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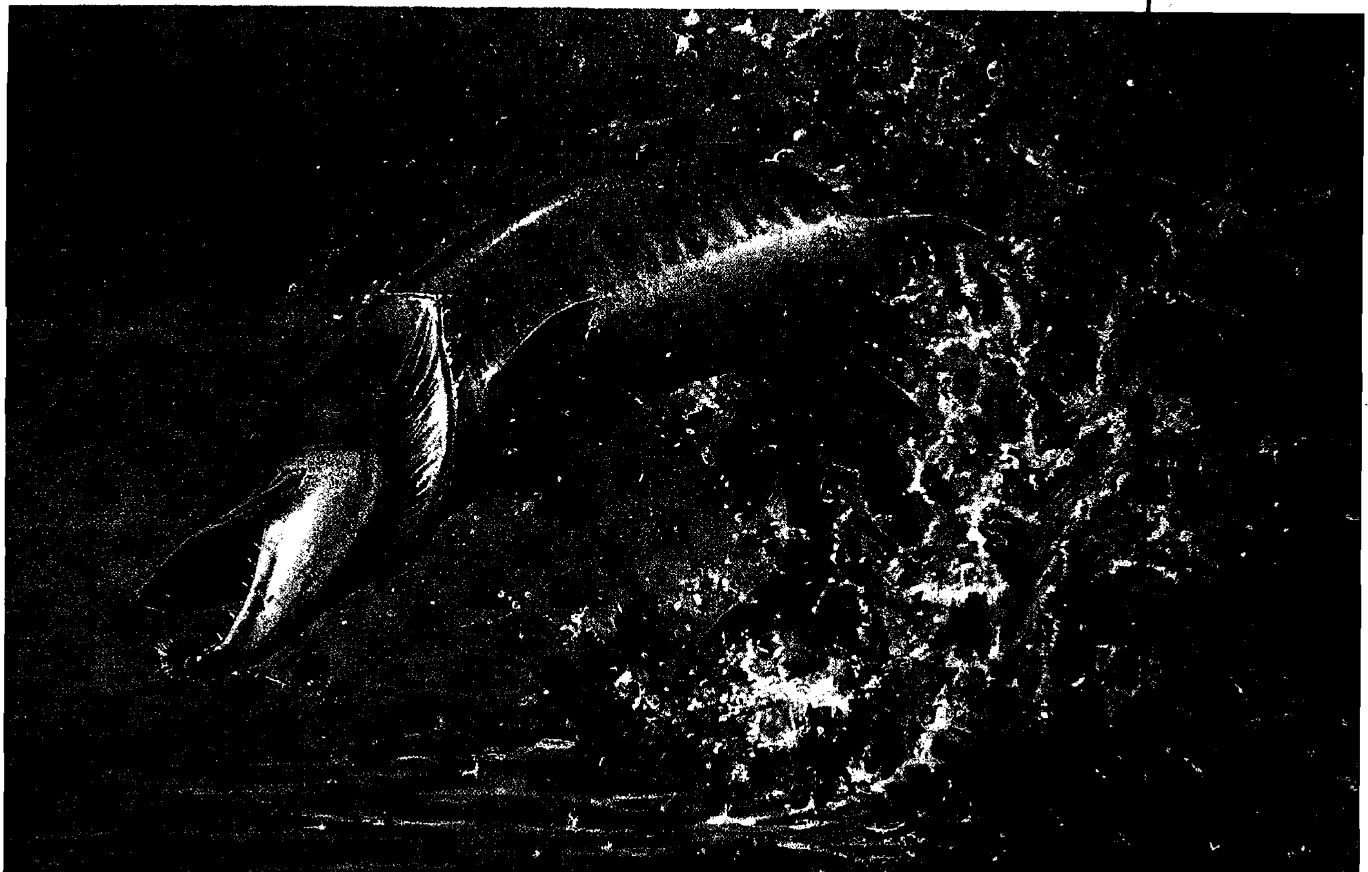

Scott Zoellick: *Musky Country*

Lake Management Plan for Big Round Lake, Polk County, Wisconsin

July 2004

Prepared by Steve McComas, Blue Water Science
with contributions from Wisconsin Department of Natural Resources,
St. Croix Chippewa Community, and the Big Round Lake Protection
and Rehabilitation District

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BIG ROUND LAKE CONTRIBUTORS:
Water Quality Monitoring Team
Dan Bergeron

Aquatic Vegetation and Shoreland Inventory, and Wildlife Inventory
Wayne Schue
Denis Tinkham

Big Round Lake Protection and Rehabilitation District
Board Members
Dan Hamilton - President
Jane Brenny - Secretary
Sallie Tinkham - Treasurer

Planning Committee
Dan Bergeron
John Geisegn
Gordon Kill
Don Makuch
Dick Martinson
Dave Nielsen
Truman Roach

OTHER CONTRIBUTORS:
Wisconsin DNR
Dan Ryan, Spooner, Project Manager

Polk County Soil and Water Conservation Department
Jeremy Williamson
Amy DeSchamps

St. Croix Chippewa Community
Beth Greiff
Martin Schutte

Lake Management Plan for
Big Round Lake, Polk County Wisconsin

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SUMMARY

Project Goals
The goals of this lake management report were:
- to examine existing lake conditions.
- to develop a lake management plan that protects, maintains, and enhances Big Round Lake water quality.

Geology and Soils
Big Round Lake is a glacial lake formed during the last retreat of the Superior glacial lobe starting about approximately 16,000 years ago. The soils deposited by the glacier are primarily sands and loamy sands.

Watershed Characteristics
The lake's watershed is approximately 18,880 acres (includes the lake). Land use is primarily forest (46%), with agriculture accounting for only about 8% of the total (USGS 2000).

Straight River Quality
The water quality of the Straight River, which flows into Big Round Lake is surprisingly good. Phosphorus concentrations were measured at about 40 ppb. This is low. It is common for streams in this part of the state to have phosphorus concentrations of around 150 ppb.

Lake Characteristics
Big Round Lake is a 1,015 acre lake located in Polk County, Wisconsin with an average depth of 10 feet and a maximum depth of 17 feet.

Lake Dissolved Oxygen and Temperature
Big Round Lake does not strongly thermally stratify during the summer. This means that wind action can mix the entire lake during the summer. Dissolved oxygen concentrations are found throughout the water column most of the time, although there are days during the summer when dissolved oxygen is depleted on the bottom of the lake.

Lake Nutrients
Phosphorus concentrations in Big Round are higher compared to other lakes in the North Central Hardwood Forest ecoregion. A three-year growing season phosphorus average is 98 ppb. A predicted phosphorus concentration based on ecoregion values and ecoregion modeling is predicted to be 55 ppb. This indicates Big Round Lake has the potential to have better water quality than it presently has. Reducing lake nutrient levels is a primary goal for the Big Round Lake Protection and Rehabilitation District.

Lake Algae
Big Round Lake has algae species that are common to lakes in this part of the state for eutrophic lake. In by mid-summer, blue-green algae concentrations increase dramatically and water clarity decreases. Elevated phosphorus levels produce the excessive algal growth.

Lake Aquatic Plants

There are fair stands of emergent vegetation that include cattails and bulrushes in shallow water near the shoreline which is beneficial as a filter for nutrients and as fish and wildlife habitat. Aquatic plant diversity is good with 20 different species identified. Curlyleaf pondweed, an exotic plant, is present in Big Round and grows to nuisance conditions in the western and northern areas of the lake.

Lake Report Card

- Lake water quality results are below average compared to Ecoregion values, meaning there is room for improvement.
- The water quality of the incoming Straight River is good and does not appear to be the source of algae blooms, rather it appears that in-lake processes (curlyleaf dieback and lake sediment nutrient release) may be the source of phosphorus contributing to algae blooms.
- The data base does not have enough years of data to examine trends, however Big Round Lake apparently has had poor water quality since at least 1980, when a WDNR report was prepared. However, Big Round Lake has the potential to get better.

Water Quality Improvement Strategy

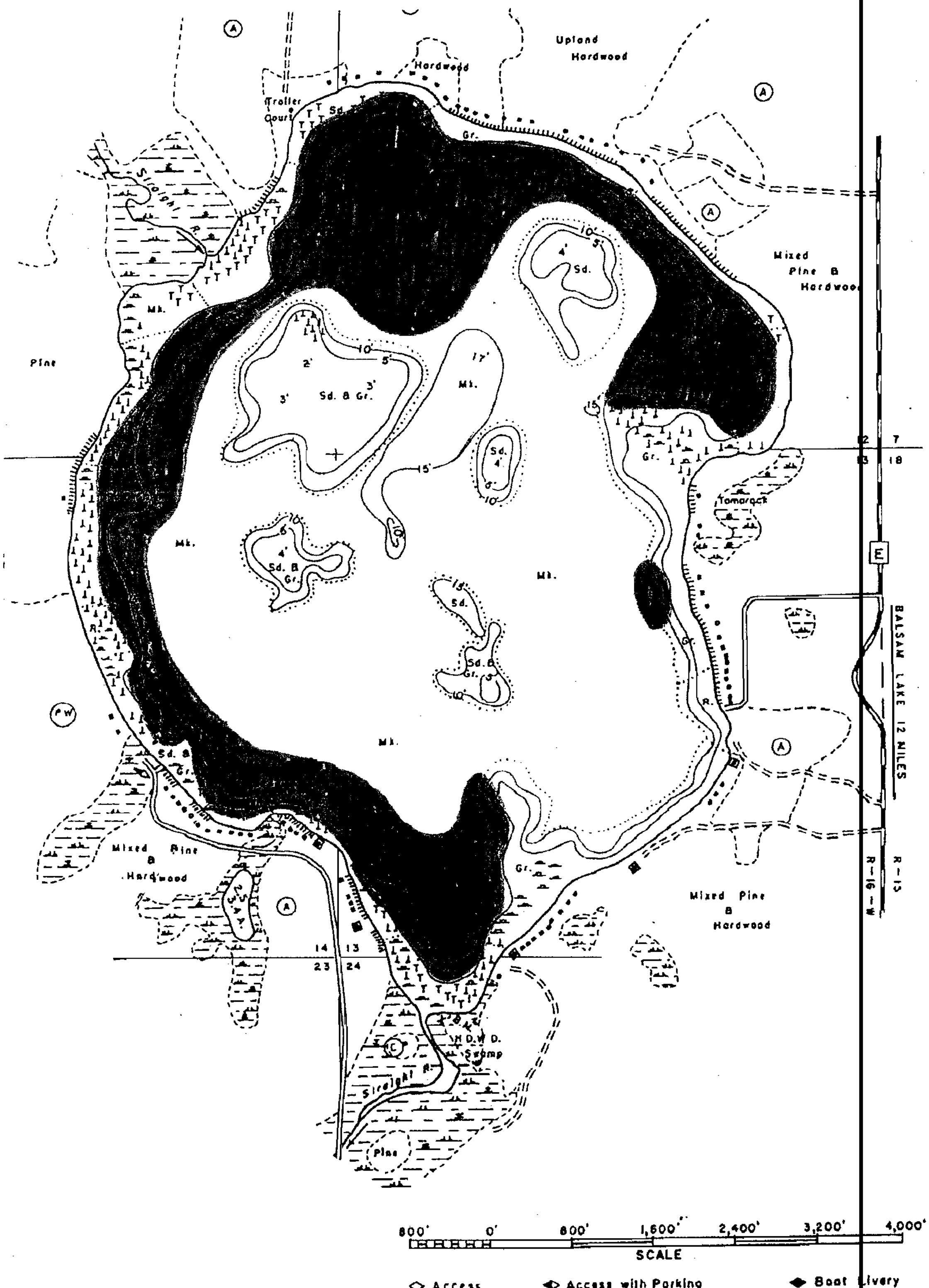
Big Round Lake is a drainage lake, meaning that there is significant stream inflow into the lake. The watershed to lake surface ratio of 19 to 1 is higher than glacial seepage lakes (seepage lakes have no major streams and generally have a watershed to lake surface ratio of 10 to 1 or less). Although the Big Round Lake watershed is moderately large, the water quality of the Straight River is very good. Using the phosphorus loading associated with just the Straight River in a lake model indicated Big Round Lake should have lower phosphorus concentrations and better water clarity than what has been observed.

It appears there is an additional phosphorus source that is impacting Big Round Lake and elevating the phosphorus concentration. The phosphorus source is likely from the lake itself. Lake water quality probably will not improve unless the in-lake phosphorus sources are reduce

Two sources of excessive lake generated phosphorus are from curlyleaf pondweed dieback and from lake phosphorus release from the sediments.

The first choice to reduce in-lake phosphorus levels is by manipulating the lake biology by way of reducing the curlyleaf pondweed distribution. Reducing nuisance curlyleaf pondweed growth would address two issues: reduce early summer nuisance growth of an exotic plant and reduce phosphorus inputs from curlyleaf dieback. It is predicted water quality would improve, but at this time there is not enough information available to determine the benefit on water quality improvement with a curlyleaf program. A recommended project is to collect data on nuisance curlyleaf distribution and sample tissue and sediment concentrations which will help to determine the long term likelihood of nuisance growth. Then implementation of a long term curlyleaf control program is recommended.

Curlyleaf Pondweed Coverage in Big Round Lake, May 7, 2003



The lake sediments represent another potential, but unquantified, phosphorus source to Big Round Lake, For reducing phosphorus release from lake sediments there are two good techniques to choose from: summer aeration or alum. Lakes in Polk County have examples of each technique. Cedar Lake has had aeration for several years and Lake Wapagasset had an alum treatment in 2001. In each case, water quality improvements have been modest. There is no guarantee that either technique will satisfactorily solve the nutrient release problem.

The most common technique to reduce sediment phosphorus release from lakes and a potential project for Big Round is alum, but it would be expensive, costing around $900,000. If the alum treatment was 100% effective in reducing the excessive phosphorus release from lake sediments, lake phosphorus levels would drop significantly in the lake but transparency would increase only about 1.6 feet as a seasonal average. Also there is no guarantee the effect would last longer than several years. It is recommended that an alum treatment be delayed until it can be determined if controlling curlyleaf pondweed can have a beneficial water quality impact.

