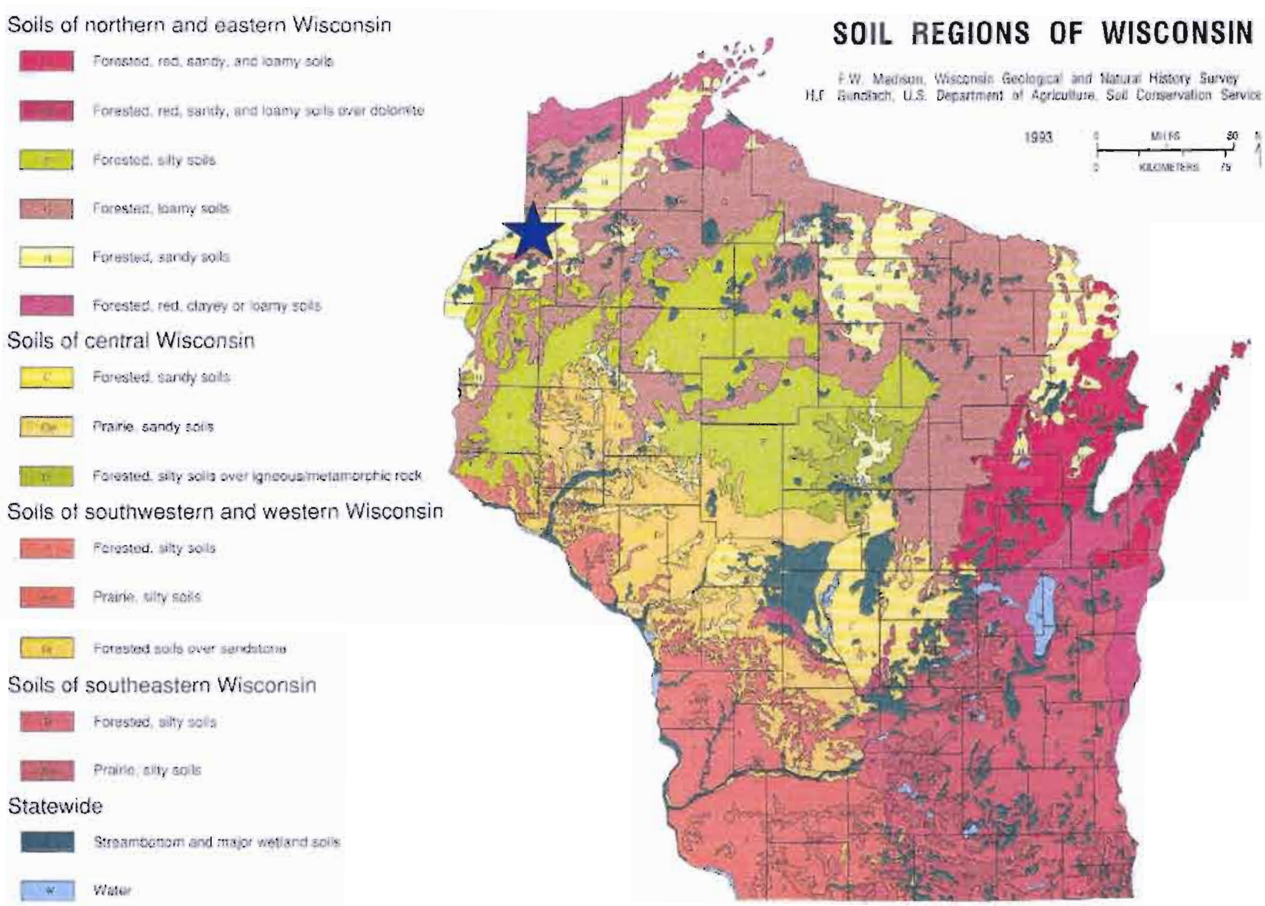


Figure 3. Big Bear Lake is located in a soils group referred to as forested sandy soils.

3. Watershed Features

3.1. Drainage Area to Big Bear Lake

The drainage area, which is the land area that drains to Big Bear Lake, is about 900 acres in size.

The drainage area to Big Bear Lake is displayed in Table 2 and is shown in Figure 4. The size of the watershed that drains to Big Bear is typical for northern Wisconsin glacial lakes.

Table 2. Watershed area for Big Bear Lake (prepared by Blue Water Science).

	Big Bear
Lake Size (ac)	189
Total Contributing Watershed Area (not including lake)(ac)	900

The drainage area to Big Bear Lake is dominated by forests and wetlands. The forests have been clear-cut at least once in the last 150 years, but have grown back and existing conditions are dominated by undeveloped land use. This condition allows the potential for good water quality to run off the land and into the lake, thus sustaining good water quality in the lake as well.

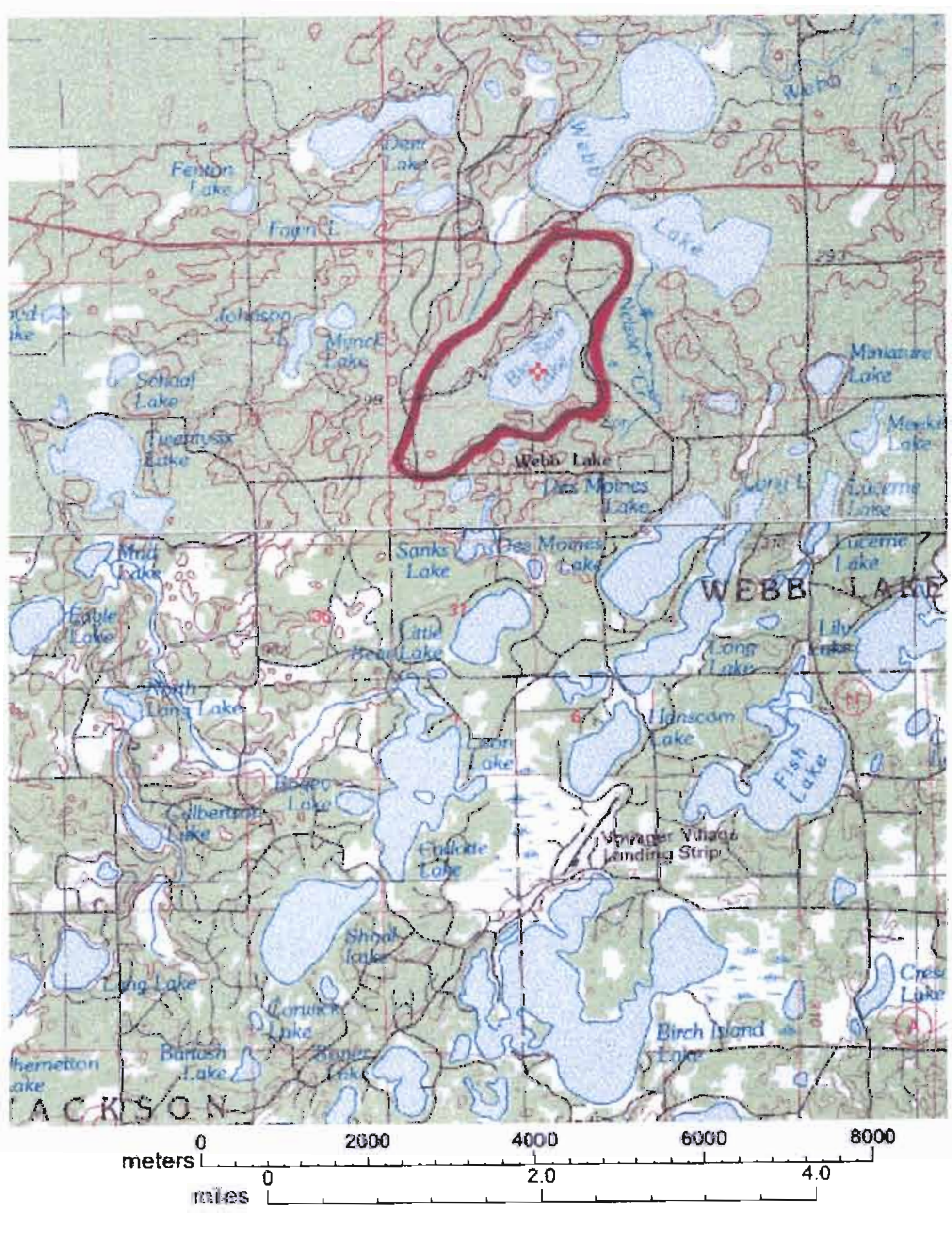


Figure 4. Watershed area for Big Bear Lake.

3.2. Source of Water to Big Bear Lake

Source of water to Big Bear Lake is from several sources that includes groundwater that seeps into the lake from fringe wetlands, from surface runoff, and from rainfall. The amount of water flowing into and out of Big Bear Lake is estimated to be about 1.1 cubic feet per second. Flows were estimated based on runoff amounts listed for Burnett County in the Wisconsin Spreadsheet Lake Model (Table 3).

Table 3. Average annual water flow into Big Bear Lake.

Watershed size (acre)	900
Average yearly runoff for Burnett County (inches)	10.8
Total water inflow (acre-feet)	810

***810 acre-feet would be enough water to fill a 790 foot deep swimming pool the size of a football field. It would also be enough drinking water to supply a town of 10,000 for a year.**

Although this is a lot of water coming into Big Bear Lake, the volume of Big Bear Lake is 1,700 acre-feet. If Big Bear Lake completely dried up, it would take 2 years to fill.

Figure 5. Jeff Henderson, Big Bear Lake, observes inflowing water to Big Bear Lake. The surface inflow is one source of water, but rainfall and groundwater are larger water sources.

3.3. Sources of Nutrients to Big Bear Lake

All lakes receive nutrients from a variety of sources. The challenge is to minimize the amount of phosphorus and nitrogen inputs to Big Bear in order to minimize algae blooms.

Currently, low levels of nutrients enter Big Bear Lake. The dominant nutrient source is rainfall. About 60 pounds of phosphorus per year falls into Big Bear (a little less than ½ pound per lake acre). Nutrients in runoff from the surrounding land contributes about 50 pounds per year.

The long term challenge will be to continue to keep the amount of nutrient inputs to Big Bear low.

Figure 6. An inflowing stream to Big Bear Lake has low nutrient concentrations which is desirable for maintaining low fertility in Big Bear.

3.4. Shoreland Inventory

The shoreland area encompasses three components: the upland fringe, the shoreline, and shallow water area by the shore. A photographic inventory of the Big Bear Lake shoreline was conducted on September 11, 2002. The objectives of the survey were to characterize existing shoreland conditions which will serve as a benchmark for future comparisons.

For each photograph we looked at the shoreline and the upland condition. Our criteria for natural conditions were the presence of 50% native vegetation in the understory and at least 50% natural vegetation along the shoreline in a strip at least 15 feet deep. We evaluated shorelands at the 75% natural level as well.

A summary of the inventory results is shown in Table 4. Based on our subjective criteria over 71% of the parcels in Big Bear Lake shoreland area meet the natural ranking criteria shorelines and upland areas. This is good for a lake in northern Wisconsin. However in the next 10 years there could be pressure to reduce natural conditions. Proactive volunteer native landscaping should maintain existing conditions and improve other parcels.

Table 4. Summary of buffer and upland conditions in the shoreland area of Big Bear Lake. Approximately 87 parcels were examined.

Big Bear Lake	Natural Shoreline Condition		Natural Upland Condition		Undevel. Photo Parcels	Shoreline Structure Present	
	>50%	>75%	>50%	>75%		riprap	wall
TOTALS (no. of photos = 87)	75 (86%)	66 (76%)	82 (71%)	54 (62%)	11 (13%)	7 (8%)	1 (1%)

Examples of shoreland conditions around Big Bear are shown in Figure 7.

A comparison of Big Bear Lake conditions to other lakes in Wisconsin and Minnesota is shown in Figure 8.

Figure 7. [top] This parcel would rate as having a shoreline with a buffer greater than 50% of the lot width and an understory with greater than 50% natural cover.
[bottom] This parcel would not qualify as having a natural shoreline buffer greater than 50% of the lot width. Also understory in the upland area would be rated as having less than 50% natural cover.

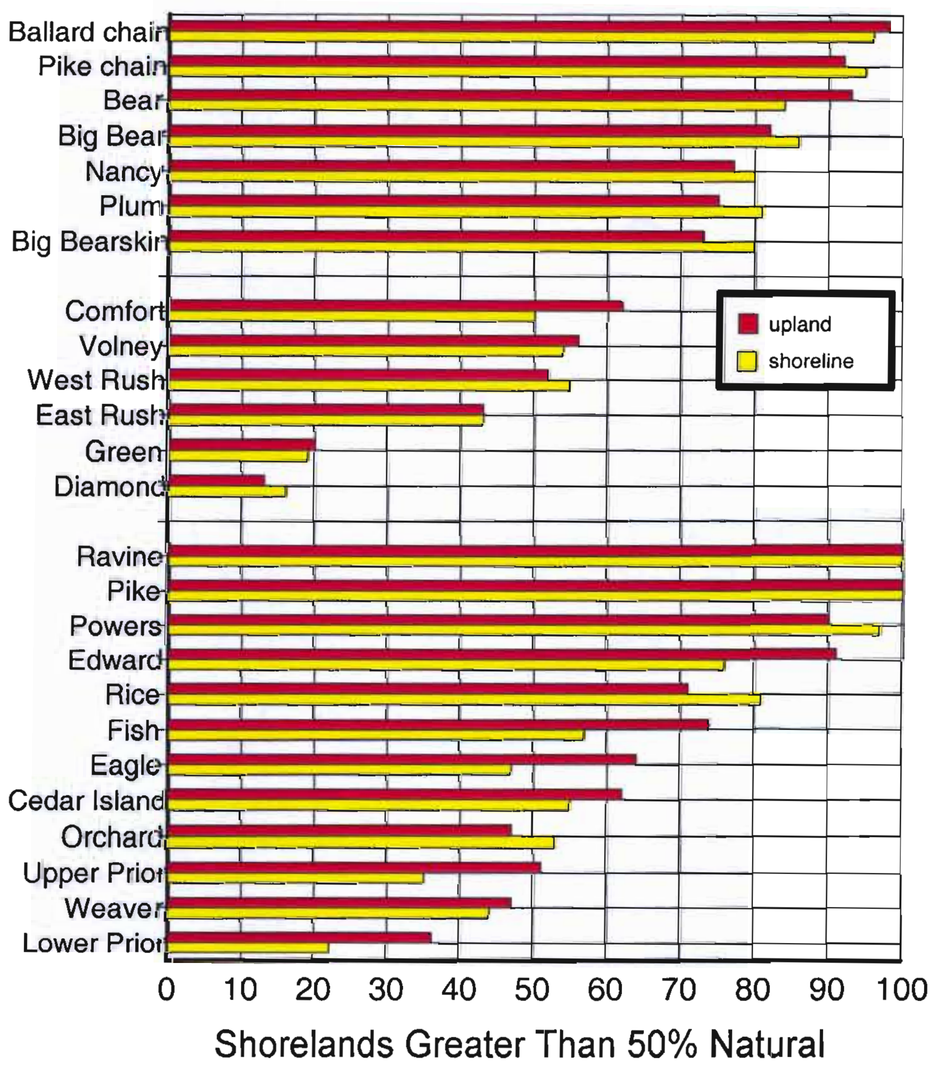


Figure 8. A summary of shoreland inventory results for 25 lakes using an evaluation based on shoreland photographs. For each lake the percentage of shoreline and upland conditions with greater than 50% natural conditions is shown.