Recommended Lake Management Programs and Projects

1. Watershed projects: In conjunction with Polk County Land and Water Resources Department, maintain programs that promote the increased use of conservation tillage, grass waterways, and nutrient management techniques.

2. On-site system maintenance: On-site wastewater treatment systems operate satisfactorily when they are properly installed and maintained. Several activities can be implemented to assist in proper operation of the system. These activities include workshops, septic tank pumping campaigns, and ordinance implementation.

Polk County requires every septic tank associated with a permanent residence pumped 2-3 years in the shoreland area to help reduce phosphorous loading to the septic system drainfield. This is the law.

3. Landscaping projects: Big Round Lake has stretches of natural shoreline conditions but natural shoreline conditions are lacking along some of the developed parcels. The challenge is to protect the existing natural conditions and to enhance shorelands that lack native vegetative buffers. A volunteer lakescaping program should be implemented.

4. Aquatic plant projects: Aquatic plants are important in Big Round Lake for fish habitat and for helping sustain good water quality. Although there is good aquatic plant diversity with 20 species identified, one exotic aquatic plant species, called curlyleaf pondweed, was found in Big Round Lake. This species should be controlled. A 3-phase aquatic plant management program is recommended. The first phase is to maintain and enhance native aquatic vegetation including shoreline plants. The second phase it too characterize lake sediments for fertility levels and the third phase is to experiment with curlyleaf pondweed control techniques.

5. Fish management options: Big Round Lake has a well-balanced fish community based on WDNR records. Walleye and northern pike spawning habitat should be protected.

6. Ongoing education program: Results from the lake questionnaire indicated lake residents rely heavily on getting lake information from the Lake District. A newsletter would be a good ongoing instrument to provide lake protection information. Abundant material is available that can inserted into newsletters.

7. Watershed and lake monitoring program: Ongoing testing should include: Secchi disk, total phosphorus, or chlorophyll a levels in the lake. The level of effort depends on the availability of volunteers and funding levels.

1. Introduction and Project Setting

Big Round Lake is located in Polk County, Wisconsin (Figure 1). Big Round 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 (WDNR 1980).

	Big Round Lake
Size (acres)	1,015
Mean depth (ft)	10
Maximum depth (ft)	17

Figure 1. Big Round Lake is located in Polk County, Wisconsin.

2. Glaciers and Soils

Big Round 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. 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.

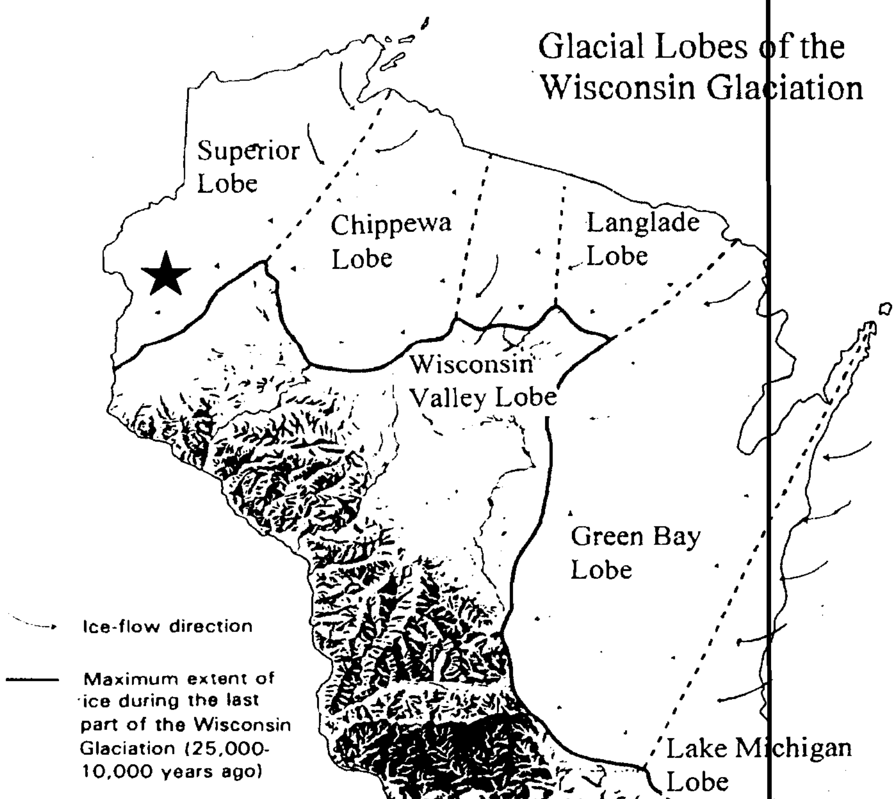


Figure 2. Glacial lobes of the Wisconsin glaciation. Big Round Lake is located in the Superior lobe.

Soil composition reflects the parent material that is present. Big Round Lake is located in an area dominated by forested silty soils and adjacent to forested loamy soils (Figure 3).

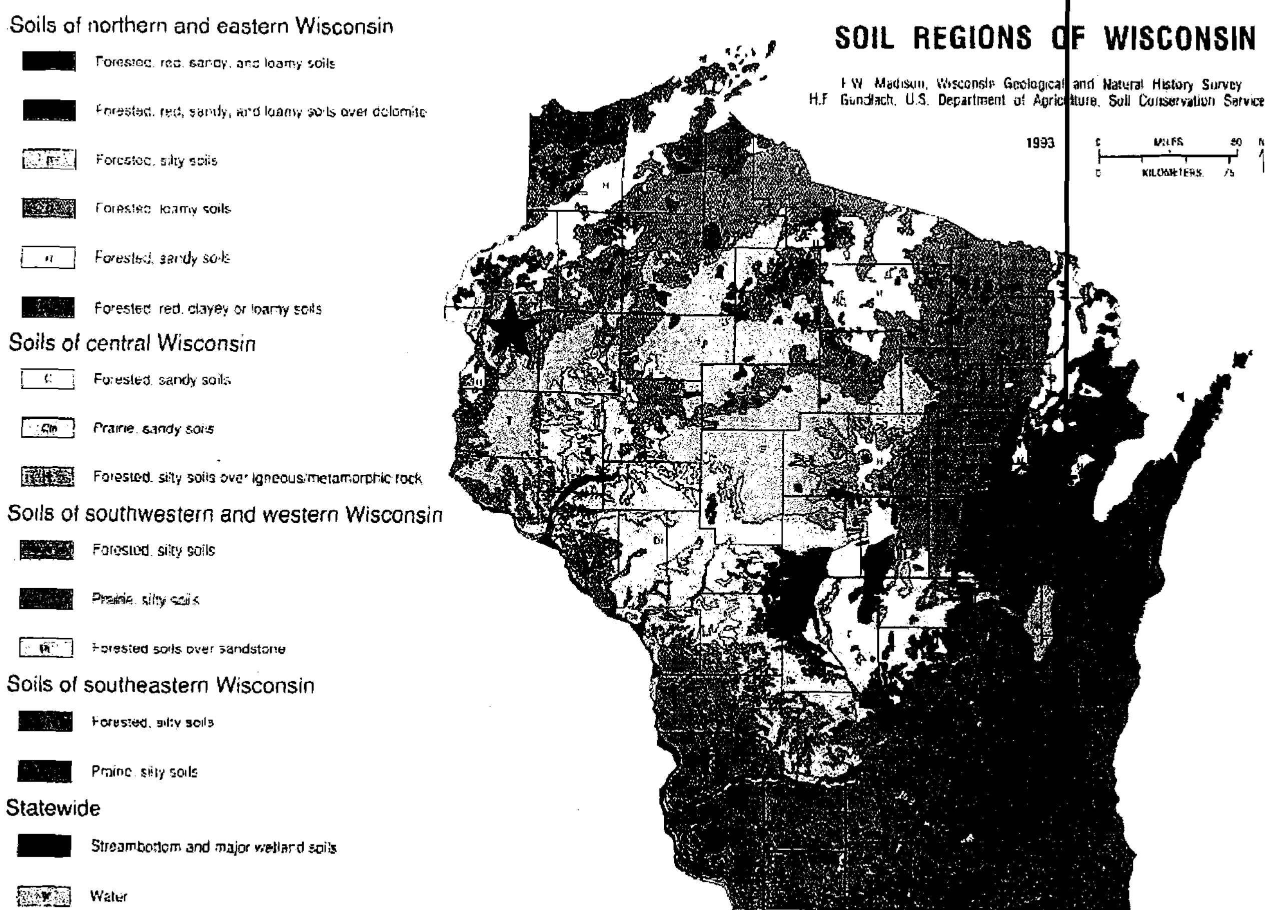


Figure 3. Big Round Lake is located within a soils group characterized as forested silty soils.

3. Watershed Features

3.1. Drainage Area and Land Use of Big Round Lake

Drainage area to Big Round Lake is 18,880 acres (based on USGS estimates from a 2000 report*) and the delineation is shown in Figure 4.

Big Round Lake and its watershed are located within several Townships in Polk County. Big Round Lake as well as its watershed lies from northwest to southeast.

Land use within the watershed is shown in Table 2. Forested land is the dominant land use.

Table 2. Land use in Big Round Lake watershed (from USGS 2000*).

	Acres	Percent
Agricultural	1,510	8
Grassland	4,531	24
Forested	8,684	46
Wetland and open water	3,210	17
Lake	1,015	5
Total Watershed Area	18,880	100%

The watershed to lake ratio of Big Round Lake is 19 to one. Big Round Lake experiences midsummer algae blooms but has a good fishery. To improve good water quality in years to come, conservation measures in the watershed and on the lakeshore of Big Round Lake should be considered. However, in-lake projects will probably be necessary as well to improve overall lake water quality.

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* Saad, D.A. and D.M. Robertson. 2000. Water-resources related information for the St. Croix Reservation and vicinity, Wisconsin. US Geol. Survey, Water Resources Invest. Rep 00-4133, Middleton, Wisconsin.

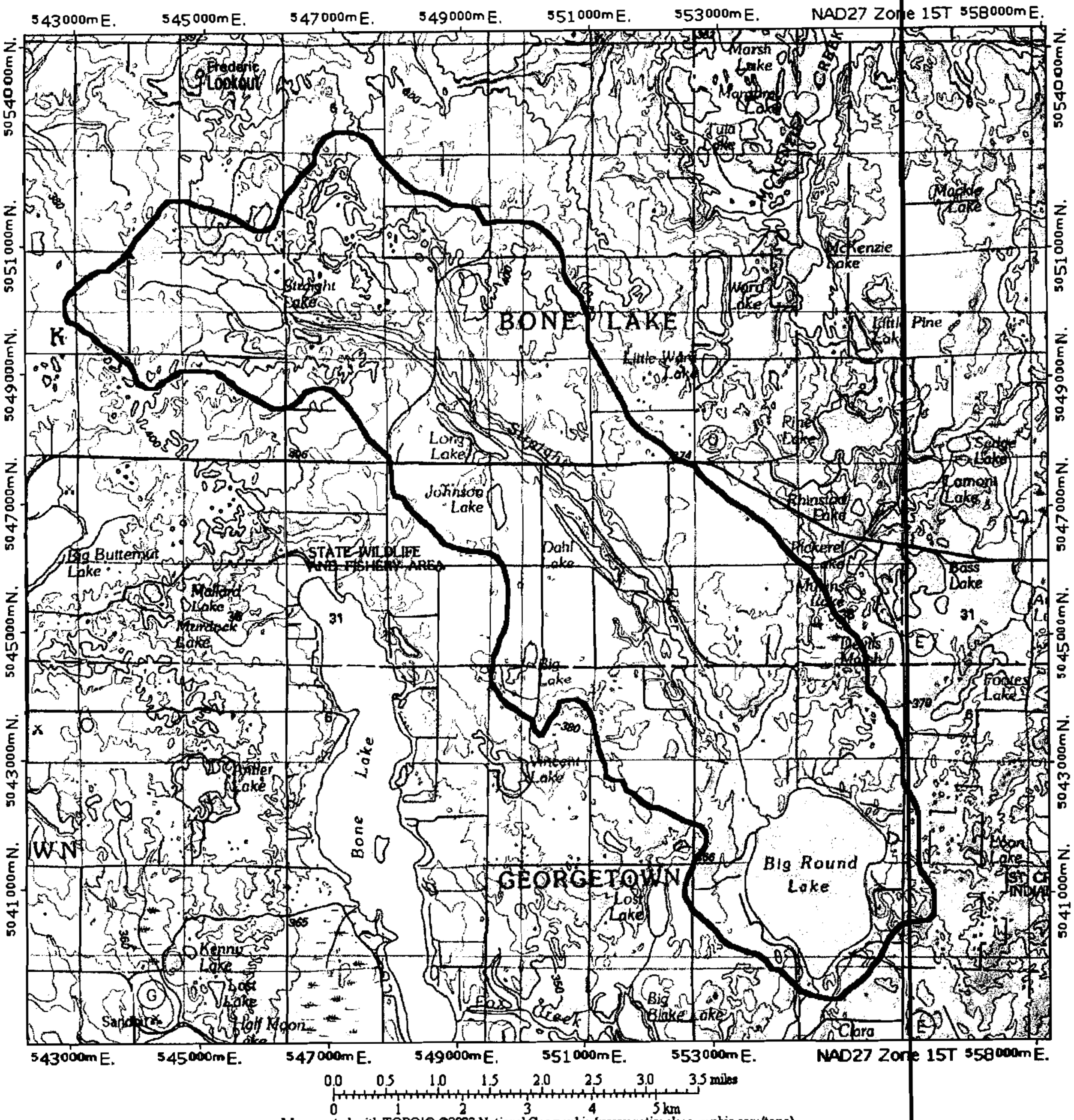


Figure 4. Watershed area for Big Round Lake (source: USGS 2000).

3.2. Source of Water and Nutrients to Big Round from the Straight River

Water: Source of water to Big Round Lake is from a combination of Straight River inflow, surface runoff, rainfall, and groundwater. The amount of water flowing into and out of Big Round Lake is estimated to be about 20 cubic feet per second. Flows were estimated based on runoff amounts listed for Polk County in the Wisconsin Spreadsheet Lake Model (Table 3).