3.5. Groundwater and Onsite Wastewater Treatment Systems

Groundwater inflow was evaluated indirectly by measuring lake water conductivity in the shallow nearshore area. The objective was to see if there was any change in conductivity. An increase or decrease in conductivity could indicate the inflow of groundwater. The groundwater could be coming from natural flows or from septic tank drainfields.

Specific conductance or conductivity is a measure of dissolved salts in the water. The unit of measurement is microSiemans/cm^2 or micro umhos/cm^2 . . . both are used. The saltier the water the higher the conductivity. For example oceans have higher conductivity than fresh water. For the conductivity survey on Big Bear Lake we used a YSI (Yellow Springs Instruments) probe attached to the end of an eight-foot pole. The survey used two people. One person held the probe under the surface of the water and recorded the reading off of a conductivity meter while the other person maneuvered the boat around the perimeter of Big Bear Lake.

Results are shown in Figure 10. The background or base conductivity was 63 umhos/cm. Several areas around Big Bear Lake had readings above background. However, because of a lack of homes or because the homes are far removed from the lakeshore, it does not appear that the elevated conductivity is from septic leachate discharges entering Big Bear Lake. Rather, the results suggest that Big Bear Lake may be receiving groundwater inflows that have slightly elevated conductivity concentrations. There is a location by the wetland that has low conductivity. This could be a source of groundwater into Big Bear Lake.

Figure 9. The submerged probe used in the conductivity survey is shown here. The entire nearshore area of Big bear Lake was surveyed.

Wetland on the southwest side of the lake appeared to be an area of groundwater inflow.

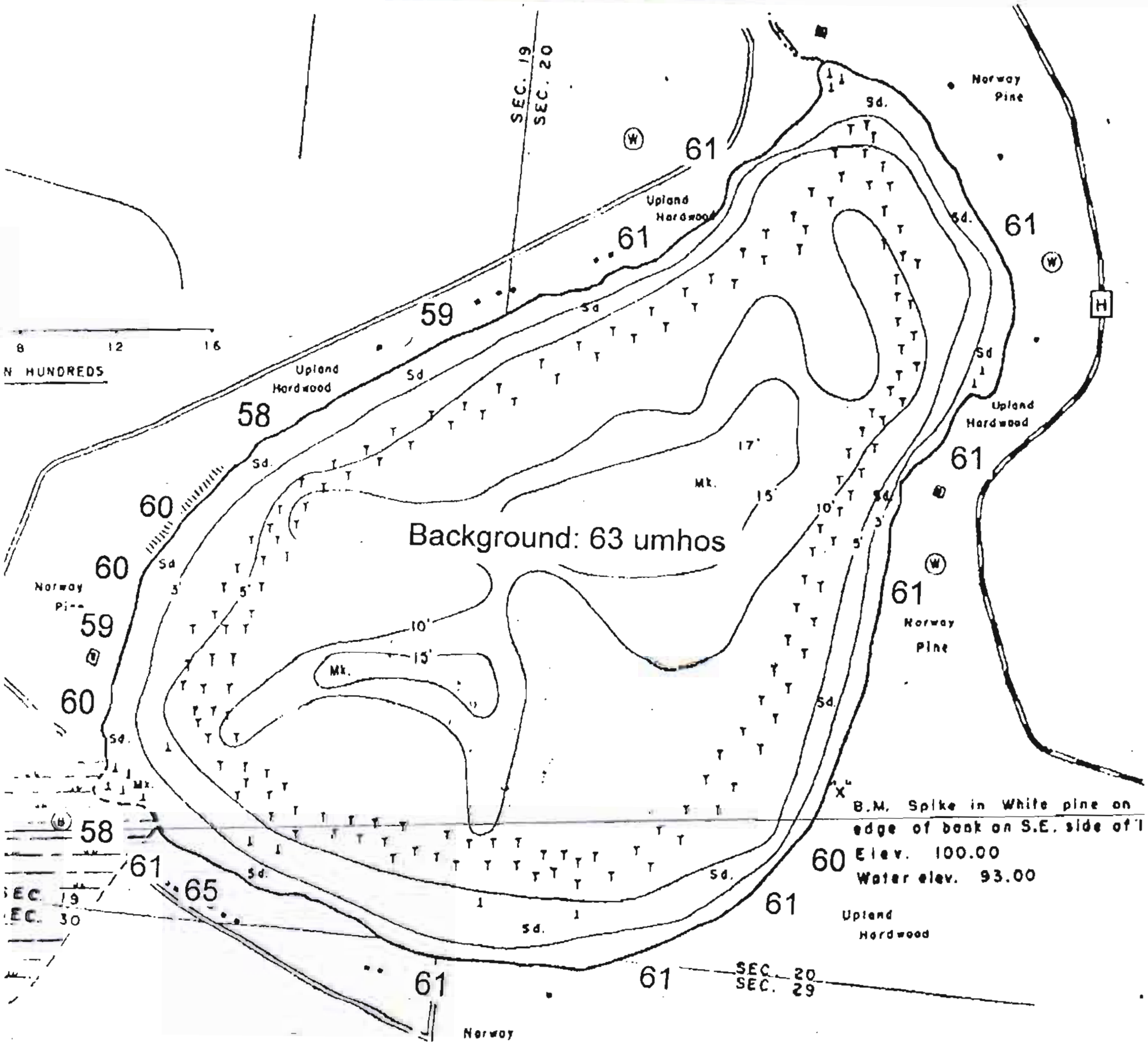


Figure 10. Big Bear Lake conductivity survey results for September 13, 2002.

Onsite Systems Status: Onsite systems appear to be in mostly good condition based on the conductivity survey results, the surrounding soils, and the setback of the cabins and homes. A conventional onsite system is shown in Figure 11. With proper maintenance (such as employing a proper pumping schedule) onsite systems are an excellent wastewater treatment option. The challenge is to maintain systems in good working condition.

Sewage bacteria break up some solids in tank. Heavy solids sink to bottom as sludge. Grease & light particles float to top as scum. Liquid flows from tank through closed pipe and distribution box to perforated pipes in trenches; flows through surrounding crushed rocks or gravel and soil to ground water (underground water). Bacteria & oxygen in soil help purify liquid. Tank sludge & scum are pumped out periodically. Most common onsite system.

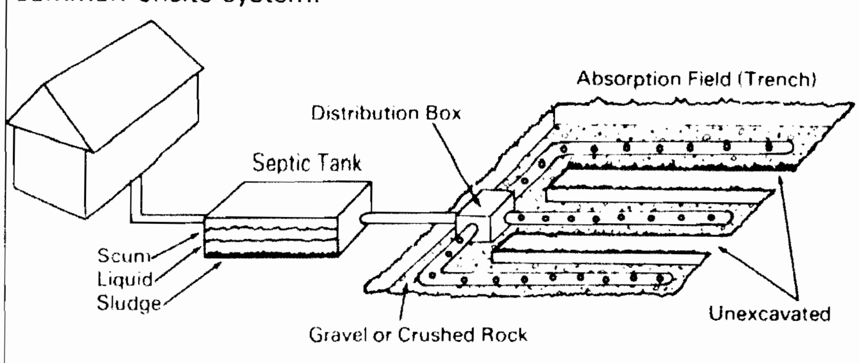


Figure 11. Typical onsite wastewater treatment system found in the Big Bear Lake watershed.

3.6. Big Bear Lake Wildlife Observations

A wide variety of wildlife are present in the Big Bear Lake area. A summary of wildlife observations in 2002 by lake volunteers is shown in Table 5.

Table 5. Summary of observations of wildlife made from the Houck property on Big Bear Lake in 2002. The wildlife was either observed on the property or observed on the lake from the property (submitted by Dean and Carolyn Houck).

Animals Observed

Animal	Time Frame
Black Bear (sub-adult)	May 4th, May 26th
Chipmunk	Spring - Fall
Gray Squirrel	Spring - Fall
Raccoon	Summer
Red Fox	April 7th
Red Squirrel	Spring - Fall
White Tail Deer	All Year
Wolverine	April 7th

Birds Observed

Bird	Time Frame
Bald Eagle	Spring - Fall
Baltimore Oriole	Summer
Belted Kingfisher	April
Black-capped Chickadee	Spring - Fall
BlueJay	Spring - Fall
Canada Goose	Spring - Fall
Common Crow	Spring - Fall
Common Merganser (Duck)	Spring
Downy Woodpecker	Spring – Fall
Golden Eye (Duck)	Spring
Goldfinch	Spring - Fall
Great Blue Heron	Spring - Fall
Gull (type ?)	Spring - Fall
Hairy Woodpecker	Spring
Hooded Merganser (Duck)	Spring
House Finch	Spring
Junco	Spring - Fall
Loon	Spring - Fall
Osprey	Spring - Fall
Pileated Woodpecker	Spring
Red Bellied Woodpecker	Spring
Red Crossbill	Spring
Robin	Spring
Ruby Throated Hummingbird	Spring - Summer
Ruffed Grouse	Spring
Tree Swallow	Summer
White Breasted Nuthatch	Spring - Fall
Wild Turkey (flock of 16)	September 30th
Wood Duck	Spring
Yellow-shafted Flicker	Spring

3.7. Watershed Synopsis

The watershed area that drains to Big Bear Lake is dominated by wilderness areas and is composed primarily of forests and wetlands.

Questions have been raised by lake users about the water quality coming into Big Bear Lake. Results of water testing indicate water coming into Big Bear Lake is typical for the region and is not polluted. Acceptable levels of nutrients are entering Big Bear Lake at the present time (Figure 12).

The challenge will be to maintain the natural attributes of the watershed which will keep watershed nutrient inputs low which will aid in preserving good lake water quality.

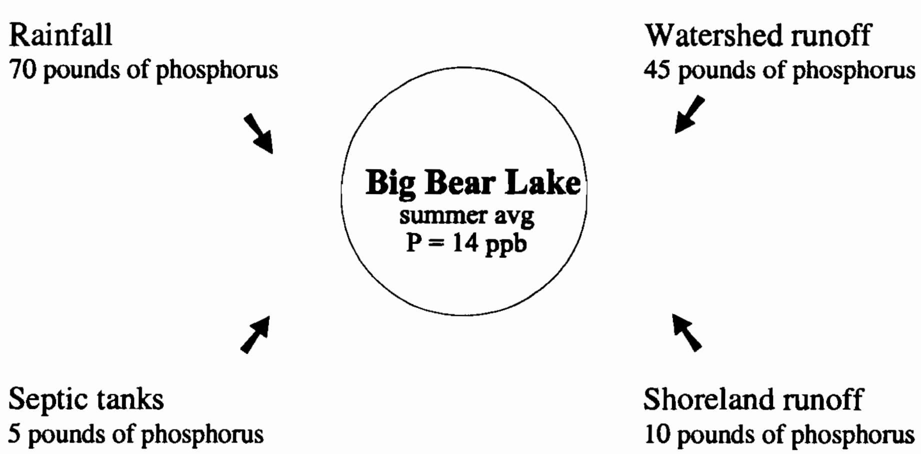


Figure 12. Estimated sources of phosphorus that feed into Big Bear Lake are shown above.

4. Lake Features

4.1. Lake Map and Lake Statistics

Big Bear Lake is approximately 189 acres in size, with a watershed of 900 acres. The average depth of Big Bear Lake is 2.7 meters (9 feet) with a maximum depth of 5.2 meters (17 feet) (Table 6). A lake contour map is shown in Figure 13. Big Bear Lake is located in an area of Wisconsin that is dominated by forests.

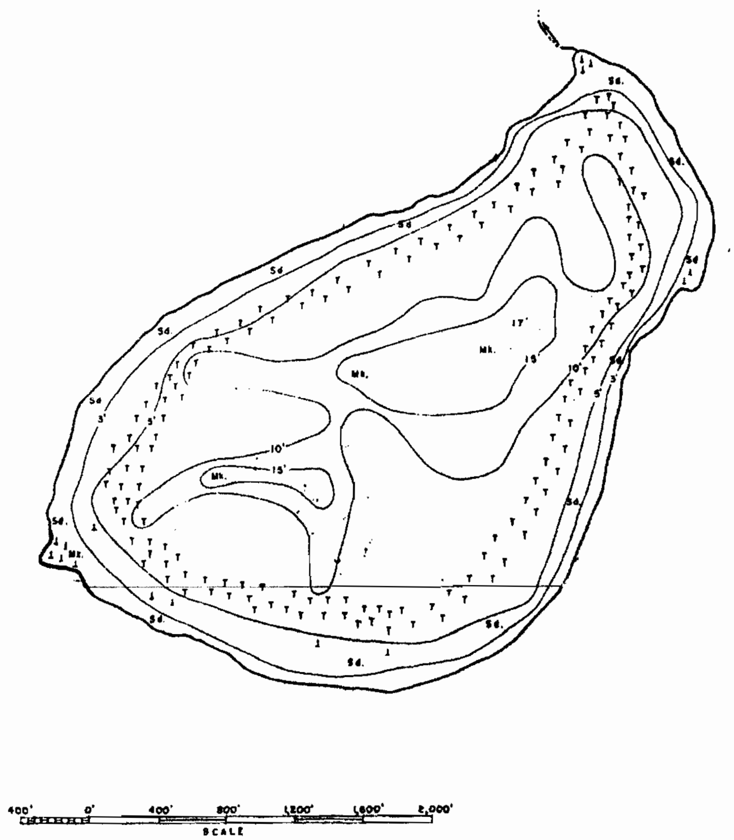


Figure 13. Big bear Lake contour map.

Table 6. Big Bear Lake Characteristics

Area (Lake):	189 acres (76 ha)
Mean depth:	9 feet (2.7 m)
Maximum depth:	17 feet (5.2 m)
Volume:	1,701acre-feet
Watershed area:	900 acres
Watershed: Lake surface ratio	4:1
Accesses (#):	1
Inlets: 1	Outlets: 0

4.2. Dissolved Oxygen and Temperature

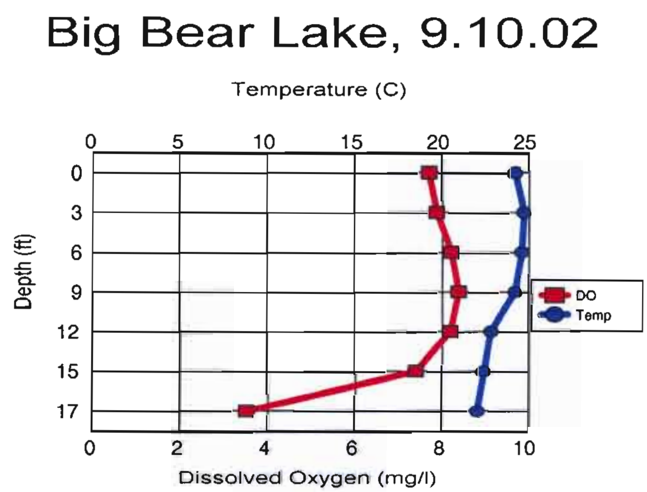
The summer dissolved oxygen and temperature profiles in Big Bear Lake in 2002 are shown in Figure 14.

One profile was obtained for the month of September, 2002 is shown in Figure 14. By examining the profiles, one can learn a great deal about the condition of a lake and the habitat that is available for aquatic life.

The September profile showed that the lake was not thermally stratified in 2002. **Thermally stratified** means that the water column of the lake is segregated into different layers of water based on their temperature. Just as hot air rises because it is less dense than cold air, water near the surface that is warmed by the sun is less dense than the cooler water below it and it "floats" forming a layer called the *epilimnion*, or *mixed layer*. The water in the epilimnion is frequently mixed by the wind, so it is usually the same temperature and is saturated with oxygen.

Below this layer of warm, oxygenated surface water is a region called the *metalimnion*, or *thermocline* where water temperatures decrease precipitously with depth. Water in this layer is isolated from gas exchange with the atmosphere. The oxygen content of this layer usually declines with depth in a manner similar to the decrease in water temperature.

Below the thermocline is the layer of cold, dense water called the *hypolimnion*. This layer is completely cut off from exchange with the atmosphere and light levels are very low. So, once the lake stratifies in the summer, oxygen concentrations in the hypolimnion progressively decline due to the decomposition of plant and animal matter and respiration of benthic (bottom-dwelling) organisms.



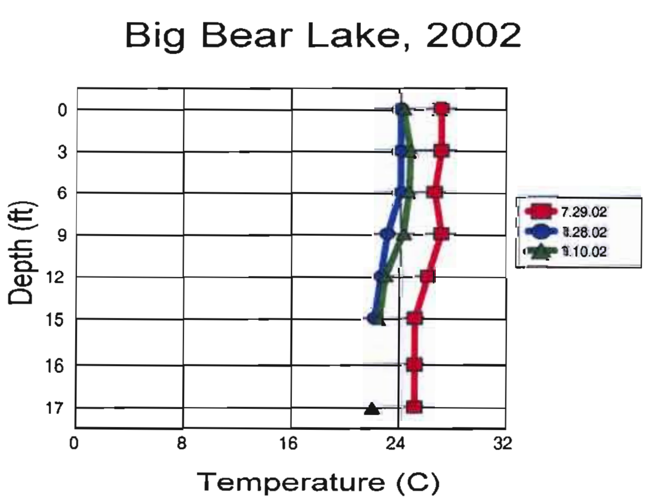


Figure 14. [top] Dissolved oxygen (DO)/temperature profile for September 2002. Dissolved oxygen data are shown with squares and temperature with circles.
[bottom] Temperature profiles are shown for July, August, and September.

4.3. Lake Water Quality Summary

Summer water chemistry data collected during 2002 included secchi disc, total phosphorus (TP), chlorophyll a (Chl a), and conductivity (Table 7). Samples were collected at the surface once per month from May through September and two feet off the bottom in the deepest area of Big Bear Lake once in September.

Table 7. Summer monitoring results for Big Bear Lake.

2002	5.25	6.25	7.29	8.28	9.10	Ave
Secchi disc (ft)	15	15	8.5	10.8	10	12
Total phosphorus (ppb) - top	<10	10	11	11	<10	10
Total phosphorus (ppb) - bottom					<10	--
Chlorophyll a (ppb)	<1	<1	2	2	2	2
Temperature ©) - top			27	24	24.2	25
Temperature ©) - bottom			25	22	22.4	23
Dissolved oxygen (ppm) - top					7.69	--
Dissolved oxygen (ppm) - bottom					3.5	--
Conductivity			70	62		66

4.3.1. Secchi Disc Transparency

The Secchi disc transparency in Big Bear Lake had an average summer depth of 12 feet in 2002. This is good water clarity and about average for this part of the state (based on ecoregion averages).

The Secchi transparency has consistently been between 8-15 ft since 1995 (Figure 15), which is a good indication that the lake is not being degraded. Continued protection of the lake and its watershed should ensure clean, clear water for the future.

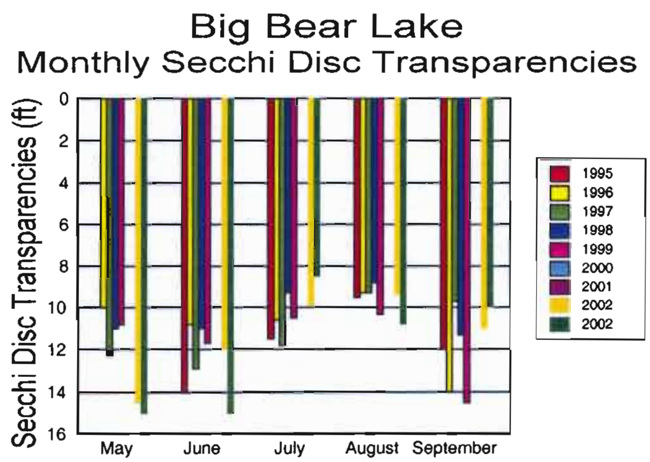


Figure 15. Monthly Secchi disc readings from 1995-2002.

Figure 16. Water quality monitoring, such as Secchi disc readings, help check the health of Big Bear Lake.

4.3.2. Phosphorus

Samples were collected at the surface in May, June, July, August, and September for Big Bear Lake. Through the summer, lake phosphorus concentrations were low, averaging 10 parts per billion (Figure 17). Total phosphorus was the same in the bottom water as in the top water in September indicating little phosphorus release from the bottom material (sediments or plants) may be occurring.

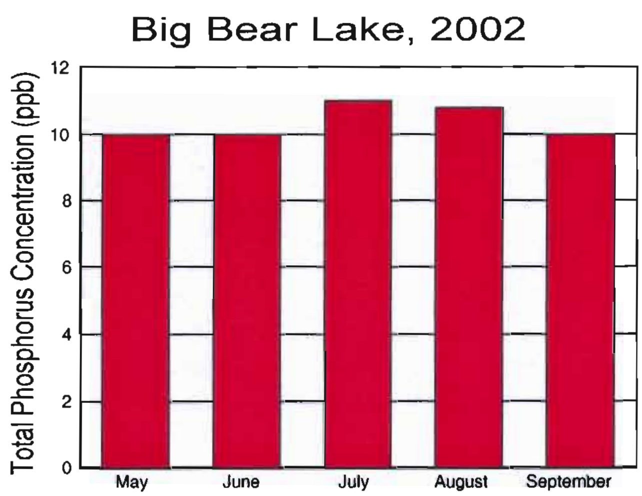


Figure 17. Monthly phosphorus concentrations for Big Bear Lake in 2002.

4.3.3. Chlorophyll and Algae

Algae are small green plants, often consisting of single cells or grouped together in filaments (strings of cells). The amount of algae in lake water can be estimated by measuring the amount of chlorophyll in the water. Open water concentrations of algae were very low in Big Bear. The highest chlorophyll reading under 3 parts per billion (ppb), and other readings coming in at 2 ppb or less (Figure 18). Low algae in the water column results from low phosphorus in the water column . . . a desirable condition.

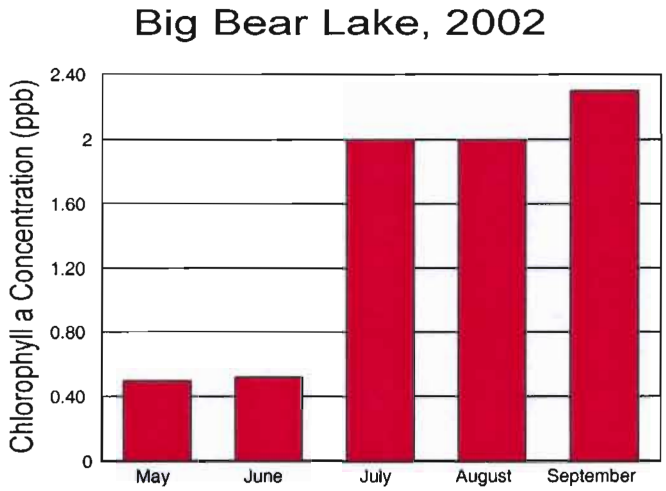


Figure 18. Monthly chlorophyll concentrations for Big Bear Lake in 2002.

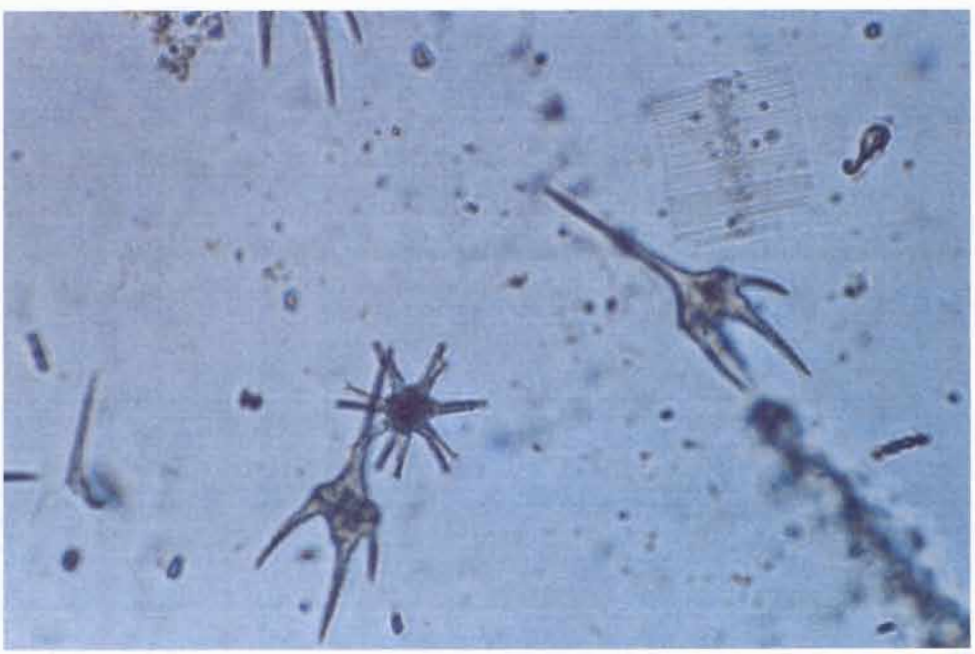


Figure 19. The open water algal conditions in Big Bear Lake on August 26, 2002 consisted of ceratium (shown above) and a lot of diatoms (also shown above)(magnified 400 times).

4.4. Zooplankton and Other Invertebrates

Zooplankton are small crustaceans that can feed on algae. Examples of zooplankton from Big Bear Lake are shown in Figure 20. Because algae in Big Bear are dominated by "good" algae, generally non-bloom forming species they are edible by the lake's zooplankton. The zooplankton community is typical for clear water lakes in northern Wisconsin. In the photos below (Figure 20), images are magnified 150 times.

Figure 20. Two examples of zooplankton species from Big Bear Lake in 2002. The animal on the left is *Daphnia*, a relatively large zooplankton (1-2 mm in length) that feeds on algae. The animal on the right is a copepod (zooplankton magnified 150 times).

Zooplankton were sampled monthly in 2002 and results of the species and their densities were found to be consistent for high quality, clear water conditions (Table 8).

Table 8. Monthly zooplankton counts for 2002. Numbers represent number of organism per liter.

	5.25	6.25	7.29	8.26	9.10
Cladocerans	42	21	15	8	3
Big daphnia	5	8	1	0	0
Little daphnia	23	13	8	6	1
Daphnia (retrocurva)	0	0	5	2	1
Ceriodaphnia	0	0	0	0	0
Bosmina	14	0	1	0	1
Copepods	102	30	63	78	35
Calonoids	35	16	45	18	19
Cyclophoids	16	3	7	37	10
Nauplii	51	11	11	23	6
Rotifers	241	22	53	54	68
TOTAL	385	73	131	140	106

4.5. Aquatic plant status

Aquatic plants are very important to lakes. They act as nurseries for small fish, refuges for larger fish, and they help to keep the water clear. Currently Big Bear Lake has a wide diversity of aquatic plants but with a non-nuisance condition (Figure 21).

The coverage of aquatic plants over the lake bottoms for Big Bear Lake is shown in Figure 22.

A sonar with recording paper graph (Lowrance X16) was used to determine depth of plant growth and canopy characteristics. For Big Lake, the deepest depth of plant growth is 14 feet.

Figure 21. Example of diversity of aquatic plants found in Big Bear Lake.

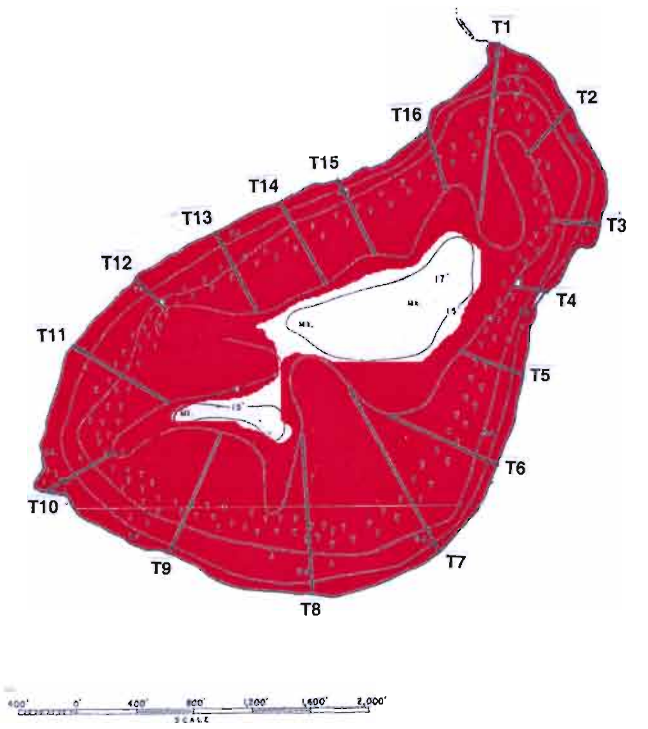


Figure 22. Big Bear Lake aquatic plant coverage based on the 2002 survey conducted by Blue Water Science.

Aquatic plants were checked on 16 transects spaced around Big Bear Lake and results are shown in Table 9.

A summary of aquatic plant statistics is shown in Table 10. The frequency of aquatic plant occurrence and their density is shown in Table11.

Table 9. Individual transect data for Big Bear Lake, September 13, 2002.

	T1		T2		T3		T4		T5		T6		T7		T8	
	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12
Bulrush					0.5											
Cattails													0.5			
Watershield	0.5														0.5	
Spatterdock															0.5	
White lilies	0.5															
Marigold								0.5								
Coontail	0.5												0.5			1
Chara													0.5			0.5
Elodea	1	0.5				0.5				0.5				0.5		
Quillwort			0.5				0.5		0.5		1		1		0.5	
Northern watermilfoil														1		
Naiads		1	0.5	1						0.5	0.5	1.5				1
Cabbage	1			0.5	0.5					0.5	0.5	0.5	1		0.5	1
Variable pondweed			1		0.5		0.5		0.5		0.5					
Floatingleaf pondweed																
Claspingleaf pondweed				0.5	0.5			0.5			0.5	0.5				
Fern pondweed	3	2.5		2		1		1		1.5		1.5		2		1.5
Flatstem pondweed	1.5			0.5		0.5								0.5		
Water celery				0.5	0.5	1		0.5		0.5	0.5	1	0.5	1		1

	T9		T10		T11		T12		T13		T14		T15		T16	
	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12
Bulrush																
Cattails	0.5															
Watershield	0.5		0.5													
Spatterdock			1													
White lilies			0.5													
Marigold	0.5		0.5													
Coontail																
Chara	1				0.5				1						2	
Elodea			1													
Quillwort	0.5				0.5		1.5				1	1.5	0.5			
Northern watermilfoil			0.5													
Naiads	1			0.5		1	1	1				1		0.5		1
Cabbage	0.5	1	0.5			1		0.5						0.5		0.5
Variable pondweed					0.5				0.5		1		0.5			
Floatingleaf pondweed			0.5													
Claspingleaf pondweed					1											
Fern pondweed		3	2	1.5		1		1						1.5		2
Flatstem pondweed		0.5														
Water celery	0.5	0.5	1	0.5	1	0.5	1.5	0.5				0.5		1.5	1	

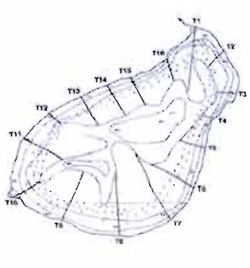


Table 10. Aquatic plant survey summary.