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

Drainage area (acre)	18,880
Average yearly runoff for Polk County (feet)(from WDNR WILMS Model)	0.66
Total water inflow (acre-feet)	12,460

The estimated 12,460 acre-feet of water flowing into Big Round Lake would be enough water to fill a swimming pool the size of a football field to a depth of 12,000 feet. It would also be enough drinking water to supply a town of 149,000 for a year.

Although this is a lot of water coming into Big Round Lake, the volume of Big Round Lake is 10,150 acre-feet. If Big Round Lake completely dried up, it would take 10 months to fill.

Watershed Nutrients: A major source of watershed nutrients to Big Round Lake is from the Straight River that carries in phosphorus along with suspended sediments. Stream sample results for 2001, 2002, and 2003 are listed in Table 4.

The primary source of phosphorus from the watershed of Big Round Lake is from forested areas and agricultural runoff.

Table 4. Straight River, total phosphorus data.

Date	Total Phosphorus (ppb)	
	Site 1 (Lat 45°33'49.63"N, Long 92°19'52.49"W) Headwaters	
2001 (sampled by the Tribe)		
May 30	<84	--
June 27	30	--
July 30	<21	--
August 29	40	--
AVERAGE	--	
2002 (sampled by the Tribe)		
June 19	50	--
July 23	30	--
August 20	40	--
September 18	40	--
AVERAGE	**40**	
2003 (sampled by the Lake District)	**Site 1 (50 paces south of 250th)**	**Site 2 (75 paces north of inlet)**
May 20	41	46
June 17	43	68
July 16	33	45
August 20	35	67
September 16	32	43
AVERAGE	**37**	**54**

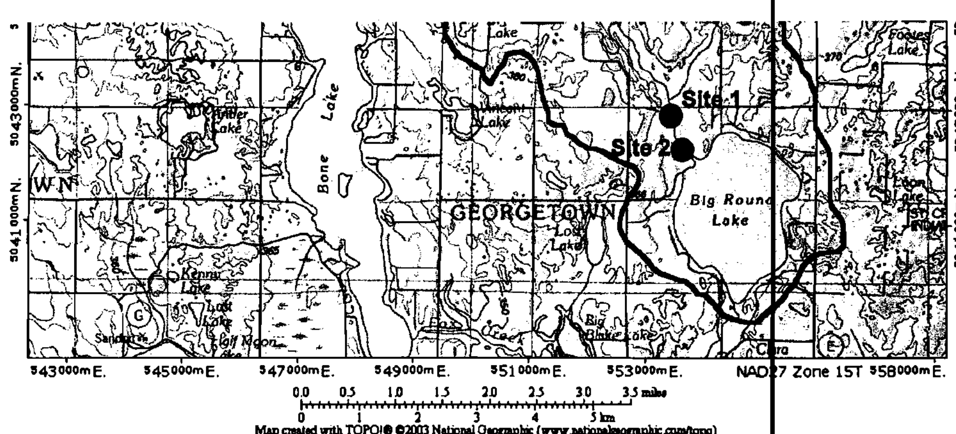


Figure 5. Site map of stream sample locations.

3.3. 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 Round Lake shoreline was conducted in August of 2003 by lake resident volunteers, Wayne Schue and Denis Tinkhan. The objectives of the survey were to characterize existing shoreland conditions which will serve as a benchmark for future comparisons.

For each photograph Blue Water Science staff 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. Although the shoreline ordinance for new development is a 35-foot deep buffer, a 15-foot deep buffer is about the minimum needed to achieve some degree of runoff water quality treatment. We evaluated shorelines and uplands at the 75% natural level as well (Figure 6 illustrates the methodology).

A summary of the inventory results is shown in Table 5. Based on our subjective criteria about 27% of the parcels in the Big Round Lake shoreland area meet the natural ranking criteria for shorelines and upland areas. This is slightly below median for "country lakes" where 50% of the parcels meet the "natural" criteria. County lakes are defined as lakes found about 1 to 2 hours driving time outside of a major Metropolitan area such as Minneapolis/St. Paul or Milwaukee.

In the next 10 years proactive volunteer native landscaping could improve the natural aspects of a number of parcels.

Table 5. Summary of shoreline buffer and upland conditions in the shoreland area of Big Round Lake. Approximately 74 parcels were examined.

Big Round Lake	Natural Shoreline Condition		Natural Upland Condition		Undevel. Photo Parcels	Shoreline Structure Present	
	>50%	>75%	>50%	>75%		riprap	wall
TOTALS (no. of parcels = 74)	39% (29)	34% (25)	27% (20)	24% (18)	14% (10)	12% (9)	1% (1)

A comparison of Big Round Lake conditions to other lakes in Minnesota and Wisconsin is shown in Table 6 and in Figure 7.

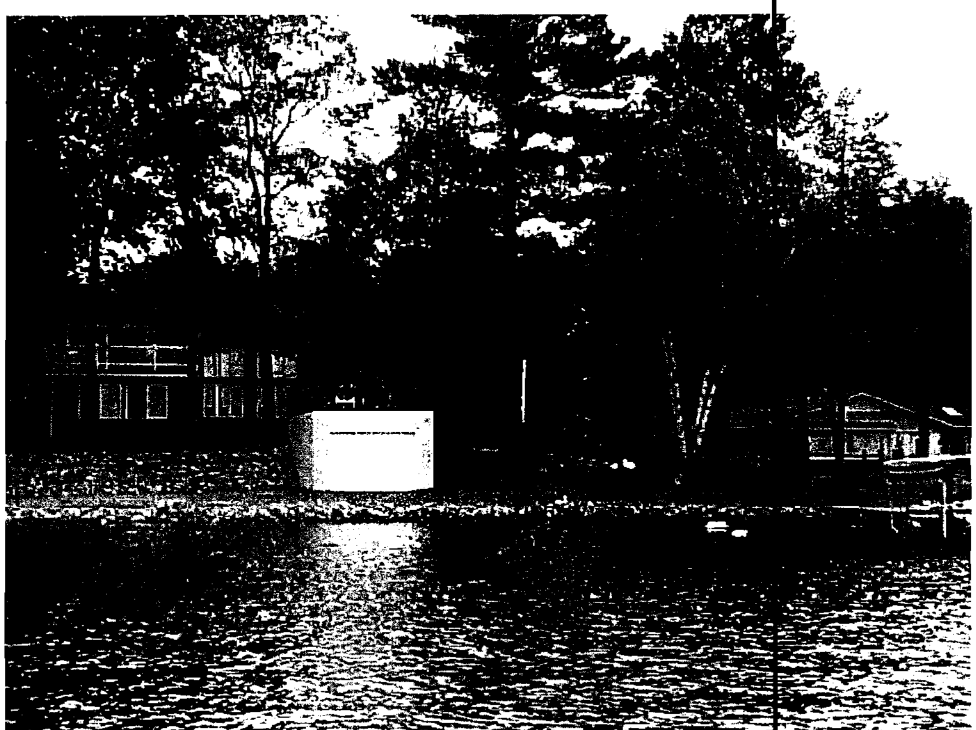


Figure 6. [top] This parcel would rate as having a shoreline with a buffer greater than 50% of the lot width and an understory with greater than 50% natural cover. [bottom] This parcel would not qualify as having a natural shoreline buffer greater than 50% of the lot width. Also understory in the upland area would be rated as having less than 50% natural cover.

Table 6. Summary of shoreland inventories from Big Round Lake and 25 other lakes in Minnesota and Wisconsin.

Lake	Eco-region	Date of Survey	Total Number of Parcels (#)	Undevel. Parcels % (#)	Natural Upland Condition > 50% % (#)	Natural Upland Condition >75% % (#)	Natural Shoreline Condition > 50% % (#)	Natural Shoreline Condition >75% % (#)	Parcels with Erosion % (#)	Parcels with Shoreline Revetment % (#)
Big Round Lake, Polk Co, WI	CHF	8.03	74	14 (10)	27 (20)	24 (18)	39 (29)	34 (25)	1 (1)	14 (10)
Lake Volney, Le Sueur Co, MN	CHF	9.21.02	79	25 (20)	54 (43)	42 (33)	56 (44)	47 (37)	0	30 (24)
Diamond Lake, Kandiyohi Co, MN	CHF	8.13-14.02	344	2 (7)	13 (44)	11 (39)	16 (56)	12 (42)	1 (5)	49 (168)
Green Lake, Kandiyohi Co, MN	CHF	9.19.01	721	1 (9)	20 (146)	12 (88)	19 (140)	14 (100)	0	62 (446)
Orchard Lake, Dakota Co, MN	CHF	9.17.01	109	4 (4)	47 (51)	30 (33)	53 (58)	32 (35)	0	54 (59)
Ravine Lake, Washington Co, MN	CHF	7.19.01	9	100 (9)	100 (9)	100 (9)	100 (9)	100 (9)	0	0
Rush Lake, Chisago Co, MN	CHF	9.16.00	524	11 (58)	48 (253)	28 (147)	51 (267)	38 (201)	1 (3)	18 (92)
West Rush	CHF	9.16.00	332	12 (40)	52 (171)	31 (103)	55 (184)	43 (142)	1 (2)	15 (50)
East Rush	CHF	9.16.00	192	9 (18)	43 (82)	23 (44)	43 (83)	31 (59)	1 (1)	22 (42)
Maple Grove Lake Summary, MN	CHF	9.30 - 10.12.99	644	14 (89)	67 (431)	48 (312)	60 (385)	48 (310)	1 (3)	20 (129)
Cedar Island	CHF	9.30 - 10.12.99	93	5 (5)	62 (58)	35 (33)	55 (51)	39 (36)	0	22 (21)
Eagle	CHF	9.30 - 10.12.99	90	14 (13)	64 (58)	52 (47)	47 (42)	41 (37)	0	35 (32)
Edward	CHF	9.30 - 10.12.99	34	12 (4)	91 (31)	88 (30)	76 (26)	71 (24)	6 (2)	3 (1)
Fish	CHF	9.30 - 10.12.99	170	7 (12)	74 (126)	44 (75)	57 (97)	41 (70)	1 (1)	20 (34)
Pike	CHF	9.30 - 10.12.99	9	56 (5)	100 (9)	100 (9)	100(9)	100 (9)	0	0
Rice	CHF	9.30 - 10.12.99	137	33 (45)	71 (97)	64 (87)	81 (111)	74 (102)	0	19 (25)
Weaver	CHF	9.30 - 10.12.99	111	5 (5)	47 (52)	28 (31)	44 (49)	29 (32)	0	14 (16)
Powers, Woodbury, MN	CHF		30	90 (27)	90 (27)	90 (27)	97 (29)	97 (29)	0	0
Upper Prior, Scott Co, MN	CHF	9.30- 10.12.99	366	10 (37)	51 (187)	36 (132)	35 (128)	31 (113)	4 (15)	46 (168)
Lower Prior, Scott Co, MN	CHF	9.24- 30.99	691	10 (66)	36 (249)	24 (166)	22 (152)	17 (117)	5 (35)	54 (373)
Comfort, Chisago Co, MN	CHF	10.9- 11.2.98	100	--	62 (62)	--	50 (50)	--	--	12 (12)
Big Bear Lake, Burnett Co, WI	LF	9.11.02	87	13 (11)	82 (71)	62 (54)	86 (75)	76 (66)	0	9 (8)
Upper Turtle Lake, Baron Co, WI	CHF	7.23-24.02	309	28 (85)	72 (224)	58 (178)	76 (234)	68 (209)	0	20 (63)
Pike Chain, Price & Vilas Co, WI			722	380	92 (633)	87 (626)	95 (684)	91 (654)	--	5 (34)
Plum Lake, Vilas Co, WI	LF	7.26.01	225	13 (30)	75 (169)	58 (130)	81 (182)	70 (158)	--	9(4)
Nancy Lake, Washburn Co, WI	LF	9.21.00	217	19 (41)	77 (167)	65 (141)	80 (174)	72 (156)		5 (11)
Big Bearskin, Oneida Co, WI	LF	8.10.99	130	--	73 (95)	63 (82)	80 (104)	67 (87)	--	0
Ballard chain, Vilas Co, WI	LF	7.23.99	110	--	98 (108)	96 (106)	96 (106)	95 (105)	--	0
Bear, Oneida Co, WI	LF	6.8.99	115	6 (7)	93 (107)	78 (90)	84 (97)	77 (89)	1 (1)	8 (9)

* CHF = Central Hardwood Forest Ecoregion
** LF = Lake and Forests Ecoregion

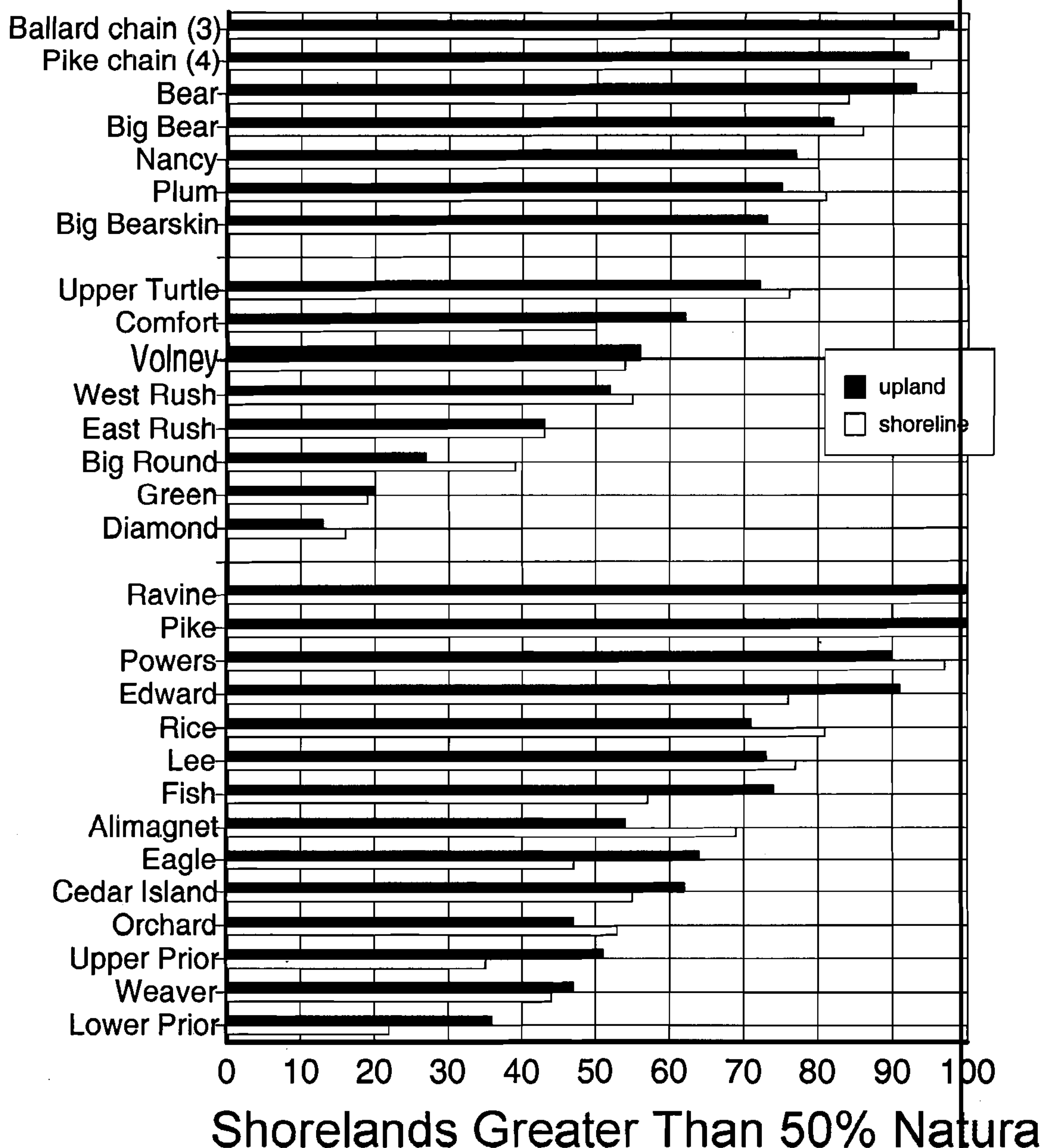


Figure 7. A summary of shoreland inventory results for lakes using an evaluation based on shoreland photographs. For each lake the percentage of shoreline and upland conditions with greater than 50% natural conditions is shown. The first tier of lakes are located in northern Wisconsin. The lower tier of lakes are in the Twin City Metropolitan area and are considered urban lakes. Although several lakes are "urban" lakes most of the shoreland is owned by the city and there is a high percentage of natural conditions. The middle tier of lakes are about an hour or two drive from the Twin Cities, and are not considered to be urban lakes, they are "country" lakes.

Big Round Lake is a country lake. It's natural shoreland conditions are slightly below average compared to the other country lakes in the middle tier.

Big Round Lake Wildlife Inventory - 2003

Late May:
Two Swans

June:
Great Blue Heron
Brown Cowbird – Male and Female
Rose Breasted Grosbeak – Male and Female
Nuthatch
Black Capped Chickadee
Red Bellied Woodpecker
Red Headed Woodpecker
American Goldfinch – Male and Female
Downy Woodpecker
Purple Finch
Blue Jay
Common Loon

June:
Bald Eagle
Mourning Dove
Mallard/Drake With Babies
Gulls
Humming Bird – Male and Female
Crow

Bluebird
Scarlet Tanager
Wild Turkey
Canadian Geese
White Tailed Deer

Chipmunk
Grey and Black Squirrels
Muskrats
Turtles

August:
Raccoon and 5 Litter

September:
Belted Kingfisher
Muskrat

Eastern Wood Peewee

October:
Tundra Swans

November:

Cardinals
Nuthatches
Chickadees
Grosbeaks
Pileated Woodpecker

Know of three people on our road (210th Ave) that have seen bears. Two saw a large one and the third saw a cub. We had one bird feeder destroyed by a bear

James and Barb Berten

Although bald eagles are quite common on our lake, we witnessed an interesting event. There were hundreds of coots congregating on our shoreline. As a bald eagle flew over, they would huddle together and flap their wings for protection. We then noticed a couple of stragglers from the group. Suddenly the eagle descended and picked up the coot and away he flew. It was breathtaking to witness

Truman and Marlene Roach

I was raking leaves on my property in October and heard something coming down the driveway. As I popped my head around an evergreen tree a whitetail buck deer stopped about 30 feet from me. It starred at me for a few seconds then took off back into the woods. This is what I like most about being on the lake. Witnessing wildlife in its native habitat.

Tim and Julie Hudson

3.4. Groundwater and On-site 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 which are salty have much higher conductivity than fresh water lakes. For the conductivity survey on Big Round 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 Round Lake.

Results are shown in Figure 8. The background or base conductivity was 150-151 umhos/cm. Only one area around Big Round Lake had a conductivity reading above background. The elevated conductivity readings could be an indicator of septic tank effluent inputs. However, just because a conductivity reading is elevated, it does not mean it is a phosphorus source. Additional testing is necessary.

Results also suggest that Big Round Lake may be receiving groundwater inflows in several areas (Figure 8). It is not surprising that springs are found in Big Round Lake. This was an active glacial area is the past and often leads to subsurface groundwater inflows.

It is interesting that results from 2003 that detect groundwater inflow are similar to findings from a WDNR groundwater study in 1980 (Figure 8). In the 1980 WDNR study, a series of observation wells were installed and monitored over the course of the 1980 project investigation. It appears that the conductivity survey conducted in 2003 was able to discern areas of groundwater inflow comparable to the more rigorous approach of using monitoring wells. These conductivity surveys are a handy tool to help illustrate active groundwater areas in lakes.

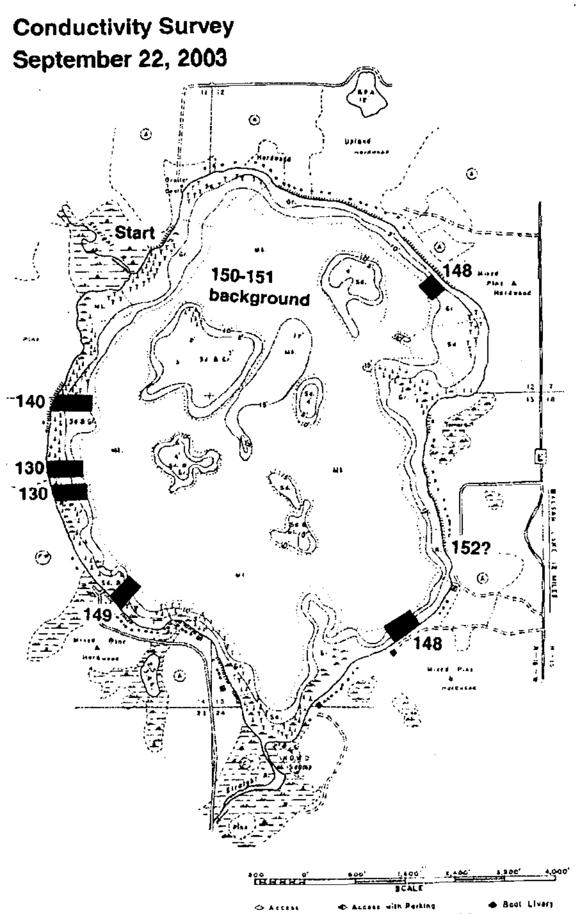


Figure 8. [left] Big Round Lake conductivity survey, September 22, 2003. [right] Big Round Lake well survey conducted by WDNR 1980.

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 9. 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.

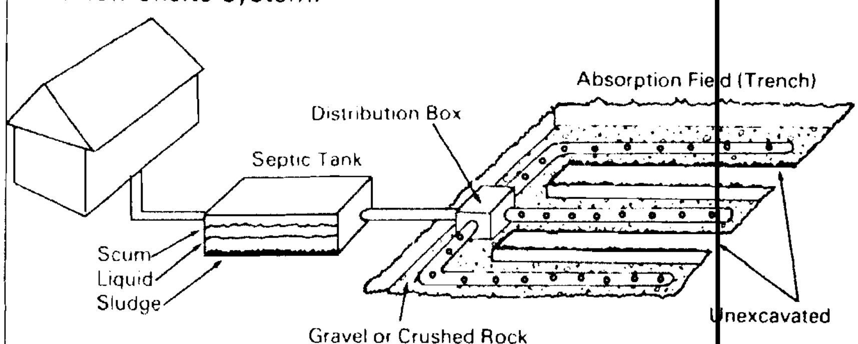


Figure 9. Typical onsite wastewater treatment system found in the Big Round Lake watershed.

3.5. Watershed Nutrient Inputs

The watershed area that drains to Big Round Lake is dominated by forested acreage and nutrient inputs from the watershed are considered modest based on stream sampling results.

Special efforts have been conducted by the St. Croix Chippewa Community and by lake volunteers to explore and sample the stream that flows into Big Round Lake. Results of the water testing indicate the pounds of phosphorus coming into Big Round Lake are actually less than would be expected for the ecoregion. The Straight River does not appear to be polluted.

Annual watershed phosphorus inputs have been estimated at 2,388 pounds of phosphorus per year. Phosphorus inputs from four sources have been estimated and are shown in Figure 10.

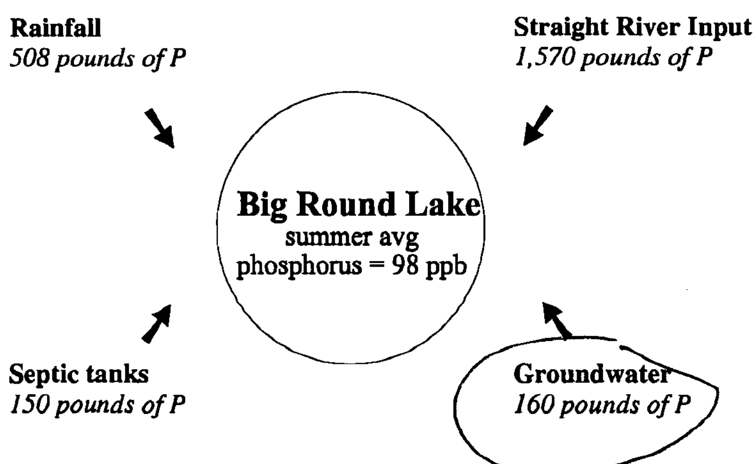


Figure 10. Sources of watershed phosphorus (P) that feed into Big Round Lake are shown above. It is estimated that approximately 2,388 pounds of phosphorus enter Big Round Lake on an annual basis.

For the Straight River phosphorus input, a stream phosphorus concentration of 40 ppb was used and an annual flow of about 20 cubic feet per second represents the water load, then the total annual phosphorus load from the Straight River is roughly 1,570 pounds.

Rainfall phosphorus inputs are about 0.50 pounds of phosphorus per surface lake acre and represent about 508 pounds of phosphorus per year.

For onsite system inputs, the WILMS model was used. Based on 30 permanent residences and 150 seasonal residences a phosphorus loading from septic systems is about 150 pounds per year.

Phosphorus loading from groundwater is another phosphorus source to Big Round Lake. The WDNR lake study in 1980 measured phosphorus concentrations in groundwater at 27 ppb. They estimated 160 pounds of phosphorus enters Big Round Lake from groundwater and thats the number used in this report.

In addition to the watershed phosphorus loading, phosphorus from the lake basin itself enters into the Big Round Lake water column. Two sources of in-lake phosphorus are from the die back of curlyleaf pondweed and from phosphorus release from lake sediments. These phosphorus sources will be evaluated in the lake section.

The total estimated annual watershed phosphorus load to Big Round Lake is estimated at 2,388 pounds.

4. Lake Features

4.1. Lake Map and Lake Statistics

Big Round Lake is approximately 1,015 acres in size, with a watershed of 18,880 acres. The average depth of Big Round Lake is 3 meters (10 feet) with a maximum depth of 5 meters (17 feet) (Table 7). A lake contour map is shown in Figure 11. Big Round Lake is located in an area of Wisconsin that is dominated by forests and open land.

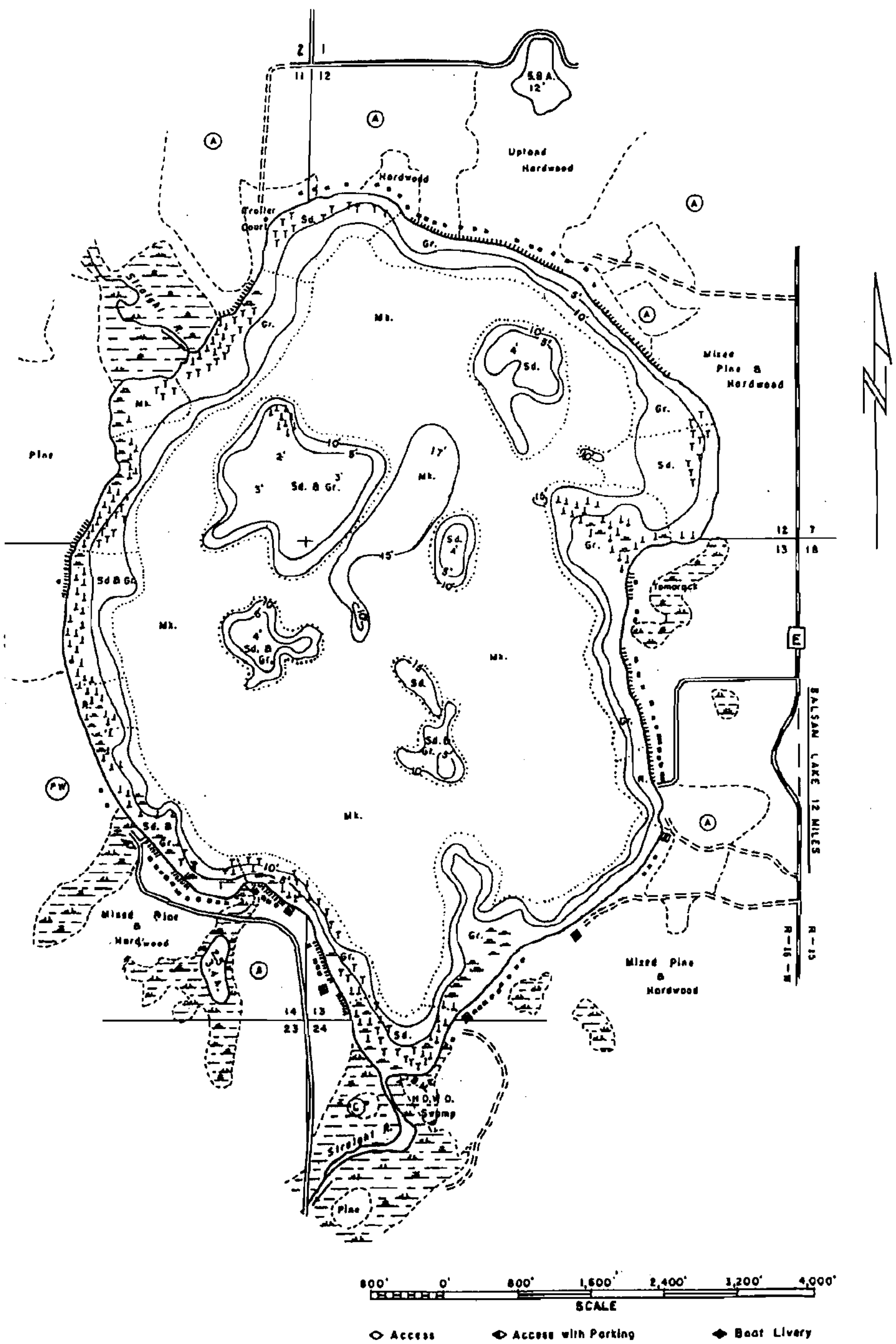


Figure 11. Big Round Lake, Polk County, Wisconsin.