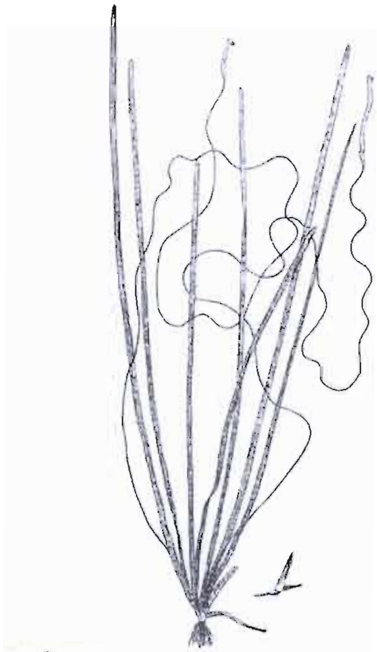
	All Stations
Number of submerged aquatic plant species found	14
Most common plant	Water celery
Rarest plant	Floatingleaf pondweed
Maximum depth of plant growth	11 feet

Table 11. Big Bear Lake (all stations) aquatic plant occurrences and densities for the September 13, 2002 survey based on 16 transects and 2 depths, for a total of 32 stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	Depth 0-6 feet (n=16)			Depth 7-12 feet (n=16)			All Stations (n=32)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Bulrush (*Scirpus sp*)	1	6	0.5	--	--	--	1	3	0.5
Cattails (*Typha sp*)	2	13	0.5	--	--	--	2	6	0.5
Watershield (*Brasenia schreberi*)	4	25	0.5	--	--	--	4	13	0.5
Spatterdock (*Nuphar variegatum*)	2	13	0.8	--	--	--	2	6	0.8
White lilies (*Nuphar spp*)	2	13	0.5	--	--	--	2	6	0.5
Marigold (*Bidens beckii*)	2	13	0.5	1	6	0.5	3	9	0.5
Coontail (*Ceratophyllum demersum*)	2	13	0.5	1	6	1	3	9	0.7
Chara (*Chara spp*)	5	31	1	1	6	0.5	6	19	0.9
Elodea (*Elodea canadensis*)	2	13	1	4	25	0.5	6	19	0.7
Quillwort (*Isoetes spp*)	11	69	0.7	1	6	1.5	12	38	0.8
Northern watermilfoil (*Myriophyllum sibiricum*)	1	6	0.5	1	6	1	2	6	0.8
Naiads (*Najas spp*)	4	25	0.8	11	69	0.9	15	47	0.9
Cabbage (*Potamogeton amplifolius*)	7	44	0.6	9	56	0.7	16	50	0.7
Variable pondweed (*P. gramineus*)	9	56	0.6	--	--	--	9	28	0.6
Floatingleaf pondweed (*P. natans*)	1	6	0.5	--	--	--	1	3	0.5
Claspingleaf pondweed (*P. richardsonii*)	3	19	0.7	3	19	0.5	6	19	0.6
Fern pondweed (*P. robbinsii*)	2	13	2.5	14	88	1.6	16	50	1.8
Flatstem pondweed (*P. zosteriformis*)	1	6	1.5	4	25	0.5	5	16	0.7
Water celery (*Vallisneria americana*)	8	50	0.8	13	81	0.7	21	66	0.8

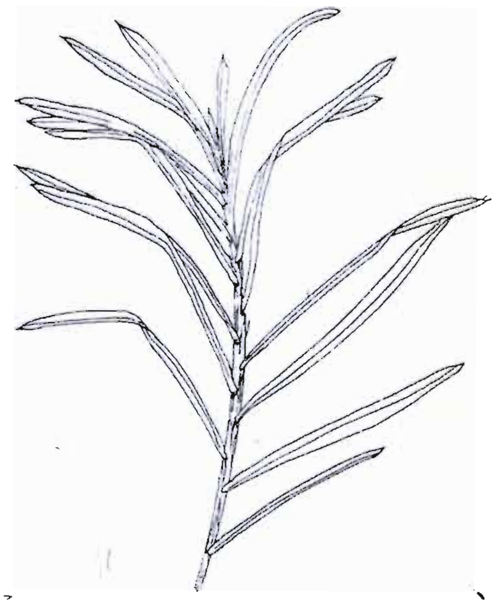
Common Plants in Big Bear Lake

Water celery



Water celery (*Vallisner ia americana*) is found in water depths.

Fern Pondweed



Fern pondweed (*Potamogeton robbinsii*) is found in all water depths.

Cabbage

Cabbage (*Potamogeton amplifolius*) is found in all water depths.

Floatingleaf Pondweed

Floatingleaf pondweed (*Potamogeton natans*) is found only in the shallow depths.

4.6. Fishery Status

The fishery status of Big Bear Lake as evaluated in 2002. A fish survey using six trapnets for four days was conducted on Big Bear Lake from September 11-14, 2002. Trap nets capture fish in the back of a series of hoops. Fish are removed from the back hoop, identified, measured, and released. A summary of the fish caught are shown in Table 12. A map of trapnet locations is shown in Figure 23. Examples of measuring fish are shown in Figure 24.

Table 12. Total fish caught each day.

	Bluegill	Pumpkin-seed	Crappie	Rock bass	Yellow bullhead	Northern pike	Bass	TOTAL
Sept 11 (Weds)	147	23	13	1	10	22	5	221
Sept 12 (Thurs)	147	32	21	1	12	12	10	235
Sept 13 (Fri)	65	7	20	1	5	10	2	110
Sept 14 (Sat)	43	18	10	2	28	2	7	110
TOTAL	402	80	64	5	55	46	24	676

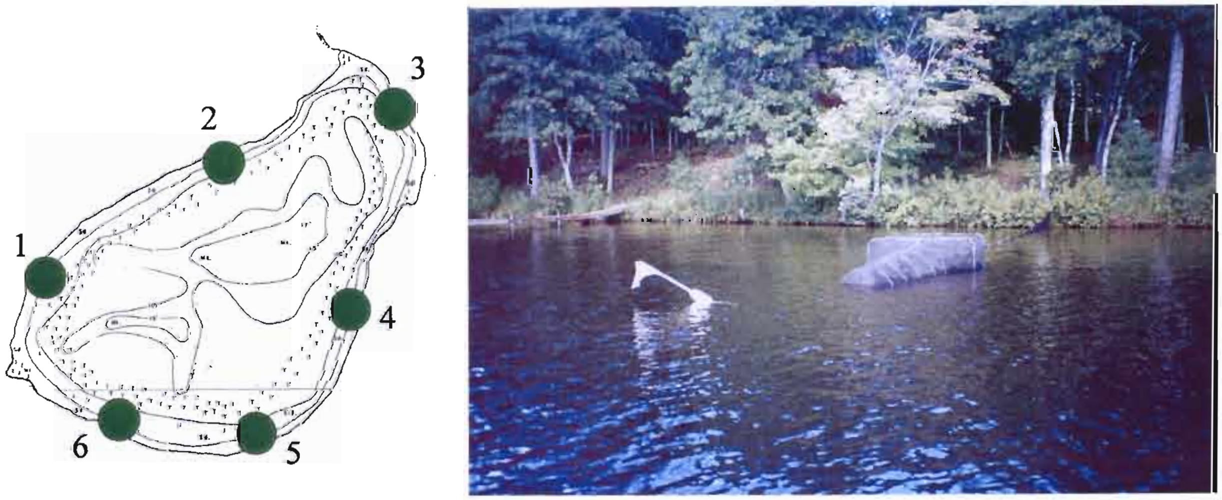


Figure 23. Trapnet locations are shown on the map to the left. An example of a trapnet in the lake is shown to the right.

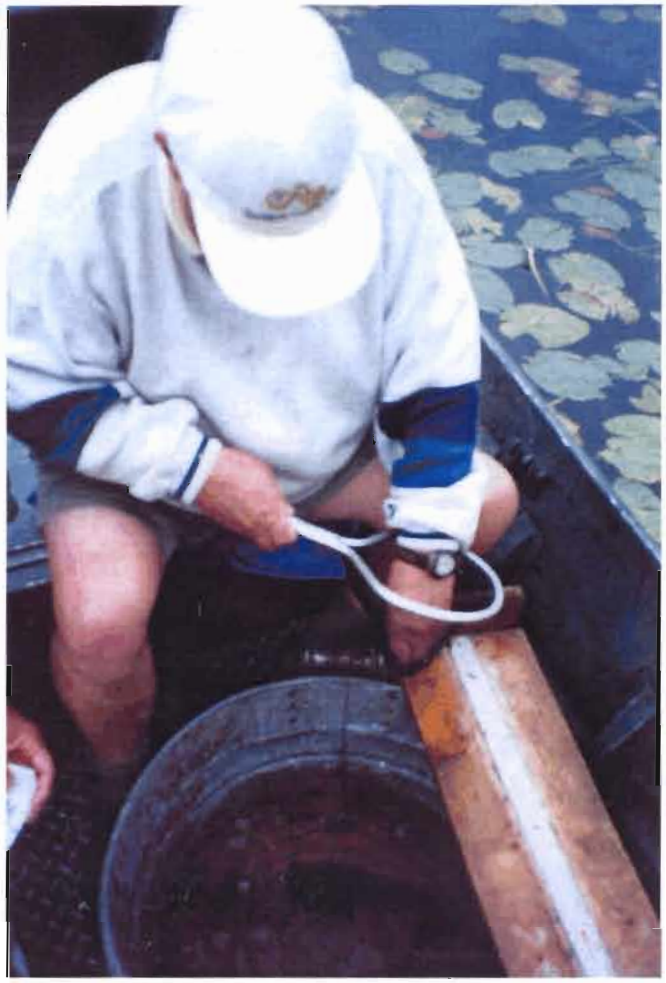


Figure 24. [top] Jeff Henderson, Big Bear Lake, is picking out and measuring bluegill sunfish.
[bottom] Example of the northern pike situation in Big Bear. Some northerns are in good condition (top fish), but many more are in poor shape (bottom fish).

The number of fish caught per day dropped off after the first two days (Figure 25) but enough were captured to get a good sample. Bluegill sunfish were the dominant species caught (Figure 26).

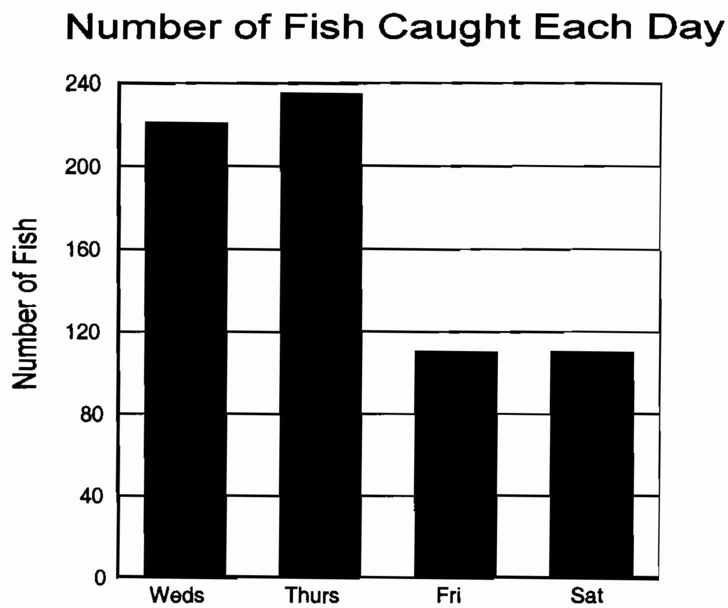


Figure 25. Total number of fish caught each day.

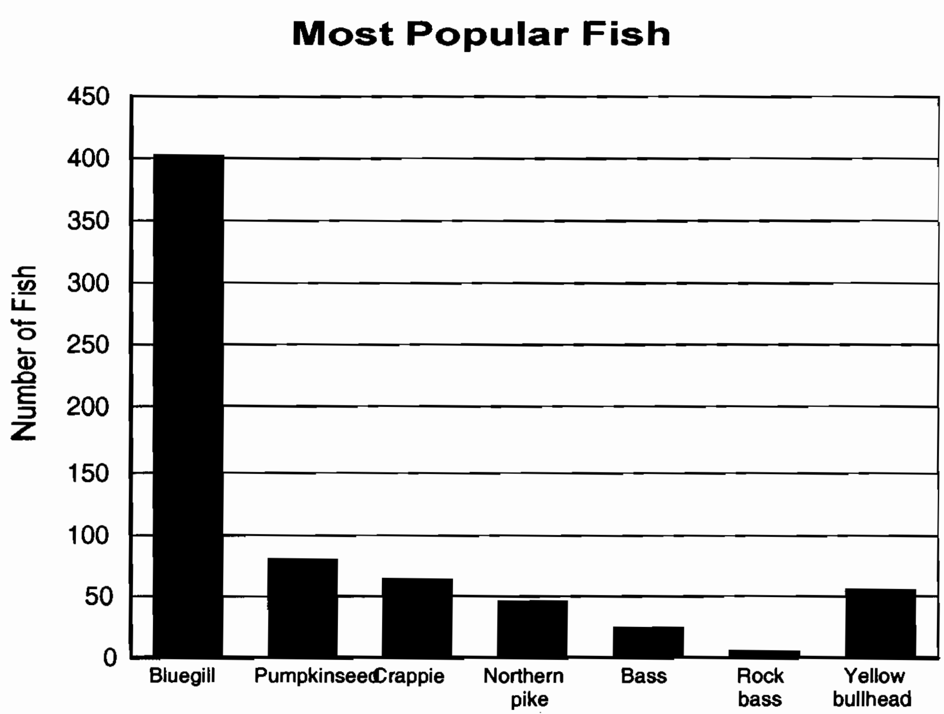


Figure 26. Total number of fish caught by species over the four days of trapnetting in September 2002.

The length measurements of Big Bear fish revealed several things about the condition of the fish community (Table 13 and Figure 28).

- Bluegill and pumpkinseed sunfish were not stunted and were in good condition.
- The crappie population was also in good shape.
- Northern pike were below average in condition, with many found to be underweight (Figure 24 shows an example).
- Although bass numbers were not high, it may be a function of trap net efficiency. Trapnets do not sample largemouth bass very well. However netting results show there is good natural reproduction based on the young-of-the-year catches.
- Forage fish species were low in numbers.

Overall, the fish community has aspects typically found in shallow lakes for this part of Wisconsin. There are also hints that the fish community undergoes periodic winterkill (meaning a loss of oxygen over winter that results in either all or some of the fish suffocating).