Table 7. Big Round Lake Characteristics

Area (Lake):	1,015 acres (411 ha)
Mean depth:	10 feet (3 m)
Maximum depth:	17 feet (5 m)
Volume:	10,150 acre-feet (1,233 Ha-M)
Fetch (longest open water distance):	mile (km)
Watershed area (including lake area):	18,880 acres (7,641 ha)
Watershed: Lake surface ratio	19 :1
Public accesses (#):	1
Inlets:	Straight River

Bulrush beds are abundant on the west side of Big Round Lake and serve as good fish habitat.

4.2. Dissolved Oxygen and Temperature

The summer dissolved oxygen and temperature profiles are shown in Figure 12.

A profile was obtained each month from July and September, 2002. 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 July profile show that the lake was thermally stratified. **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.

The July profile indicates that the epilimnion extended to a depth of about 12 ft, and that oxygen was present at all depths.

However, in the 1980 WDNR feasibility study, it was found over the course of the summer that there were periods when dissolved oxygen was depleted in the bottom water. There was also strong evidence that phosphorus was subsequently released from the lake sediments.

Because Big Round Lake is relatively shallow, it appears the lake can mix over the summer. This is how phosphorus that is released from the lake sediments can be transported up into the water column.

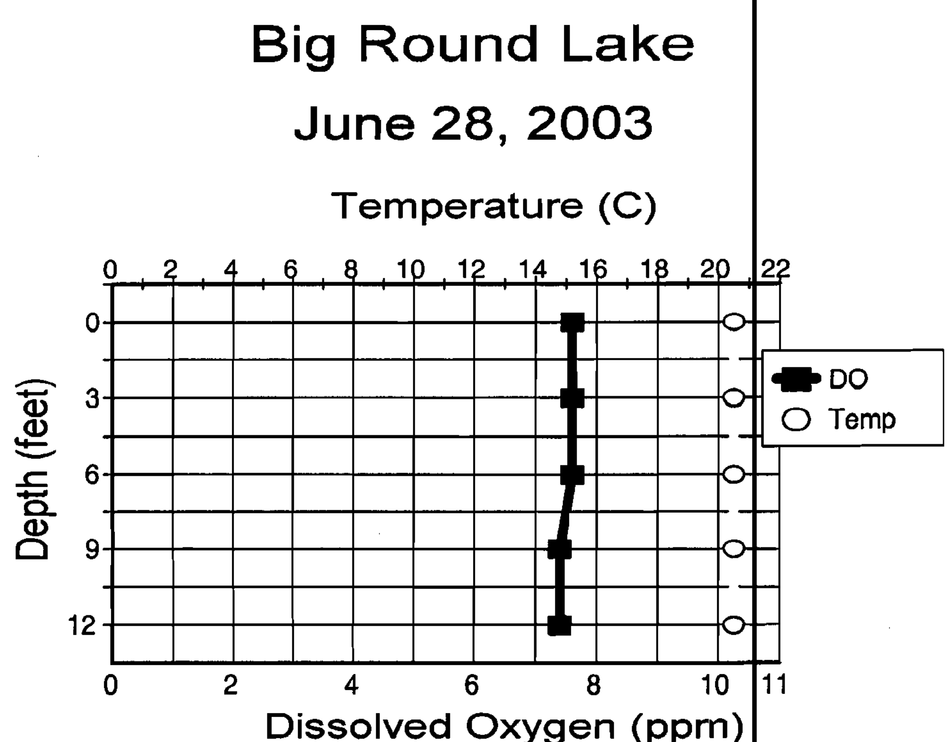


Figure 12. Dissolved oxygen (DO)/temperature profiles for June 28, 2003. Dissolved oxygen data are shown with squares and temperature with circles.

4.3. Lake Water Quality Summary

Summer water chemistry data collected during 2002 included secchi disc, total phosphorus (TP), and chlorophyll a (Chl a) (Table 8). Samples were collected at the surface and two feet off the bottom in the deepest area of Big Round Lake. Total phosphorus was higher in the bottom water than the top water indicating some phosphorus release from the bottom material (sediments or plants) may be occurring, but it is minor. Overall, the three water quality indicators (Secchi disc, total phosphorus, and chlorophyll a) in 2002 indicate Big Round is in fair shape.

Table 8. Big Round Lake 2001 data (collected by St. Croix Tribe).

Date	Secchi Disc (m)		TP - top (ppb)	TP - bottom (ppb)	Chlorophyll a (ppb)
	Site 14	Site 15	Site 14	Site 14	Site 14
4.30.01		1.2			
5.30.01	1.4		<84	<84	8
6.11.01		2.6			
6.27.01	1.7		30	30	9
7.9.01		1.4			
7.30.01	0.85		61	76	67
8.14.01		0.45			
8.29.01	0.3		220	210	116
Average	**1.1**	**1.5**	**104**	**100**	**50**

Big Round Lake 2002 data (collected by St. Croix Tribe).

Date	Secchi Disc (m)		TP - top (ppb)	TP - bottom (ppb)	Chlorophyll a (ppb)
	Site 14	Site 15	Site 14	Site 14	Site 14
6.19.02	1.4	1.2	30	4	15
7.23.02	1.7	0.7	50	4	71
8.20.02	0.7	0.8	160	5	84
9.18.02	1.2	1.4	90	20	38
Average	**1.25**	**1.0**	**83**	**8**	**52**

Big Round Lake 2003 data (collected by Lake District).

Date	Secchi Disc (ft)	TP - top (ppb)	TP - bottom (ppb)	Chlorophyll a (ppb)
5.6.03			18	
5.7.03	15.4			
5.24.03	11.3			
6.13.03	9.0			
6.17.03		37	26	8
6.18.03	8.9			
7.4.03	8.0			
7.16.03		58	35	12
7.21.03	5.3			
7.28.03	7.5			
8.5.03	2.4			
8.20.03	1.9	104	104	123
9.6.03	1.4			
9.16.03		170	179	169
9.22.03	3.6			
10.8.03	5.4			
Average	**6.8**	**107**	**72**	**101**

Viewing the results of Secchi disc summer averages from 2001 through 2002 indicates clarity is somewhat stable (Table 9 and Figure 13) from the perspective that there is no apparent trend for increasing or decreasing water clarity in Big Round Lake.

Table 9. Historical seasonal (May - September) average lake monitoring results for Big Round. The number in parenthesis is the number of data points used to calculate the seasonal average.

	Secchi Disc (ft)	Total Phosphorus (ppb) at top	Chl a (ppb) at top
2001	3.6 (4) / 5.0 (4)	104 (4)	50 (4)
2002	4.1 (4) / 3.3 (4)	83 (4)	52 (4)
2003	6.8 (11)	107 (4)	101 (4)

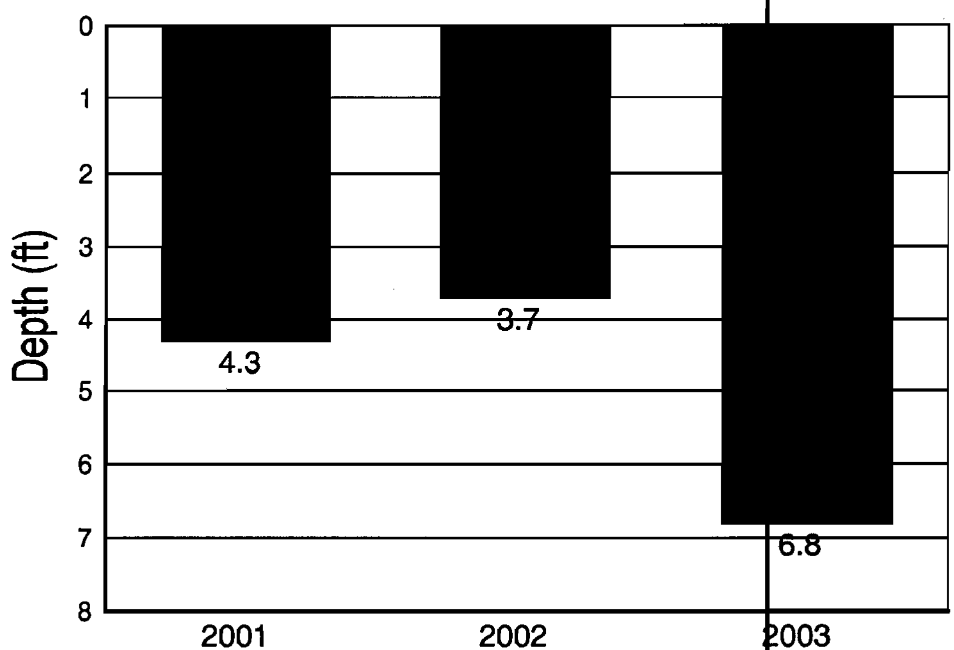


Figure 13. Annual summer Secchi disc averages for Big Round Lake.

4.3.1. Secchi Disc Transparency

Water clarity is commonly measured with a Secchi disc. A typical seasonal pattern shows good clarity in May and June with a drop off in July, August, and September (Figure 14). This is a typical pattern for lakes like Big Round Lake.

The low water clarity in late summer is due to algae blooms.

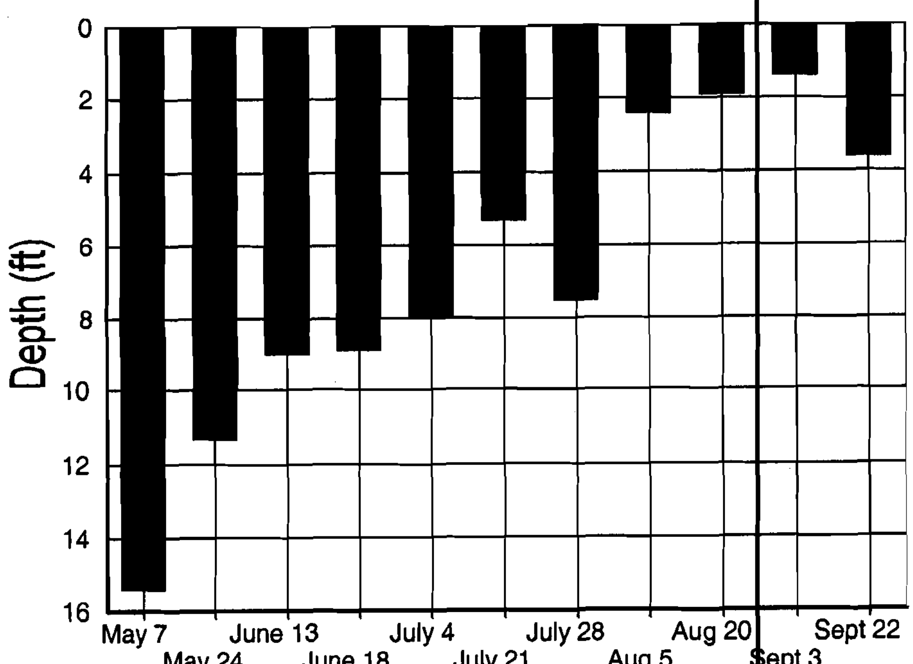


Figure 14. Monthly Secchi disc readings for 2003.

4.3.2. Total Phosphorus

Phosphorus is the nutrient more often associated with stimulating nuisance algae growth. Lake phosphorus concentrations for the summer of 2003 are shown in Figure 15. Phosphorus concentrations in Big Round Lake in early summer are moderate. However, by the end of the summer they are high enough to produce significant algae blooms.

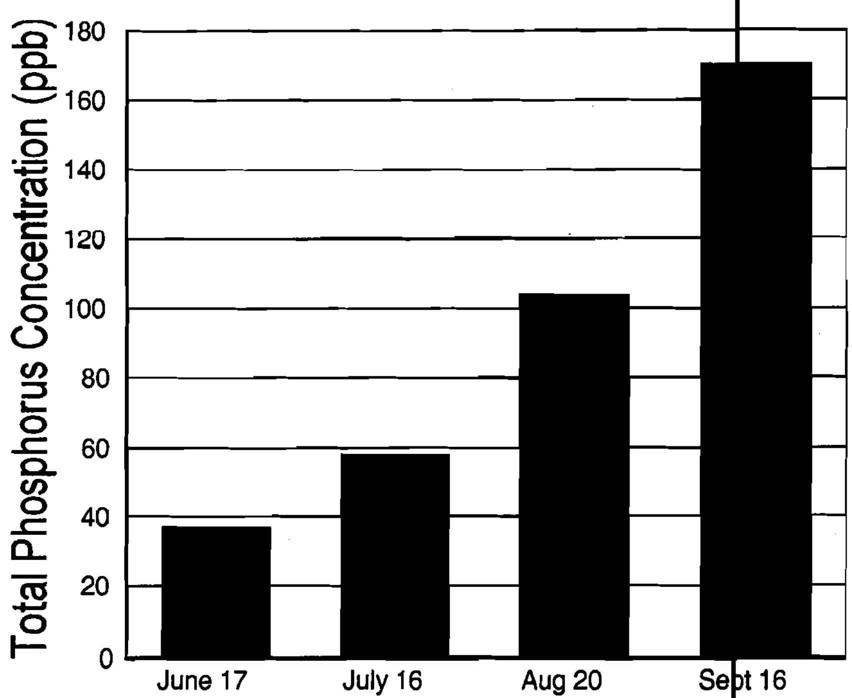


Figure 15. Monthly surface total phosphorus concentrations for 2003.

4.3.3. Chlorophyll

Algae are small green plants, often consisting of single cells or grouped together in filaments (strings of cells). Algae blooms are significant in Big Round Lake by the end of the summer. The amount of algae can be characterized by measuring the chlorophyll content in lake water. Chlorophyll results in 2003 are shown in Figure 16. In June and July chlorophyll was low and then increased in August and September. This is a common pattern for eutrophic lakes like Big Round Lake.

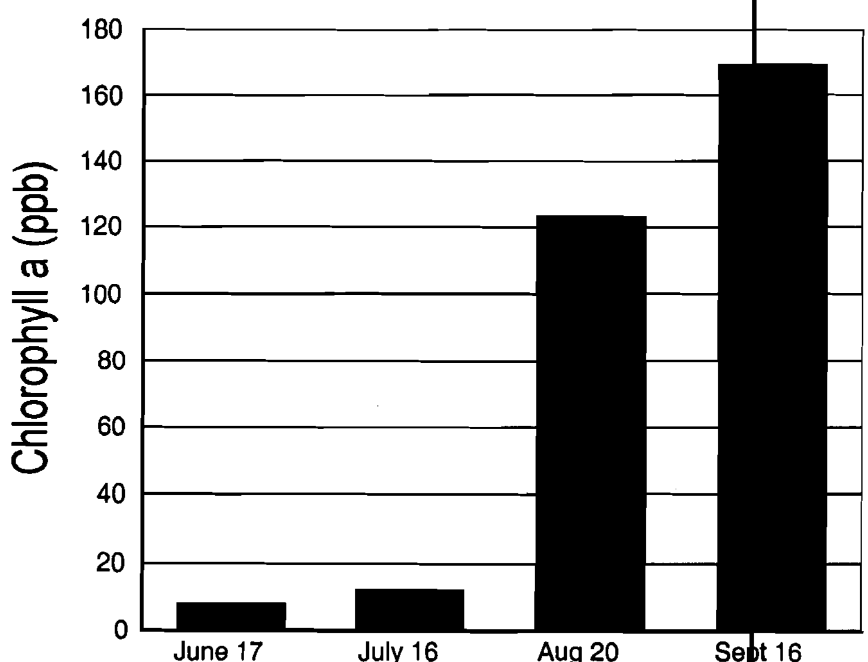


Figure 16. Monthly chlorophyll concentrations in Big Round Lake for 2003.

4.4. Algae

In mid to late summer, algae numbers increase and reduce transparency in Big Round Lake. The dominant late summer algal species in Big Round Lake in 2003 was *Microcystis* (Figure 17). This is a common bloom forming species in eutrophic lakes.

Figure 17. Blue-green algae from Big Round Lake in August 2003. [top] *Microcystis*, a blue-green algae species, is the dominant blue-green species. [bottom] *Ocillatoria* (long straight filament) and *Anabaena* (the spiral-filament), blue-green species are also present in Big Round Lake.

4.5. Zooplankton

Zooplankton are small crustaceans that can feed on algae. A variety of different zooplankton are commonly found in lakes. An example of a large-sized zooplankton species from Big Round Lake is shown in Figure 18. The zooplankton community in Big Round Lake is typical for lakes in Northern Wisconsin. In the photo, the image is magnified 150 times.

Figure 18. The animal in the middle of the picture is a *Daphnia*, a relatively large zooplankton (1-2 mm in length) that feeds on algae.

Zooplankton in Big Round Lake were sampled on three dates in 2003 and results are shown in Table 10. Like many lakes, the big Daphnids are present in the early summer, but their numbers decline as the summer progresses. This is a common pattern in many lakes.

Table 10. Zooplankton counts for Big Round Lake.

Date	5.7.03 (#/l)	6.28.03 (#/l)	9.22.03 (#/l)
Depth (ft)	10	10	5
Cladoceran	30	14	3
Big Daphnids	28	1	1
Little Daphnids	2	4	2
Ceriodaphnia	0	0	0
Bosmina	0	5	0
Chydorus	0	4	0
Copepods	17	18	274
Calonoids	5	7	129
Cyclopoids	11	8	109
Nauplii	1	3	36
Rotifers	0	0	27
Total	47	32	304

4.6. 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 Round Lake has a fair diversity of aquatic plants as well as having one exotic plant, curlyleaf pondweed.

Aquatic plants were monitored on two occasions in 2003. In the first survey, in early summer, the exotic species, curlyleaf pondweed was delineated and mapped. In the second survey, later in the summer, a systematic plant survey using 25 line transects was conducted.

In May of 2003, curlyleaf pondweed distribution was estimated to be at 315 acres (Figure 19). Of that coverage, roughly 100 acres grow to nuisance conditions where the plant tops out at the lake surface.

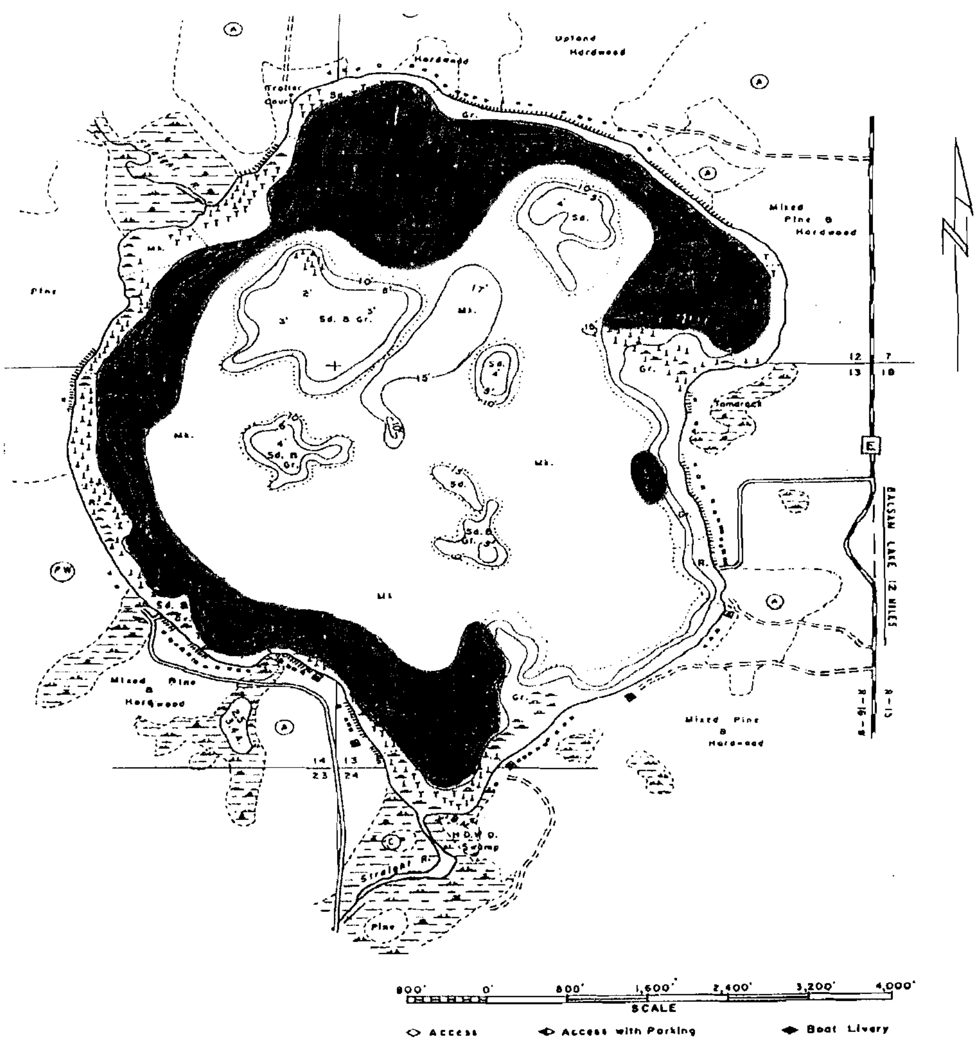


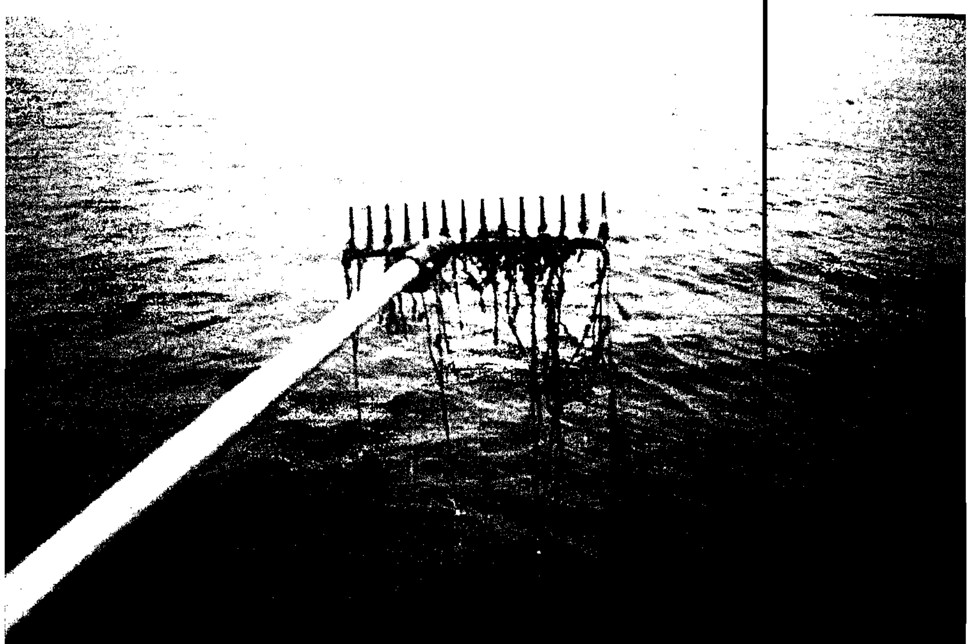
Figure 19. Curlyleaf pondweed coverage on Big Round Lake on May 7, 2003. Curlyleaf pondweed coverage was estimated at 315 acres.

Later in the summer on September 22, 2003, a systematic aquatic plant survey was conducted using 25 line transects.

A summary of aquatic plant statistics is shown in Table 11 and line drawings of common Big Round Lake aquatic plants are shown on the next page.

Table 11. Summer aquatic plant survey summary.

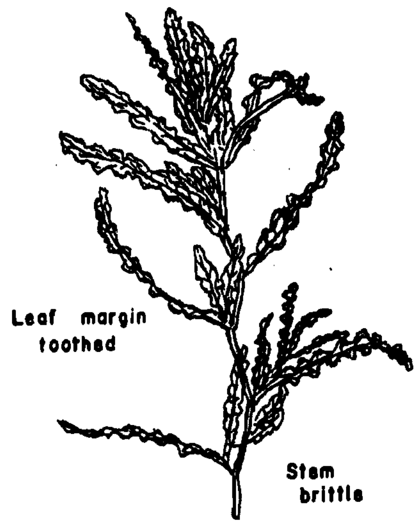
	All Stations
Number of submerged aquatic plant species found	20
Common plant species	coontail, northern watermilfoil, claspingleaf pondweed
Rarest plant	cabbage
Maximum depth of plant growth	12 feet



Curlyleaf pondweed, present in May, dies back in mid summer. Shown above is curlyleaf in May. It was just starting to resprout in the September survey.

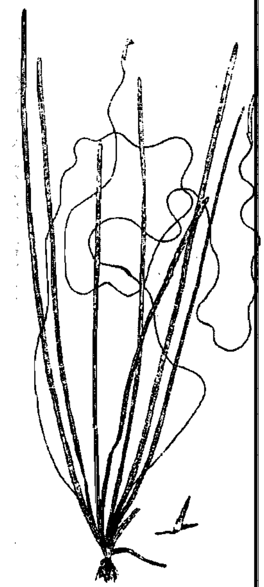
Common Plants in Big Round Lake

Curlyleaf pondweed



Curlyleaf pondweed (*Potamogeton crispus*) is an exotic plant found in Big Round Lake.

Water celery



Water celery (*Vallisneria americana*) is found in water depths to 10 feet.