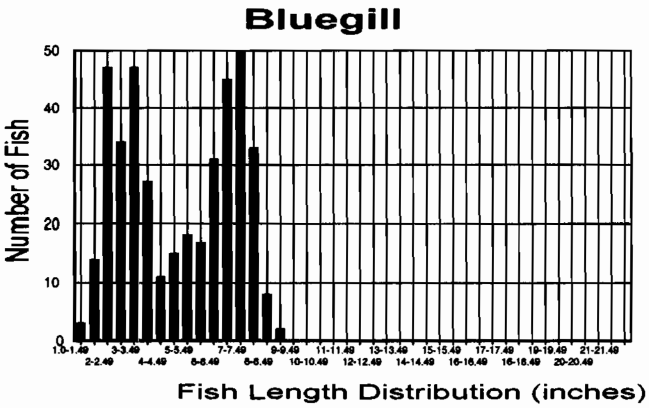
Figure 27. Big Bear Lake volunteers helping to count and measure fish.

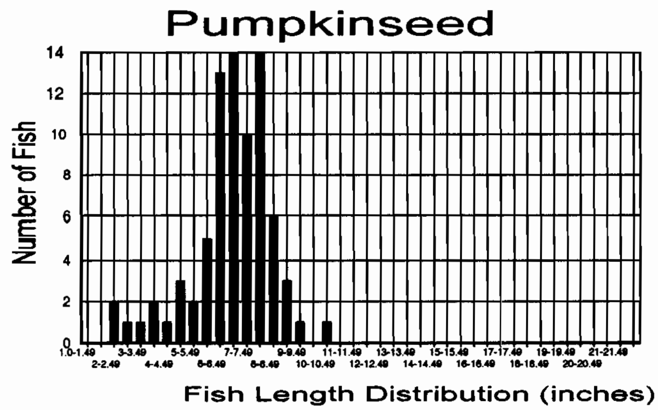
Table 13. Fish length distribution for Big Bear Lake. All fish were measured in inches.

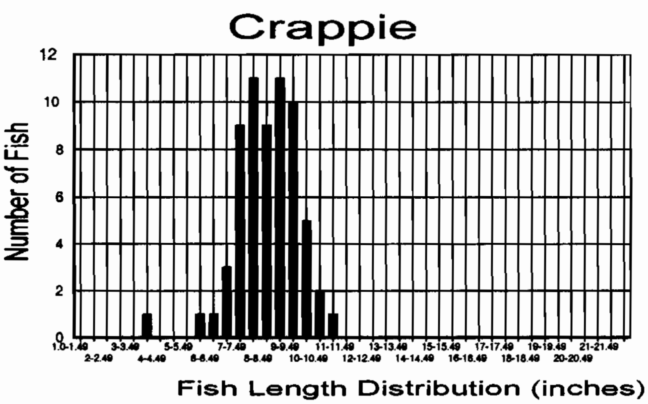
Size	Bluegill	Pumpkin-seed	Crappie	Northern pike	Bass	Rock bass	Yellow bullhead
1.0-1.49	3						
1.5-1.99	14				6		
2.0-2.49	47	2			5		
2.5-2.99	34	1			2	1	
3.0-3.49	47	1			2	1	
3.5-3.99	27	2	1		1		
4.0-4.49	11	1				1	
4.5-4.99	15	3					
5.0-5.49	18	2			1		
5.5-5.99	17	5	1				
6.0-6.49	31	13	1		3		
6.5-6.99	45	14	3				
7.0-7.49	50	10	9				
7.5-7.99	33	14	11				4
8.0-8.49	8	6	9				10
8.5-8.99	2	3	11				6
9.0-9.49		1	10			2	8
9.5-9.99			5				5
10.0-10.49		1	2				4
10.5-10.99			1				4
11.0-11.49					1		4
11.5-11.99					1		9
12.0-12.49				1	1		1
12.5-12.99							
13.0-13.49				1			
13.5-13.99				3			
14.0-14.49				4			
14.5-14.99				3			
15.0-15.49				8			
15.5-15.99				4	1		
16.0-16.49				6			
16.5-16.99				5			
17.0-17.49				4			
17.5-17.99				2			
18.0-18.49				1			
18.5-18.99				2			
19.0-19.49				1			
19.5-19.99				1			
20.0-20.49							
20.5-20.99							
21.0-21.49							
21.5-21.99							
TOTAL	402	80	64	46	24	5	55

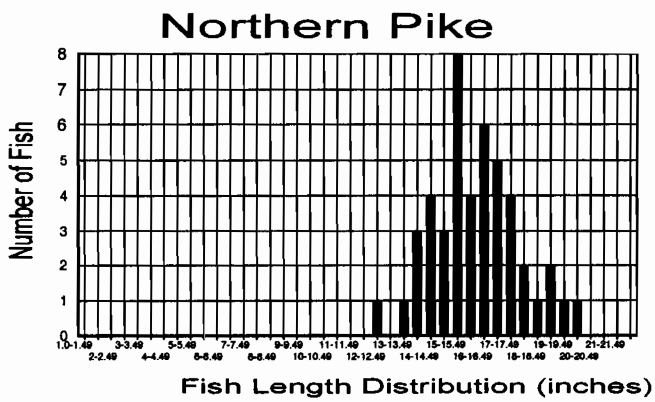
Table 13. Fish length distribution for Big Bear Lake. All fish were measured in inches.

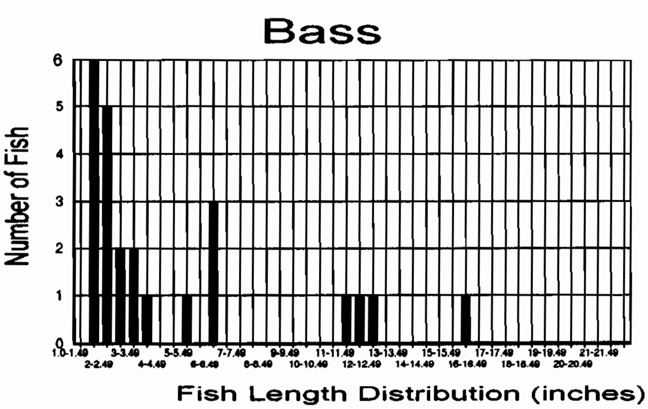
Size	Bluegill	Pumpkin-seed	Crappie	Northern pike	Bass	Rock bass	Yellow bullhead
1.0-1.49	3						
1.5-1.99	14				6		
2.0-2.49	47	2			5		
2.5-2.99	34	1			2	1	
3.0-3.49	47	1			2	1	
3.5-3.99	27	2	1		1		
4.0-4.49	11	1				1	
4.5-4.99	15	3					
5.0-5.49	18	2			1		
5.5-5.99	17	5	1				
6.0-6.49	31	13	1		3		
6.5-6.99	45	14	3				
7.0-7.49	50	10	9				
7.5-7.99	33	14	11				4
8.0-8.49	8	6	9				10
8.5-8.99	2	3	11				6
9.0-9.49		1	10			2	8
9.5-9.99			5				5
10.0-10.49		1	2				4
10.5-10.99			1				4
11.0-11.49					1		4
11.5-11.99					1		9
12.0-12.49				1	1		1
12.5-12.99							
13.0-13.49				1			
13.5-13.99				3			
14.0-14.49				4			
14.5-14.99				3			
15.0-15.49				8			
15.5-15.99				4	1		
16.0-16.49				6			
16.5-16.99				5			
17.0-17.49				4			
17.5-17.99				2			
18.0-18.49				1			
18.5-18.99				2			
19.0-19.49				1			
19.5-19.99				1			
20.0-20.49							
20.5-20.99							
21.0-21.49							
21.5-21.99							
TOTAL	402	80	64	46	24	5	55

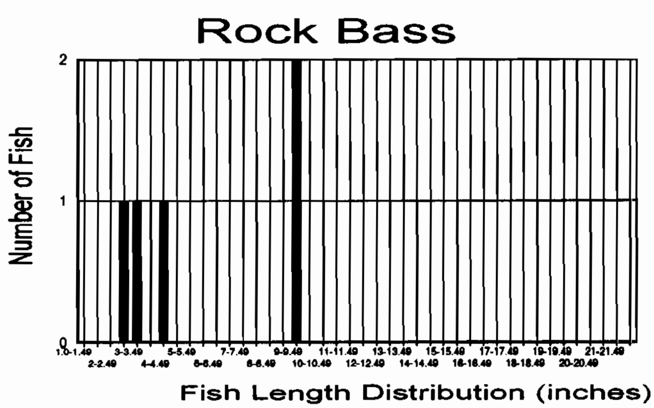












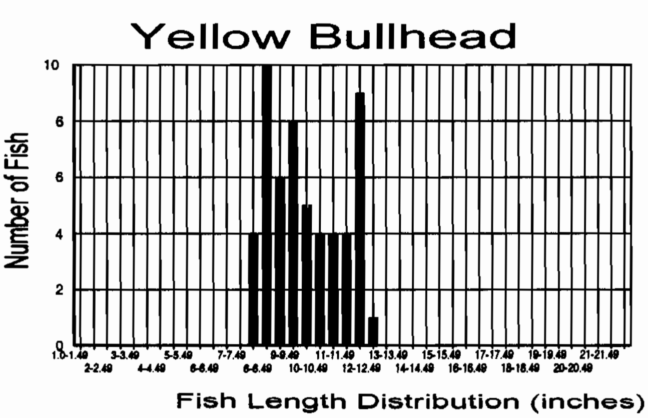


Figure 28. Fish length distribution of all fish caught during the Big Bear Lake fish survey.

Fish Community Review: A shallow lake, like Big Bear, will have a different fish assemblage compared to a larger, deeper lake. A shallow lake, like Big Bear, will be warmer than deeper lake and this can be stressful for a cool water fish species like northern pike. That is one reason why northerns in Big Bear are in poor condition (that is, skinny with few large fish present). Crappies and bluegills may be tough competitors for young northerns and may limit northern pike success.

Largemouth bass are present but their status is difficult to gage because trapnetting is not a good survey method for them . However, because natural reproduction is occurring, we are not recommending any bass stocking.

WDNR fisheries manager, Larry Damon, has mentioned that Big Bear has experienced winterkills in the past. A partial or whole-fishery winterkill readjusts the fish community. This may explain why bluegills and crappies are doing well. Wintertime dissolved oxygen readings would help to determine the potential for winterkill in Big Bear Lake.

Figure 29. Big Bear Lake volunteers also helped to bring in the nets at the end of the survey.

5. Lake and Watershed Assessment

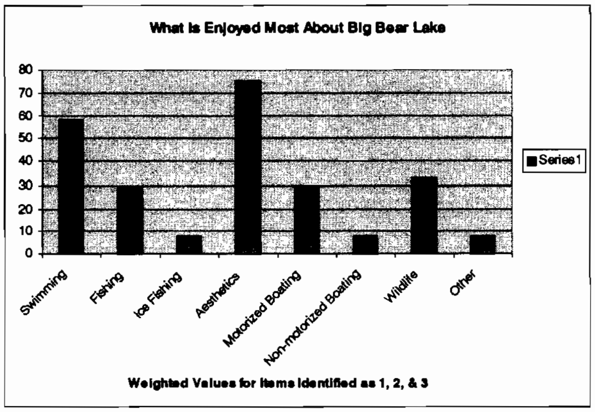
5.1. Lake Questionnaire Results

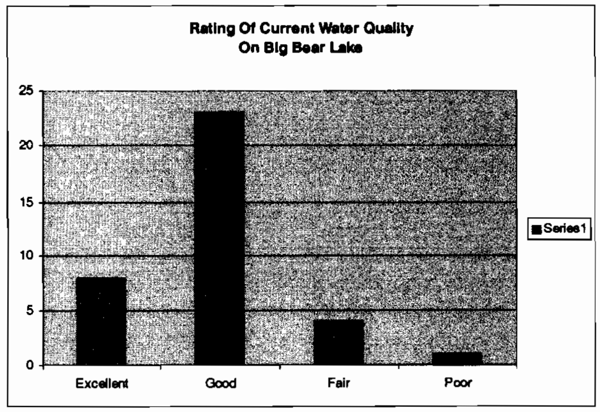
- The questionnaire was sent to approximately **100** Big Bear Lake property owners and responses were compiled by the Lake Association.

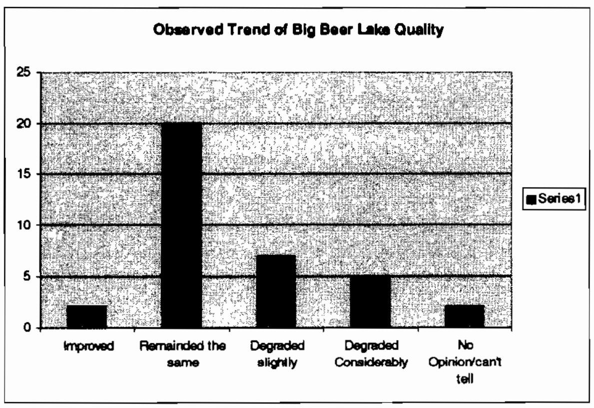
- 36 (36%) property owners responded to the Big Bear Lake questionnaire.

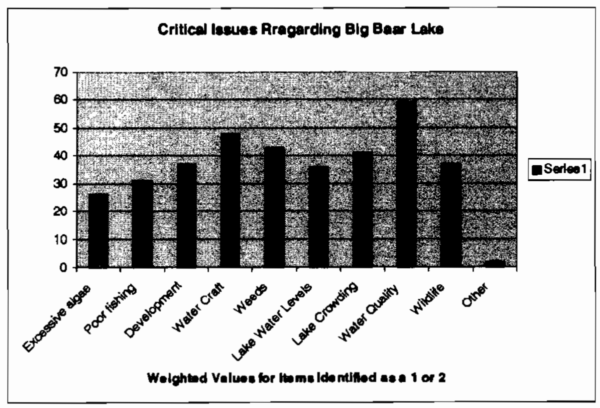
- Of those responding:
  - There was an average of **17 ½** years of experience owning property on the lake.
  - **22** (61%) indicated a willingness to volunteer time & labor to support the study … 3 more indicated "maybe".
  - **24** (67%) responders indicated a willingness to help finance the study … 3 more indicated "maybe".