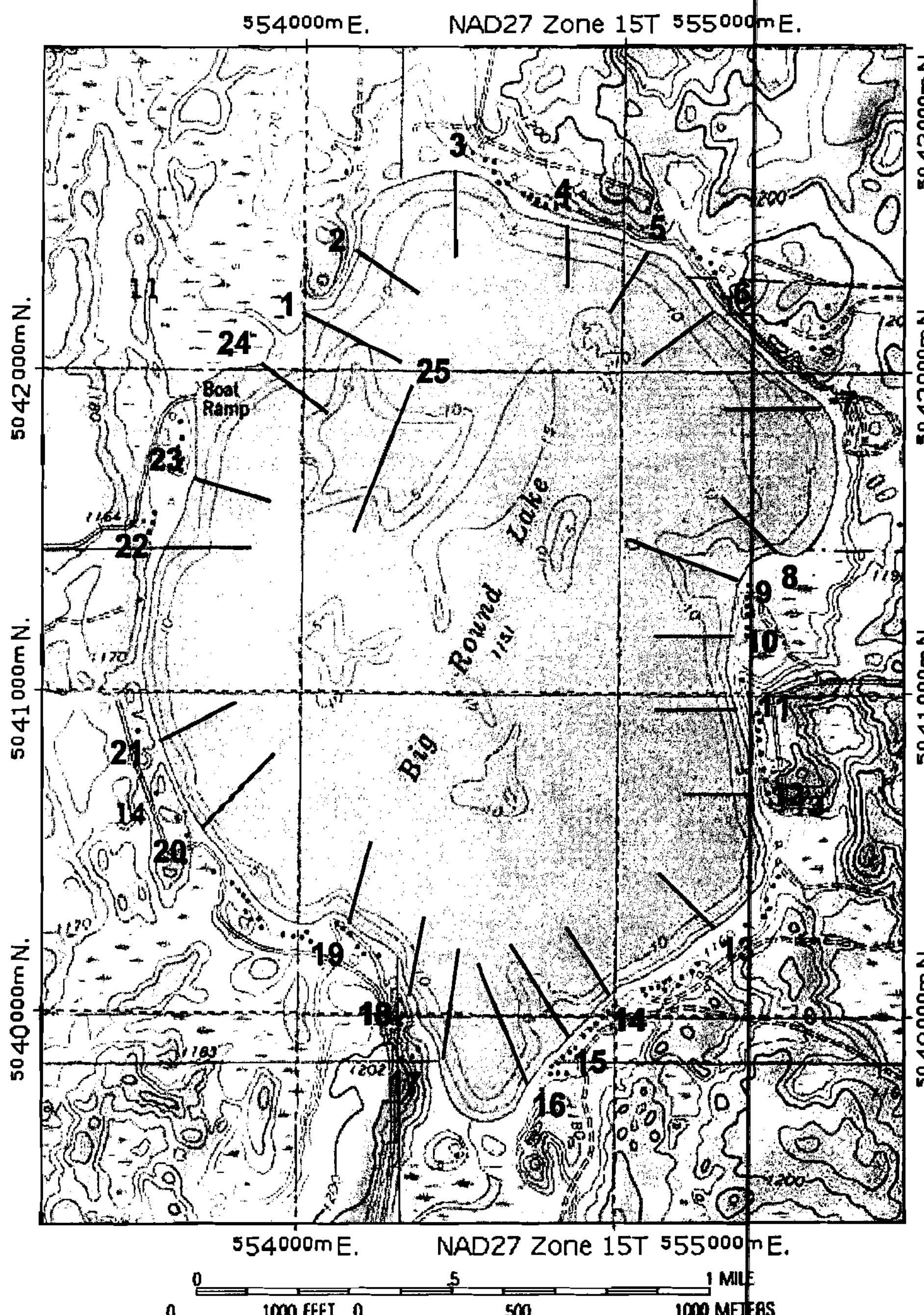
Northern watermilfoil

Northern watermilfoil (*Myriophyllum sibiricum*) is found in water depths to 10 feet.

Coontail

Coontail (*Ceratophyllum demersum*) is dominant in all water depths.

Details of the Aquatic Plant Survey: Aquatic plants were surveyed on September 22, 2003 using 25 line transects. Transect locations are shown in Figure 20. Aquatic plant results are shown in Figure 21 and in Tables 12 and 13.



Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

Figure 20. Line transects used in the September 22, 2003 aquatic plant survey.

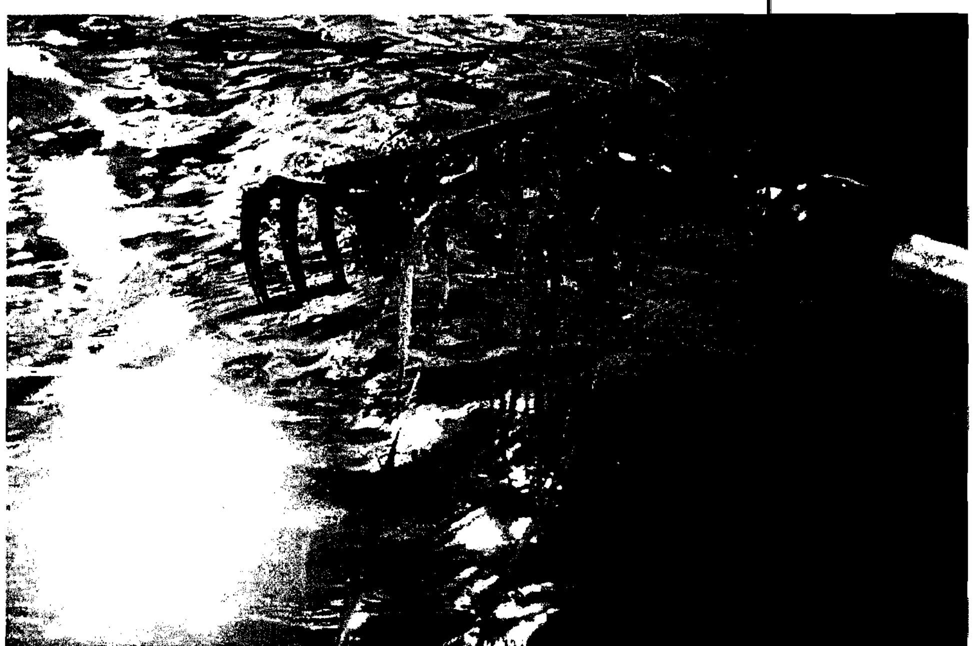


Figure 21. [top] Dan Bergeron, Big Round Lake resident, assisted with the aquatic plant survey.
[bottom] Water celery was a common aquatic plant found in the Big Round Lake aquatic plant survey.

Table 12. Big Round Lake aquatic plant occurrences and densities for the September 22, 2003 survey based on 26 transects and 3 depths, for a total of stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	Depth 0-4 feet (n=26)			Depth 5-8 feet (n=26)			Depth 9-12 feet (n=26)			All Stations (n=78)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Pickerel plant (*Pontederia cordata*)	1	4	0.5	--	--	--	--	--	--	1	1	0.5
Bulrush (*Scirpus sp*)	6	23	1.8	--	--	--	--	--	--	6	8	1.8
Wild rice (*Zizania aquatica*)	1	4	2.0	--	--	--	--	--	--	1	1	2.0
Star duckweed (*Lemna trisulca*)	5	19	1.2	8	31	1.0	3	12	1.0	16	62	1.1
Spatterdock (*Nuphar variegatum*)	1	4	1.0	--	--	--	--	--	--	1	1	1.0
White lilies (*Nymphaea tuberosa*)	1	4	0.5	--	--	--	--	--	--	1	1	0.5
Coontail (*Ceratophyllum demersum*)	13	50	1.2	18	69	1.8	17	65	1.6	48	62	1.6
Chara (*Chara sp*)	3	12	0.7	3	12	0.5	--	--	--	6	8	0.6
Moss (*Drepanocladus sp*)	1	4	0.5	3	12	0.8	1	4	0.5	5	6	0.7
Elodea (*Elodea canadensis*)	2	8	0.8	1	4	2.0	--	--	--	3	4	1.2
Northern watermilfoil (*Myriophyllum sibiricum*)	13	50	0.9	15	58	1.1	3	12	1.0	31	40	1.0
Naiads (*Najas sp*)	4	15	0.8	--	--	--	--	--	--	4	5	0.8
Buttercup (*Ranunculus sp*)	2	8	0.8	--	--	--	--	--	--	2	3	0.8
Cabbage (*Potamogeton amplifolius*)	1	4	0.5	--	--	--	--	--	--	1	1	0.5
Curlyleaf pondweed (*P. crispus*)	2	8	0.5	--	--	--	--	--	--	2	3	0.5
Claspingleaf pondweed (*P. richardsonii*)	12	46	0.6	10	38	0.7	4	15	0.6	26	33	0.7
Flatstem pondweed (*P. zosteriformis*)	7	27	0.7	6	23	0.7	8	31	0.7	21	27	0.7
Sago pondweed (*Stuckenia pectinata*)	4	15	0.6	5	19	0.7	--	--	--	9	12	0.7
Water celery (*Vallisneria americana*)	19	73	1.6	7	27	0.6	--	--	--	26	33	1.3
Stargrass (*Zosterella dubia*)	3	12	0.8	1	4	0.5	1	4	1.0	5	6	0.9
Filamentous algae	1	4	0.5	1	4	0.5	--	--	--	2	3	0.5

Table 13. Individual transect data for Big Round Lake for September 22, 2003.

	T1			T2			T3			T4			T5			T6			T7			T8			T9		
	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12
Bulrush																						4			2		
Buttercup																1						0.5					
Chara								0.5		0.5							0.5		1								
Claspingleaf pondweed		0.5					0.5		0.5			0.5					0.5	1					0.5		0.5		
Coontail	0.5	0.5	3	1.5	0.5	2			1.5			1			2			1			1.5	1	2				
Curlyleaf pondweed	0.5																										
Cabbage																											
Elodea																									0.5		
Flatstem pondweed	0.5		0.5	0.5	0.5	1			0.5						1					0.5							
Moss							0.5																				
Northern watermilfoil				1	1			0.5															0.5				
Naiads	0.5																										
Pickerel plant	0.5																										
Sago pondweed					1		0.5																		0.5		
Star duckweed		1		1.5	0.5	2		0.5												1			0.5				
Stargrass		0.5		1																							
Spatterdock																											
White lilies																											
Water celery	1						0.5			0.5									2				0.5		0.5		
Wild rice	2																										
Filamentous algae																											
No plants											X		X	X										X		X	X

Table 13. Individual transect data for Big Round Lake for September 22, 2003.

	T10			T11			T12			T13			T14			T15			T16			T17			T18		
	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12
Bulrush																0.5						1.5					
Buttercup																											
Chara	0.5	0.5																									
Claspingleaf pondweed				0.5	0.5		0.5							1		0.5			1	1	0.5	0.5				1	
Coontail					1		3	0.5	1	1	1	1	0.5	1				2	1	3	2	1	3		2	1.5	
Curlyleaf pondweed																											
Cabbage																0.5											
Elodea																											
Flatstem pondweed		0.5		0.5			1					0.5							1		0.5	0.5					
Moss																											
Northern watermilfoil		0.5			0.5		1						0.5	2				1	1			0.5	1		1.5	2	
Naiads																0.5											
Pickerel plant																											
Sago pondweed														1								1					
Star duckweed																			2							1	
Stargrass																											
Spatterdock																											
White lilies																									0.5		
Water celery	2			4	0.5		2	0.5		3	1		2			2			2			1				0.5	
Wild rice																											
Filamentous algae																											
No plants			X			X									X		X							X			X

Table 13. Individual transect data for Big Round Lake for September 22, 2003.

	T19			T20			T21			T22			T23			T24			T25			T26		
	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12	0-4	5-8	9-12
Bulrush	2															0.5								
Buttercup																								
Chara																								
Claspingleaf pondweed		1					0.5			0.5	0.5		1	0.5		0.5						1		
Coontail	1	1		1	2.5	2	0.5	1.5	1		2	1.5		3	2	1.5	1.5	1		3	2		3	
Curlyleaf pondweed				0.5																				
Cabbage																								
Elodea																						1	2	
Flatstem pondweed				1		0.5		1									0.5	1					1	
Moss								1			0.5	0.5		1										
Northern watermilfoil	1	3		1	1		0.5	0.5		1	0.5		1	1	1	0.5	1.5	1	1				0.5	
Naiads																			1			1		
Pickerel plant																								
Sago pondweed							0.5	0.5									0.5						0.5	
Star duckweed		2		1		0.5				0.5	1		1				1							
Stargrass										1					1	0.5								
Spatterdock													1											
White lilies																								
Water celery	0.5	1		1			0.5	0.5		1									3			2		
Wild rice																								
Filamentous algae														0.5		0.5								
No plants			X																					X

4.7. Fishery Status (prepared by WDNR)

The fishery status of Big Round Lake has been summarized by the WDNR.

Summary of WDNR Fish Survey for Big Round Lake in 1997:
Big Round Lake is a 1,015 acre lake located in central Polk County. Comprehensive type fish surveys which include walleye population estimates and creel surveys were conducted in 1989, 1991, and 1997. The 1997 fish population was characterized by an abundant largemouth bass population with a strong mode of bass around the 14 inch length limit and declining growth rates; a moderate walleye population (adult P.E.=3.7/acre) supported by both stocking and natural reproduction; an increasing northern pike population; and a panfish population which was below average for Big Round Lake. Management recommendations include continued alternate year walleye fingerling stocking and are evaluation of the 14-inch bass size limit.

Previous Activities:
Past management of Big Round Lake has consisted primarily of walleye stocking. Walleye fingerling or fry stocking has occurred regularly since 1933, with the exception of the years from 1938 until 1965. Muskellunge were stocked in 1969 and 1970, but was discontinued due to opposition from lakeshore owners.

Past electrofishing surveys occurred in 1963, 1970 through 1972, 1976, 1982, 1987, and 1992 through 1994. The 1992, 1993, and 1994 . The 1992, 1993, and 1994 surveys were conducted by GLIFWC. In 1989 and 1991, more comprehensive type surveys were conducted which included walleye population estimates and creel surveys.

The 1997 survey is similar to the 1989 and 1991 surveys. Early spring and late spring fyke-netting and electrofishing, fall electrofishing, and summer and winter creel surveys were conducted.

1997 Survey Results:
Total fishing pressure in 1997 was estimated at 42,286 hours, or 41.7 hours per acre. This compares to 64.3 hours per acre in 1991, and 55.3 hours per acre in 1989. In 1997, open water fishing accounted for 75% of total fishing pressure.

<u>Walleye</u>
The 1997 spring spawning walleye population was estimated at 3.7 adults per acre (Table 3). This is an 89% increase from a 1991 estimate (2.0/acre), and is identical to a 1989 estimate. The total walleye estimate (adults plus juveniles) in 1997 was 5.1 per acre, compared to 3.4 per acre in 1991 and 5.1 per acre in 1989.

Electrofishing surveys conducted since 1963 indicate the presence of a moderate to moderately low walleye population, with the population possibly being the highest in the 1970's and 1980's (Table 4).