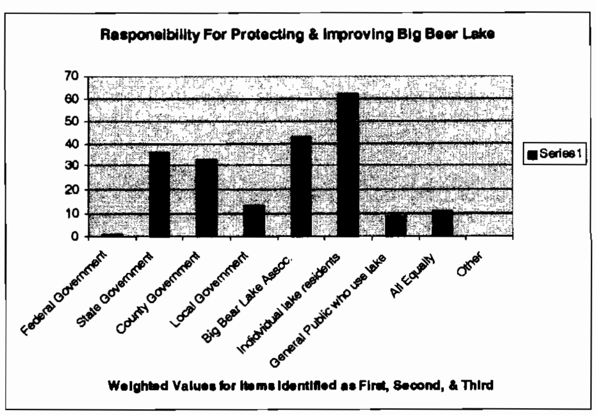
The sum of the amount responders were willing to contribute was **$2,215.**

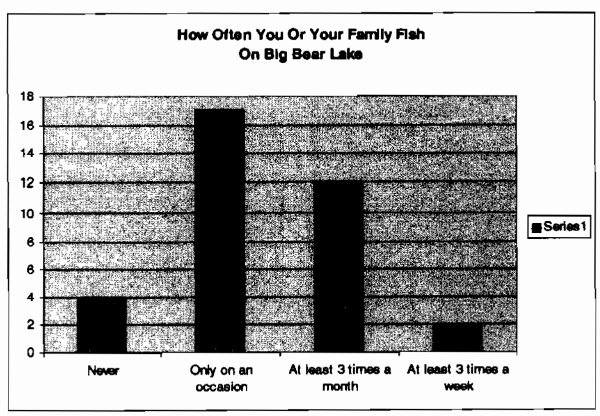

What is Enjoyed Most About Big Bear Lake
80
70
60
50
40
30
20
10
0
Series1
Swimming
Fishing
Ice Fishing
Aesthetics
Motorized Boating
Non-motorized Boating
Wildlife
Other
Weighted Values for Items Identified as 1, 2, & 3

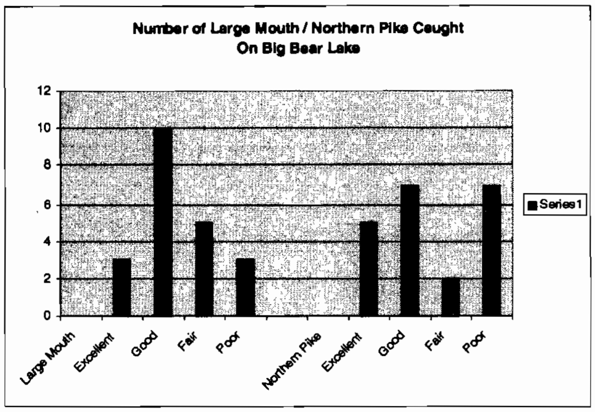

Rating Of Current Water Quality
On Big Bear Lake
25
20
15
10
5
0
Series1
Excellent
Good
Fair
Poor

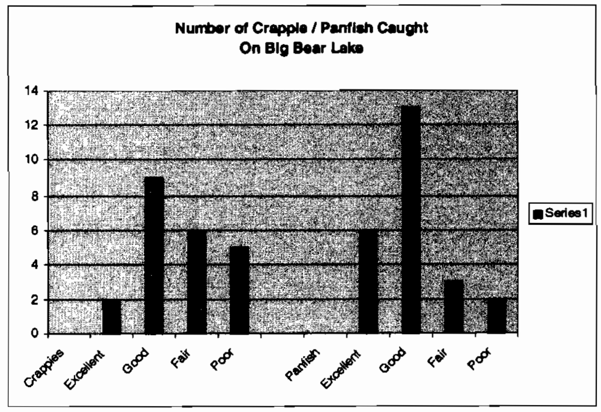

Observed Trend of Big Bear Lake Quality
25
20
15
10
5
0
Series1
Improved
Remainded the same
Degraded slightly
Degraded Considerably
No Opinion/can't tell

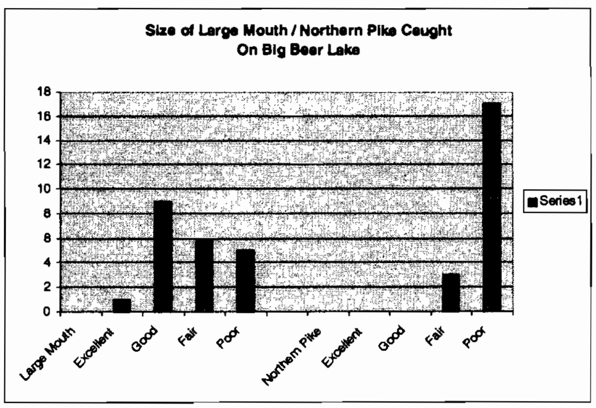

Critical Issues Rragarding Big Bear Lake
70
60
50
40
30
20
10
0
Series1
Excessive algae
Poor fishing
Development
Water Craft
Weeds
Lake Water Levels
Lake Crowding
Water Quality
Wildlife
Other
Weighted Values for Items Identified as a 1 or 2

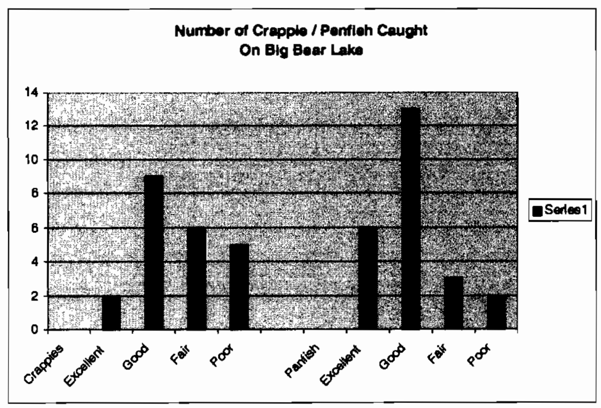

Responsibility For Protecting & Improving Big Bear Lake
70
60
50
40
30
20
10
0
Series1
Federal Government
State Government
County Government
Local Government
Big Bear Lake Assoc.
Individual lake residents
General Public who use lake
All Equally
Other
Weighted Values for Items Identified as First, Second, & Third

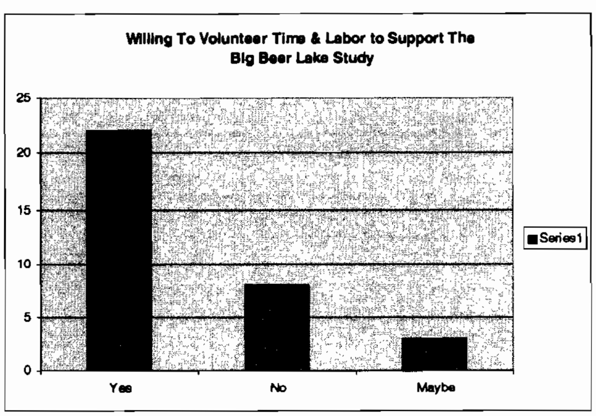

How Often You Or Your Family Fish
On Big Bear Lake
18
16
14
12
10
8
6
4
2
0
Series1
Never
Only on an occasion
At least 3 times a month
At least 3 times a week

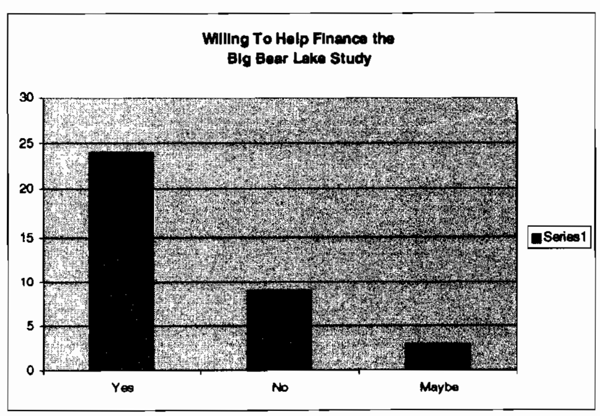

Number of Large Mouth / Northern Pike Caught
On Big Bear Lake
12
10
8
6
4
2
0
Large Mouth
Excellent
Good
Fair
Poor
Northern Pike
Excellent
Good
Fair
Poor
Series1


Number of Crappie / Panfish Caught
On Big Bear Lake
14
12
10
8
6
4
2
0
Crappies
Excellent
Good
Fair
Poor
Panfish
Excellent
Good
Fair
Poor
Series1


Size of Large Mouth / Northern Pike Caught
On Big Bear Lake
18
16
14
12
10
8
6
4
2
0
Large Mouth
Excellent
Good
Fair
Poor
Northern Pike
Excellent
Good
Fair
Poor
Series1


Number of Crappie / Panfish Caught
On Big Bear Lake
14
12
10
8
6
4
2
0
Crappies
Excellent
Good
Fair
Poor
Panfish
Excellent
Good
Fair
Poor
Series1


Willing To Volunteer Time & Labor to Support The
Big Bear Lake Study
25
20
15
10
5
0
Yes
No
Maybe
Series1


Willing To Help Finance the
Big Bear Lake Study
30
25
20
15
10
5
0
Yes
No
Maybe
Series1

5.2. Big Bear Lake Status

The status of Big Bear Lake is good and probably could be graded as a high "B" and maybe even an "A". Values for phosphorus, chlorophyll and secchi depth are within ecoregion values, which if turned into grades would be above average.

An ecoregion is a geographic region in the State that has similar geology, soils, and land use. Big Bear Lake is in the Northern Lakes and Forests ecoregion. Lakes in this ecoregion have the best water quality values in the State. The results of the water quality analysis for Big Bear Lake are in line for what is expected for relatively unimpacted lakes in this ecoregion (Table 14). A map showing the ecoregion areas and the Big Bear Lake location is displayed in Figure 30.

Table 14. Summer average quality characteristics for lakes in the Northern Lakes and Forest ecoregion, as noted in Description Characteristics of the Seven Ecoregions in Minnesota, by G. Fandrei, S. McCollar. 1988. Minnesota Pollution Control Agency.

Parameter	Northern Lakes & Forests	Big Bear (2002)
Total phosphorus (ug/l) - top	14-27	10
Chlorophyll (ug/l)	<10	2
Chlorophyll - max (ug/l)	<15	2
Secchi disc (ft)	8-15	11.9

These results indicate that Big Bear Lake is in a protection status in terms of water quality, meaning no drastic lake or watershed restoration projects are needed. At this point in time, the challenge is to keep the lake in good shape.

An important component to watch and control is nutrient inputs -- both phosphorus and nitrogen. If phosphorus concentrations increase to around 30 ppb or above, nuisance algae blooms could develop, and this could cause a cascade of problems.

Likewise, construction and lake resident activities can have significant impacts on phosphorus inputs. Studies in Maine show that clearing the trees off your property, even a partial clearing can increase phosphorus inputs to the lake from the runoff. Shoreland projects to reduce nutrient inputs are important.

Level III Ecoregions of Wisconsin

Revised April 2000

National Health and Environmental Effects Research Laboratory

U.S. Environmental Protection Agency

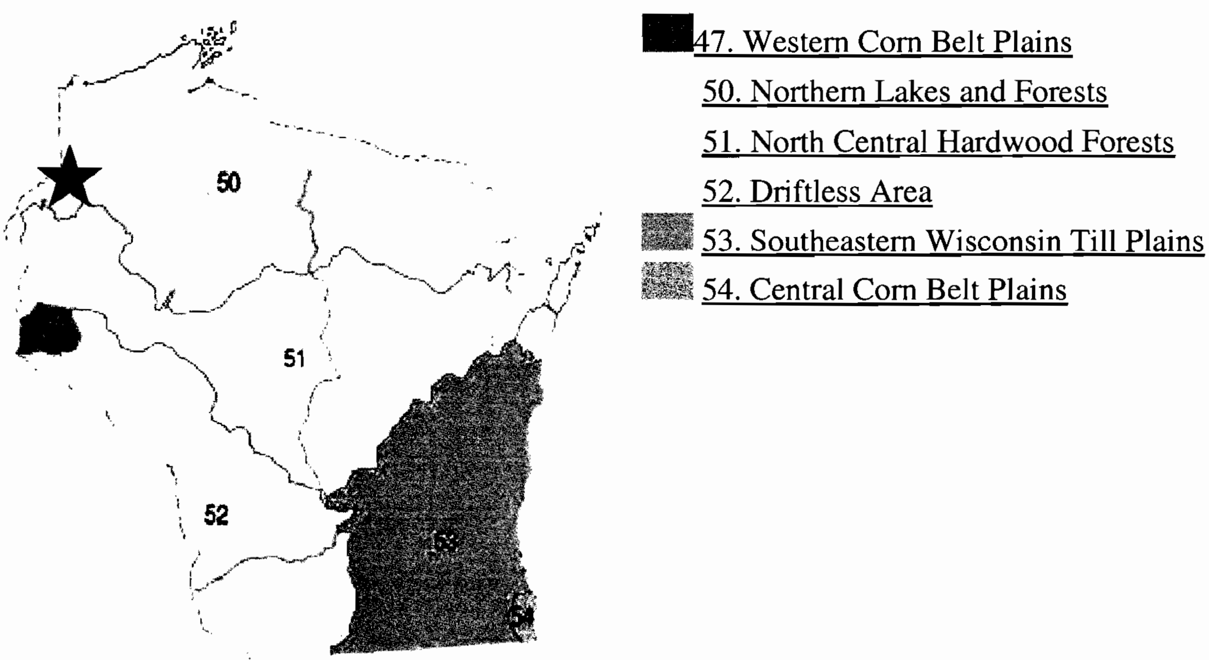


Figure 30. Ecoregion map for Wisconsin.

5.3. How Sensitive is Big Bear to Change

Water quality in Big Bear Lake is excellent. The small watershed, low soil fertility and natural land use cover can account for the water quality observed in the lake. Lake phosphorus models were run using this information. There is good agreement between the predicted lake phosphorus concentration and the observed phosphorus concentration for Big Bear Lake.

Figure 31. A wet meadow on the north side of Big Bear Lake acts as a water filter and probably helps remove nutrients before they enter Big Bear Lake. This helps protect lake water quality.

6. Lake Project Ideas for Protecting the Lake Environment (which includes water quality and wildlife)

Project ideas for Big Bear Lake are geared toward long-term protection of water quality. Aquatic plant management has a corrective component with small-scale approaches proposed for addressing nuisance growth of milfoil.

A list of lake projects ideas has 4 broad categories:

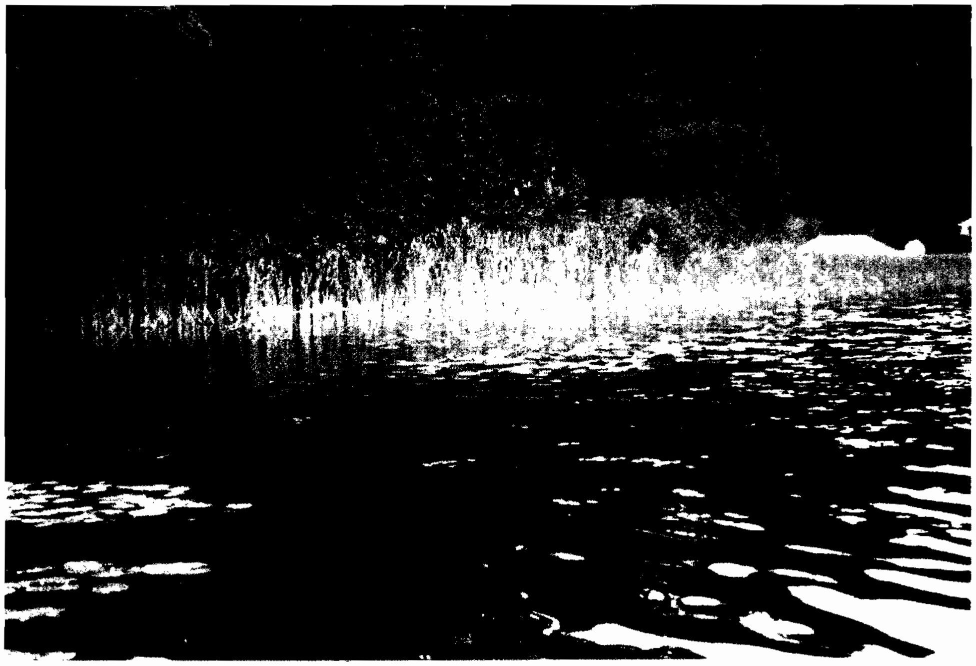
1. Shoreland protection and landscaping (*maintain native shorelines and uplands and maintain on-site wastewater treatment systems*).
2. Fish management program (*fish for crappies, which in turn may help the northern pike*).
3. Aquatic plant management (*maintain native diversity*).
4. Lake monitoring program (*keep track of any lake changes*).

Details for these projects areas are given in the next few pages.

6.1. Shoreland Projects and Landscaping

The overall project objective is to protect the natural character of the watershed which helps maintain good runoff water quality.
Ways to accomplish this include:

- Educating new waterfront property owners on the value of shoreline habitat and good landscaping practice. Since lake fronts already are in a shoreline restoration program. Information about how to participate in this program should be continued.
- Maintain on-site wastewater treatment systems with periodic pumping and good use practices.
- Keep records of county shoreland ordinances updated and relay information to lake residents with newsletters.



Emergent shoreline vegetation is important for water quality and wildlife in Big Bear Lake.

6.2. Fish Management Program

The fish management program is based on findings from the 2002 fish survey combined with results of the lake resident survey indicating fishery preferences and perceived problems and WDNR input.

The objective of the fish management program is to improve the quality of the northern pike population while not adversely impacting the panfish.

It appears the main factor contributing to skinny northerns is a lack of forage. Its possible that the surprisingly robust crappie population is probably competing with northerns for forage . . . and winning.

One approach is to concentrate fishing on crappies. Crappies eat zooplankton when young and small fish when they are mature. Reducing crappie numbers could reduce competition with northerns and bass and could stimulate their recruitment into bigger fish sizes.

Lastly, we recommend dissolved oxygen testing in January and February to check the possibility of winterkill. Dissolved oxygen conditions should be correlated with ice-on days and snow cover.

6.3. Aquatic Plant Management

A high priority lake protection recommendation is to maintain the healthy native aquatic plant communities in Big Bear Lake. Currently, Big Bear Lake has a variety of emergent and submergent aquatic plant growth. Aquatic plants are vital for helping sustain clear water conditions and contribute to fish habitat.

The challenge is to maintain and/or protect submerged aquatic plants in Big Bear Lake. Several plant improvement ideas are given below:

- Conduct a lake soil fertility survey to determine fertility level in lake soils. Sample areas with plants and areas without plants. If soil fertility is similar, then something other than nutrients are inhibiting plant growth.
- Maintaining good shoreland conditions can promote improved plant distribution.

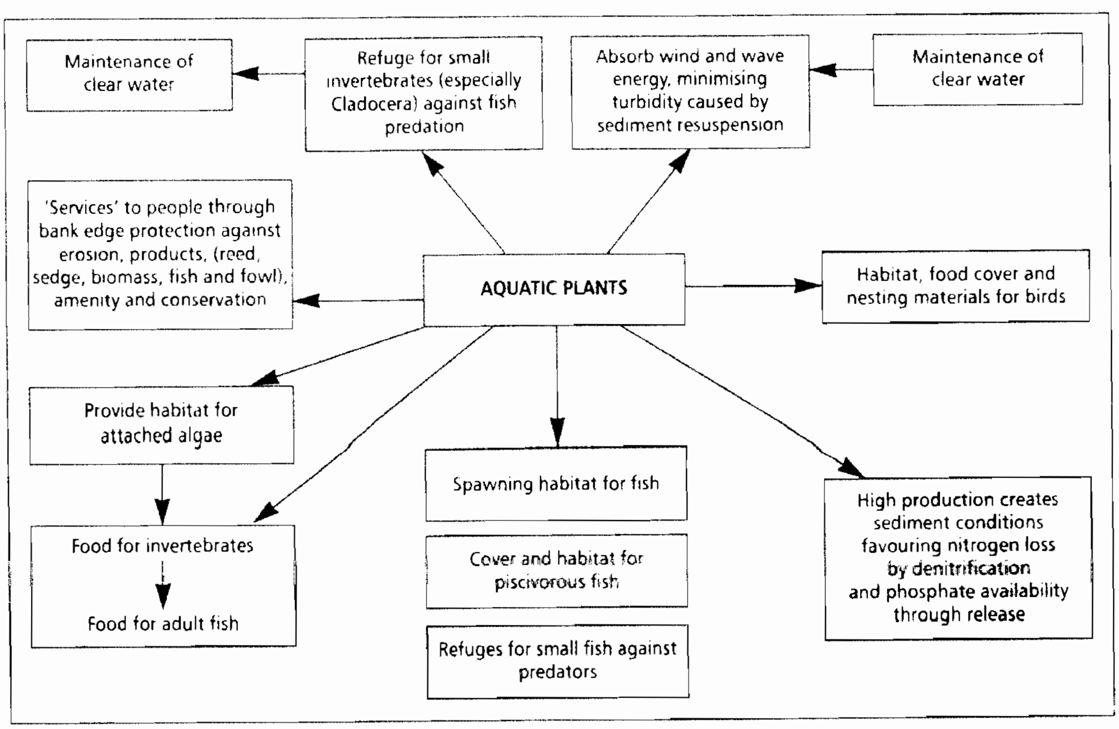


Figure 22. Links between aquatic plants and other organisms, including ourselves (source: Moss and others. 1996. A guide to the restoration of nutrient-enriched shallow lakes. Broads Authority Norwich, England).

6.4. Lake Monitoring Program

A lake monitoring program is outlined in Table 14. It is designed to be flexible to accommodate the volunteer work force and a fluctuating budget.

Table 14. Big Bear Lake Water Quality Monitoring Program

Category	Level	Alternative	Labor Needed	Cost/Year
A. Dissolved oxygen	1	Check dissolved oxygen at Big Bear Lake outlet every one to two weeks in December, January, February, and March depending on winter conditions.	Moderate	$0
	2	Check dissolved oxygen at Big Bear Lake outlet every one to two weeks in December, January, February, and March, depending on winter conditions.	Moderate	$0
	3	Check dissolved oxygen in several locations around Big Bear Lake in December, January, February, and March.	Moderate to high	$0
	4	Collect dissolved oxygen and temperature profiles in all three lakes, once or twice a month from May-September.	Moderate	$0
B. Water clarity	1	Secchi disc taken at spring and fall turnover.	Low	$0
	2	Secchi disc monitoring once per month May - October.	Low-moderate	$0
	3	Secchi disc monitoring twice per month, May - October.	Moderate	$0
C. Water chemistry	1	Spring and fall turnover samples are collected and sent to UW-Stevens Point. Selected parameters for analysis include: TP and chlorophyll.	Low	$200
	2	Spring and fall turnover samples are collected and sent to UW-Steven Point. Standard package of parameters is analyzed.	Low	$600
	3	Sample for phosphorus and chlorophyll once per month from May - September (surface water only).	Low-moderate	$300
	4	Sample for phosphorus and chlorophyll twice per month from May - October.	Moderate	$600
	5	Sample for phosphorus, chlorophyll, Kjeldahl-N, nitrate-nitrite-N, and ammonia-N once per month (May-October)	Moderate	$960
	6	Sample for phosphorus, chlorophyll, Kjeldahl-N, nitrate-nitrite-N, and ammonia-N twice per month (May-October).	Moderate	$1,920
D. Special samples or surveys	1	Special samples: suspended solids, BOD, chloride, turbidity, sampling bottom water, and other parameters as appropriate. Aquatic plant surveys, etc.	--	$50+

UW-Stevens Point Lab Analysis Costs:

Total phosphorus	$12.00	Total suspended solids	$8.00
Chlorophyll a	$20.00	Total volatile solids	$8.00
Kjeldahl-N	$12.00	Dissolved solids	$8.00
Nitrate/Nitrite-N	$10.00	Turbidity	$6.00
Ammonia-N	$10.00	BOD	$20.00

For 2002, a recommended program consists of Level A1 on an annual basis, Level C3 every 2 to 3 years and an aquatic plant survey (Level D1) every three years.

Return to committee

UWSP - ENVIRONMENTAL TASK FORCE LAKES PROGRAM

(phone 715/346-3209)

BIG BEAR LAKE Project
BURNETT County, T0N R14W S19, 20

BIG BEAR LAKE
Natural Seepage Lake

Area Information:

Lake Surface Area	189 Acres
Area with Depth < 3 ft	NA Acres
Area with Depth >20 ft	NA Acres
Watershed Size	NA Sq.Mi.
Shoreline Dev. Factor	1.14

Depth Information:

Maximum	17.0 ft	5.2 m
Average	7.0 ft	2.1 m

Hydrological Information:

Watershed-Lake Area Ratio	NA
Estimated Retention Time	NA Years

Residence Information:

Seasonal Cottages	70
Permanent Cottages	6

Major Perceived Problems:

Monitoring Data for Site LAKE CENTER-SURFACE:

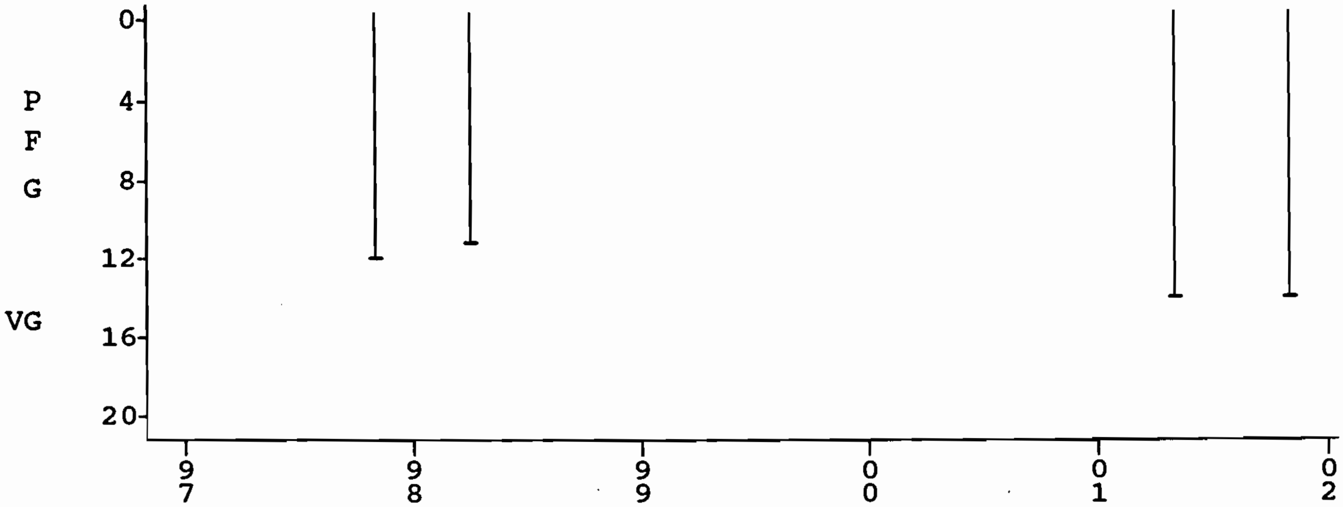
Date	**11/13/01**	**05/08/01**	**11/13/00**	**04/09/00**
pH (SU)	7.50	7.57	7.58	7.65
Conductivity (umhos/cm)	79	75	80	79
Alkalinity (mg/l CaCO3)	39	41	38	39
Magnesium (mg/l CaCO3)	4.0	56.0	12.7	10.6
Calcium (mg/l CaCO3)	28.0	32.0	23.3	25.4
Total Hardness (mg/l CaCO3)	32.0	88.0	36.0	36.0
Turbidity (NU)	2.7	2.0	0.5	1.4
Color (SU)	22.0	14.0	9.0	11.0
Color (SU)	22.0	14.0	9.0	11.0
Reactive Phosphorus(mg/l P)	<0.003	0.012	0.002	0.003
Total Phosphorus (mg/l P)	0.031	0.030	0.029	0.010
Ammonium (mg/l N)	<0.01	0.01	<0.01	<0.01
Nitrate - Nitrite (mg/l N)	0.02	0.02	0.03	0.01
Total Inorganic Nitrogen	0.02	0.03	0.03	0.01
Total Kjeldahl N (mg/l N)	0.62	0.57	0.99	0.36
Total Nitrogen (mg/l N)	0.64	0.59	1.02	0.37
* N / P Ratio	20.6	19.7	35.2	37.0
Chloride (mg/l Cl)	<0.5	<0.5	<0.5	0.2
Sulfate (mg/l /SO4)	2.3	1.8	2.3	1.8
Sodium (mg/l Na)	1.7	1.5	1.8	1.6
Potassium (mg/l K)	0.4	0.5	0.5	0.4
pHs (SU)	8.82	8.73	8.91	8.73
** Saturation Index (SU)	-1.32	-1.16	-1.33	-1.08
Temperature (C)	4	NA	NA	8
Secchi Disc (ft)	14.0	14.0	NA	NA
Secchi Disc (meters)	4.27	4.27	NA	NA
Dissolved Oxygen (mg/l)	NA	NA	NA	NA

NOTE: Use **Understanding Lake Data** booklet for data interpretation
"<" and ">" mean "less than" and "greater than" respectively
* N/P ratio <10 generally indicates N limiting
N/P ratio >15 generally indicates P limiting
** Saturation Index >1 may indicate marl deposition

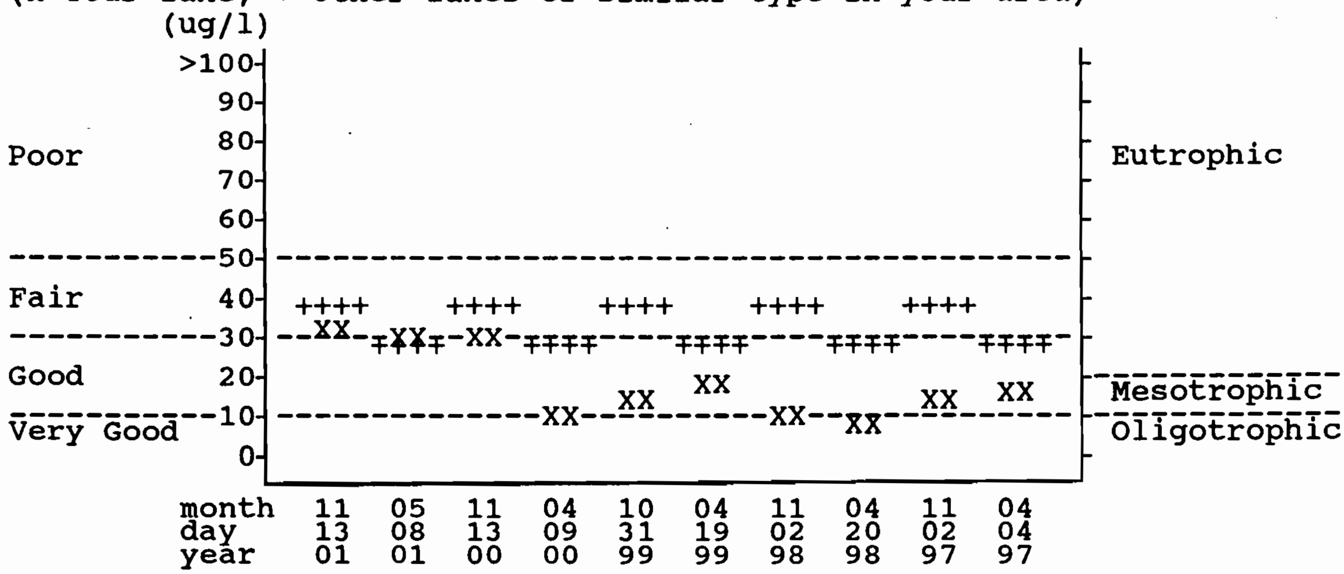
BIG BEAR LAKE Project
BURNETT County, T0N R14W S19, 20

BIG BEAR LAKE
Site: LAKE CENTER-SURFACE

Secchi Disc Depth (feet)



Generalized Water Quality Index Based on Total Phosphorus
(X=Your lake, +=Other lakes of similar type in your area)

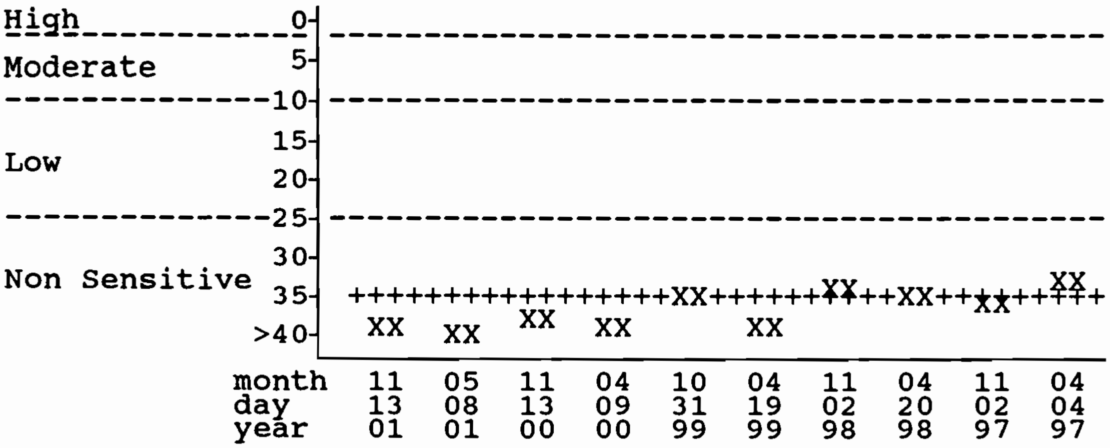


B11

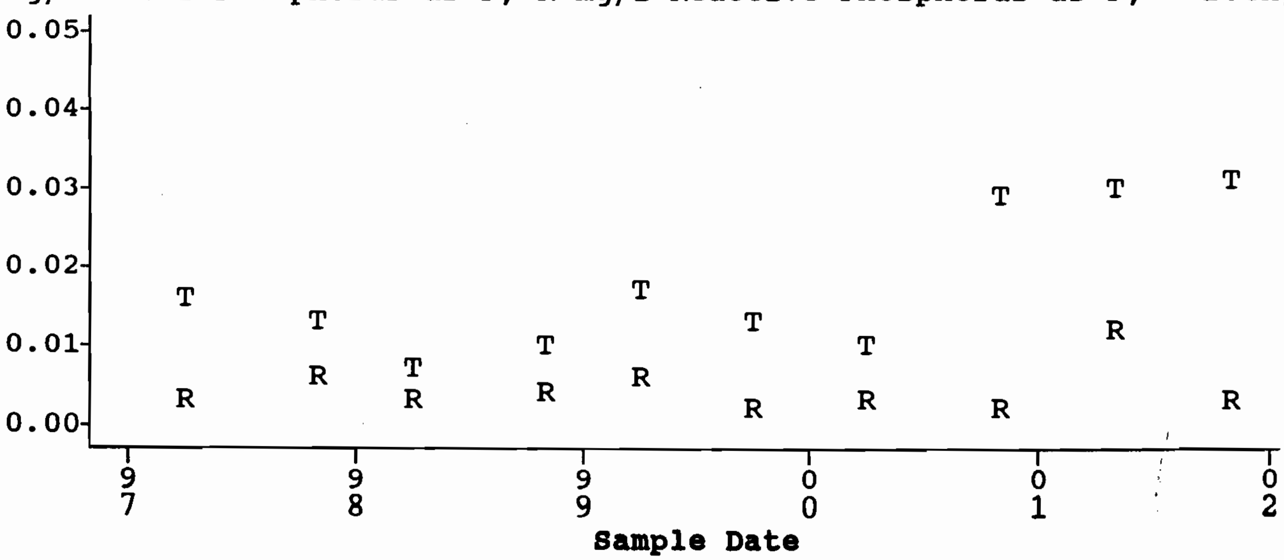
BIG BEAR LAKE Project
BURNETT County, T0N R14W S19, 20

BIG BEAR LAKE
Site: LAKE CENTER-SURFACE

Sensitivity to Acid Rain Index Based on Alkalinity
(X=Your lake, +=Other lakes of similar type in your area)
(mg/l as CaCO3)



Total and Reactive Phosphorus Concentrations Over Time
(T=mg/l Total Phosphorus as P, R=mg/l Reactive Phosphorus as P, *=Both)

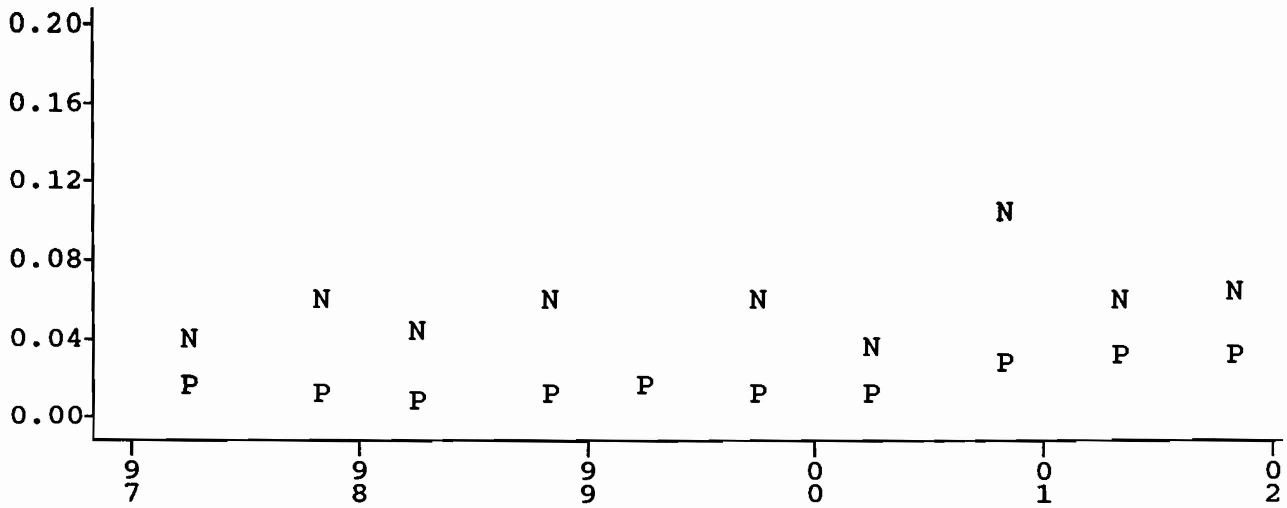


B12

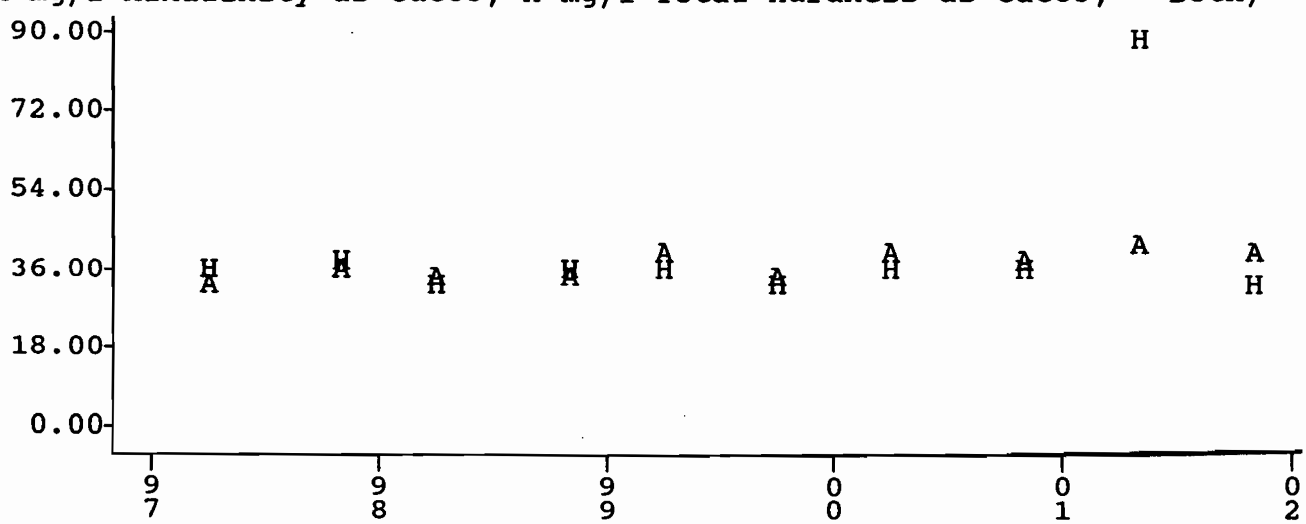
BIG BEAR LAKE Project
BURNETT County, T0N R14W S19, 20

BIG BEAR LAKE
Site: LAKE CENTER-SURFACE

Total Phosphorus and Total Nitrogen Concentrations Over Time
(P=mg/l Total Phosphorus as P, N=0.1 x Total Nitrogen, *=Both)



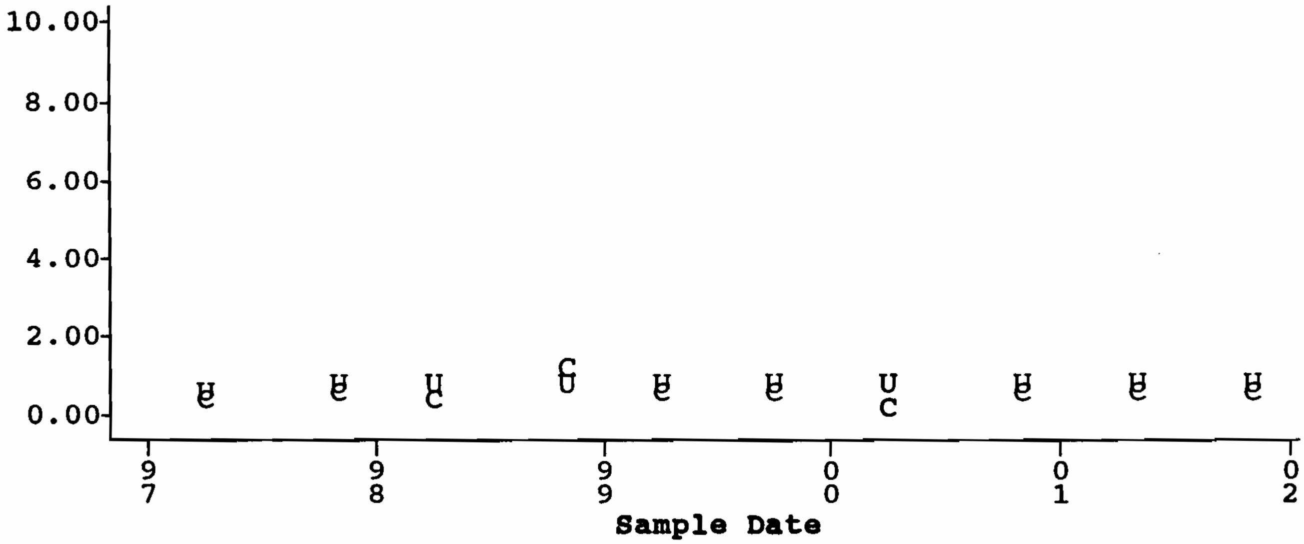
Alkalinity and Total Hardness Concentrations Over Time
(A=mg/l Alkalinity as CaCO3, H=mg/l Total Hardness as CaCO3, *=Both)



BIG BEAR LAKE Project
BURNETT County, T0N R14W S19, 20

BIG BEAR LAKE
Site: LAKE CENTER-SURFACE

Chloride Concentration and Conductivity Over Time
(C=mg/l Chloride, U=0.01 x Conductivity as umhos/cm, *=Both)



DATA FOR COMPARISON TO YOUR LAKE

The following is a summary of lake surface water chemistry DATA COLLECTED 1967-79 BY THE WDNR, BUREAU OF RESEARCH. Listed values are averages for available NATURAL SEEPAGE lakes in the NORTHWEST region of the state.

Average Area Information:
Lake Surface Area 407 Acres
Shoreland Dev. Factor 2.02

Average Depth Information:
Maximum 51.0 ft 15.5 m
Average 19.6 ft 6.0 m

Average Hydrological Information:
Watershed-Lake Area Ratio 6.0
Estimated Retention Time 3.08 Years

PARAMETER	AVERAGE	MIN	MAX	No. of LAKES
pH (SU)	6.80	5.90	7.80	45
Alkalinity (mg/l CaCO3)	35	3	202	45
Magnesium (mg/l CaCO3)	12.3	4.1	53.4	45
Calcium (mg/l CaCO3)	22.5	2.5	65.0	45
Turbidity (NU)	1.6	1.0	3.8	25
Color (SU)	0.0	0.0	0.0	0
Winter Reactive Phosphorus (mg/l P)	0.013	0.003	0.060	37
Spring Reactive Phosphorus (mg/l P)	0.015	0.004	0.143	36
Summer Reactive Phosphorus (mg/l P)	0.011	0.003	0.062	44
Fall Reactive Phosphorus (mg/l P)	0.019	0.003	0.159	39
Winter Total Phosphorus (mg/l P)	0.025	0.009	0.085	37
Spring Total Phosphorus (mg/l P)	0.027	0.009	0.178	36
Summer Total Phosphorus (mg/l P)	0.031	0.009	0.150	44
Fall Total Phosphorus (mg/l P)	0.037	0.009	0.215	39
Winter Total Inorganic Nitrogen	0.27	0.08	0.96	37
Spring Total Inorganic Nitrogen	0.25	0.03	1.14	36
Summer Total Inorganic Nitrogen	0.21	0.00	0.86	44
Fall Total Inorganic Nitrogen	0.28	0.04	1.44	39
Winter Total Nitrogen (mg/l N)	0.75	0.34	1.97	37
Spring Total Nitrogen (mg/l N)	0.72	0.27	2.04	36
Summer Total Nitrogen (mg/l N)	0.74	0.13	1.92	44
Fall Total Nitrogen (mg/l N)	0.77	0.33	2.26	39
Winter N / P Ratio	41.8	11.3	120.0	37
Spring N / P Ratio	38.3	11.5	136.0	36
Summer N / P Ratio	33.2	7.4	102.0	44
Fall N / P Ratio	31.9	8.1	224.4	39
Chloride (mg/l Cl)	2.0	1.0	9.0	45
Spring Secchi Disc (meters)	3.20	0.80	6.70	33
Summer Secchi Disc (meters)	2.80	0.70	6.70	43
Fall Secchi Disc (meters)	3.30	1.10	7.00	37