The size distribution of the walleye population in 1997 was not as good as in 1989 or 1991, in that fewer large fish were present. In 1989, 52% of the fyke-netted walleyes were 20 inches or larger. In 1991, 44% of fyke-netted walleyes were 20 inches or larger. In 1997, only 6% of the walleyes captured by fyke-netting were 20 inches or larger.

In 1997, the mean length of captured walleyes during marking and first recapture was 16.1 inches for males and 19.9 inches for females. In 1991, it was 15.5 inches for males and 23.8 inches for females, while in 1989 it was 18.9 inches for males and 22.2 inches for females. The sex ratio of fyke-netted walleyes in 1997 was 9 males to 1 female. Walleye growth rates in 1997 were slightly above average through age 7, and below average for older walleyes (Table 5).

WDNR Fish Summary - continued

Because walleye fingerlings have been stocked in all but three years from 1982 to 1996, it is difficult to determine the contribution of stocking. Walleye year classes have varied substantially over the years. There seems to be a pattern of stronger year classes every other year, as stronger year classes occurred in 1994, 1992, 1990, and 1988. It is likely that the walleye population is a combination of stocking and natural reproduction.

In 1997, about 16% of total fishing pressure was directed at walleyes, 16% of open water pressure and 15% of ice fishing pressure. Walleye catch and harvest in 1997 were estimated at 757 (0.8/acre) and 425 (0.4/acre). In 1991, catch and harvest were 3,025 (3.0/acre) and 297 (0.3/acre). In 1989, catch and harvest were 5,158 (5.1/acre) and 1,718 (1.7/acre). In 1997, 70% of walleye harvest occurred during open water.

Angling exploitation of walleyes in 1997 was 6.8%, compared to 10.7% in 1991 and 32.6% in 1989. In 1997, most exploitation occurred during open water (4.3%).

In 1997, tribal spearers harvested only one walleye. Since 1985, walleye spearing harvest has ranged from a low of one in 1997 to a high of 109 in 1990, with a mean of 37.

Largemouth Bass
Spring electrofishing catch per effort in 1997 (239/ha) indicates the presence of an abundant largemouth bass population. A population estimate of bass 12 inches and larger was 9,653 (95% C.L.+4,880) or 9.5 bass per acre. The CPE of past surveys indicate that-the bass population has been 'increasing, especially in the last 10 years.

The 14-inch bass length limit implemented in 1989 has substantially changed the density and size structure of the bass population. Compared to 1989 and 1991, the 1997 length frequency distribution was compressed, with fewer large and small sized bass present, and large numbers of bass around and just below the size limit. In 1997, 63% of the captured bass were in the 13.0 to 14.9-inch size range, while this figure was 3% in 1989 and 15% in 1991. In 1997, only 1% of the captured bass were 16 inches or larger, while this figure was 5% in 1989 and 3% in 1991.

Growth of bass in 1997 declined significantly compared to 1989 in every age group, but especially for older bass. Bass growth was above the regional average in 1989, but in 1997, growth of age 5 and older bass was below average, and age 9 bass averaged only 15.9 inches in length.

In 1997, about 19% of total fishing pressure was directed at bass; 25% of open water pressure and 5% of ice fishing pressure. More bass were harvested than any other game fish. Also, the catch rate of bass was 1.2 per hour, exceeded only by the catch rate of bluegills. Bass catch and harvest were estimated to be 30,367 (30.0/acre) and 2,206 (2.2/acre) in 1997. This is twice the harvest of 1991 (1,100) and 1989 (1,120).

In 1997, about 93% of the harvest occurred during open water. The mean length of harvested bass was 14.6 inches.

Northern Pike
The northern pike population has increased compared to previous surveys. Fyke-netting CPE in 1997 was 3 per net night, late spring electrofishing CPE was 17 per hour, and a total of 170 northern pike were captured during the survey. In the 1991 survey, a total of only 3 northern pike were captured, and in 1989 only 14 northerns were captured.

No large northern pike were captured. The largest fyke-netted northern was 25.9 inches, and the largest northern captured by electrofishing was 27.4 inches. The reason for the lack of large northern pike is that there were apparently few old northerns present in 1997 (the oldest northern captured was age 5). Northern pike growth rates are slightly above average.

WDNR Fish Summary - continued

In 1997, about 15% of total fishing pressure was directed at northern pike; 14% of open water pressure and 17% of ice fishing pressure. Northern pike catch and harvest were estimated at 8,501 (8.4/acre) and 1,473 (1.5/acre) in 1997. This is much higher than in 1991, when catch and harvest were 151 (0.2/acre) and 59 (O.l/acre). In 1997, 69% of northern pike harvest occurred during open water. The)mean size of harvested northern pike was 22.6 inches.

Muskellunge
Only two muskellunge were captured during the course of the survey, both in the 38.0 to 38.4-inch size range. Only 0.2% of total fishing pressure was directed at muskellunge. Estimated harvest was six muskellunge with a mean size of 41.0 inches.

Panfish
Fyke nets were set to sample panfish from June 18 through June 30 (13 net nights). A total of 14 fish species were captured, with bluegills and pumpkinseeds captured in considerably greater numbers than other species.

The bluegill size distribution was poor, with a percent stock density of 9% and a relative stock density-7 of 1%. Pumpkinseed PSD was 33% and RSD-7 was 3%. There is some question if a representative panfish sample was obtained, as Big Round Lake is known for producing desirable-sized bluegill.

Black crappies and yellow perch were sampled during early spring fyke netting (4/21-24/97). Crappies were common and perch were abundant. Most crappies were in the 4.8 to 5.5-inch size range. Most perch were in the 3.7 to 4.8-inch size range. Only 1% of the crappies and 3% of the perch were 9 inches or larger. The growth rates of bluegills, pumpkinseeds, and crappies were all above average.

About 50% of total fishing pressure was directed at panfish; 45% of open water pressure and 63% of ice fishing pressure. Bluegills were harvested in the greatest numbers (15.9/acre), followed by black crappies (3.2/acre) and yellow perch (1.8/acre). Bluegill and crappie harvest in 1997 was considerably lower than in 1991 or 1989. In 1991, there was an exceptionally high harvest of bluegills (182.7/acre) which seems to have adversely impacted the bluegill population through 1997.

In 1997, most bluegill (74%) and crappie (63%) harvest occurred during open water. The average length of harvested bluegills was 7.5 inches, and for crappies was 9.4 inches.

Conclusions and Recommendations
Largemouth bass are abundant and the primary predator in Big Round Lake. This is not surprising, in that this lake has nearly ideal habitat conditions for largemouth bass. The 14-inch minimum length limit has undoubtedly been mostly responsible for the increase in bass numbers. The 14-inch limit is also probably largely responsible for a large buildup of mid-sized. bass which has resulted in substantially reduced growth rates and a reduction in the number of large bass.

Unlike most Polk County lakes, the walleye population in Big Round Lake seems to be doing fairly well. In terms of density, the 1997 population is similar to the 1989 population. A density of 3.7 adult walleyes per acre can provide desirable fishing and makes Big Round Lake one of the better walleye lakes in the area.

On the down side, the walleye population no longer has the good numbers of large walleyes that Big Round Lake has been known for. In both the 1989 and 1991 surveys, it was noted that angling and spearing exploitation was higher for 20-inch and larger walleyes (39.2% in 1989 and 18.5% in 1991) than for the harvestable population as a whole. Based on this data, a regulation change to allow only one walleye over 20 inches to be harvested was submitted for Big Round Lake, but was rejected by the Bureau of Fisheries Management.

The 1997 survey was not able to correlate walleye stocking to year class strength because stocking has occurred almost annually in recent years. However, both the 1989 and 1991 surveys found a correlation

WDNR Fish Summary - continued

between stocking and year class strength, and also found evidence of natural reproduction.

The northern pike population increased significantly from 1991 to 1997. The reason for increased recruitment is unknown, but an improved northern pike population is a welcome event.

Big Round Lake has always been a popular lake for panfishing. It seems to provide a pulse fishery, with several years of good panfishing followed by several poor years. In 1991, an exceptional panfish harvest occurred. An estimated 123,094 bluegills were harvested during ice fishing alone.

Following the huge panfish harvest in 1991, panfishing success has been sporadic, with no sustained period of good panfishing occurring. It may be possible that the bluegill population might still be recovering from the 1991 harvest, and/or the large bass population could be reducing bluegill numbers by predation.

Management recommendations include continued alternate year stocking of small walleye fingerlings at the rate of at least 50 per acre. Current fishing regulations appear appropriate with the exception of the 14-inch bass length limit. I believe limited harvest of bass less than 14 inches may be necessary to reduce the strong mode of bass just under 14 inches, which would hopefully improve bass growth rates, and allow some bass to reach large size. Possibly the current 14-inch length limit regulation could be modified to allow one bass less than 14 inches to be harvested.

Walleye natural reproduction contributes to the walleye population, and protection of both walleye and northern pike spawning areas through the water regulation permit system is important. Fish and wildlife habitat sensitive areas need to be documented on Big Round Lake.

4.8. In-Lake Nutrient Inputs

When evaluating lake water quality and then formulating improvement projects it is important to know where the phosphorus is coming from. Watershed nutrient inputs were described in Section 3.5. However there are nutrient inputs from the lake basin itself.

Two sources of in-lake nutrients that contribute to Big Round Lake algae blooms are from the die back of curlyleaf pondweed and from phosphorus release from the lake sediments.

From curlyleaf research conducted by Steve McComas (unpublished) a reasonable phosphorus load from the dieback of curlyleaf pondweed is 3 pounds of phosphorus per acre of curlyleaf. Since there are 315 acres of curlyleaf in Big Round Lake, the phosphorus contribution from curlyleaf pondweed dieback is estimated at 945 pounds.

The phosphorus loading from the lake sediment is more complicated. The abrupt increase in the lake water column phosphorus concentration when the stream loading was known to be constant is attributed to lake sediment phosphorus release. This was also the conclusion in the 1980 WDNR lake feasibility study. We have estimated the lake sediment phosphorus release to be 4,667 pounds.

The 4,667 pounds was estimated by back calculating the overall phosphorus load from a lake model that used a lake phosphorus concentration of 98 ppb.

The total annual lake phosphorus load is 8,000 pounds. By substracting phosphorus loads from the other sources we are left with 4,667 pounds coming from lake sediments. This sediment input is equivalent to 84 mg of phosphorus per meter^2 of lake bottom per year. That is a rate well within known lake phosphorus release rates.

The estimated phosphorus load from the lake is 5,612 pounds of phosphorus.

5. Lake and Watershed Assessment

5.1. Lake Questionnaire Results

The Big Round Lake questionnaire was developed to better understand the concerns, goals, and attitudes of homeowners living around the lake. Their thoughts and ideas about the use and the quality of your lake are shown below. The questionnaire was sent to 173 property owners, 62 (38.8%) property owners responded to the Big Round Lake questionnaire.

1. **How many years have you been a resident of Big Round Lake?**

1-5 years	13%
5-10 years	34%
10-20 years	26%
20-30 years	16%
30-40 years	10%
50+ years	1%

2. **Are you retired?**
   Yes: 37%

   Are you employed:
   Yes: 63%

3. **Do you own or rent your lake residence?**
   Own: 100%
   Rent: 0%

4. **Is your lake residence a:**

House	50%
Cottage	37%
Mobile home	7%
Other	6%

5. What type of residence do you have?
Seasonal: 32%
Year round: 68%

6. How many in each age group use your residence?

7. Is your lake residence used as your permanent or seasonal home?
Permanent: 18%
Seasonal: 82%

8. Do you rent out your lake residence?
Yes: 2%
No: 98%

9. How many watercrafts do you have at the lake?
2.5 average watercrafts

10. Rate summer activities in order of importance?
(Listed in order of most important to least important based on total number of tallies.)

1	Boating
2	Fishing
3	Swimming
4	Peacefully doing nothing
5	Water skiing
6	Jet skiing
7	Gardening
8	Sailing
9	Scuba diving

11. If you fish, which best described what you do with the catch?

Keep	8%
Release	22%
Both	70%

12. To help the Lake District understand your concerns, please rate the level of importance to you of each of the following.

	Very Important	Important	Not Very Important	Not a Concern
Algae	62%	23%	8%	7%
Aquatic plants (weeds)	55%	28%	8%	9%
Boating/fishing violations	32%	37%	10%	21%
Boat traffic/congestion	22%	38%	20%	25%
Crime	50%	18%	13%	19%
Eurasian milfoil threat	63%	25%	4%	8%
Fishing quality	60%	30%	5%	5%
Noise	33%	32%	17%	18%
Over development	25%	47%	14%	14%
Shoreline erosion	30%	43%	13%	14%
Water depth	40%	28%	19%	13%
Water quality	68%	23%	2%	7%
Zebra mussel threat	42%	28%	10%	20%
Other significant mentioned, swimmers itch	12 total	--	--	--

13. From the list above lake concerns, which three concern you the most? (Top three based on most tallies.)

Algae
Water quality
Fishing quality

14. Do you feel the lake is better, worse, or stayed the same as previous years?

Better	16%
Worse	37%
Stayed the same	47%

5.2. Big Round Lake Status

The status of Big Round Lake is eutrophic meaning it has high fertility. Big Round has higher phosphorus concentrations than many of the surrounding lakes. One way to compare the status of Big Round Lake is to compare it to other lakes in a similar setting or ecoregion.

Ecoregions are geographic regions that have similar geology, soils, and land use. The continental United States has been divided into 84 ecoregions, and there are six ecoregions in Wisconsin. A map of Wisconsin ecoregions is shown in Figure 22. Big Round Lake is in the North Central Hardwood Forest ecoregion but close to the Northern Lakes and Forests ecoregion (Figure 22). Lakes in this area of the state have some of the best water quality values in the State. A range of ecoregion values for lakes in the two ecoregions along with actual Big Round Lake data are shown in Table 14.

Table 14. Summer average quality characteristics for lakes in the Northern Lakes and Forest ecoregion (Minnesota Pollution Control Agency, 1988).

Parameter	Northern Lakes & Forests	North Central Hardwood Forest	Big Round (2003)
Total phosphorus (ug/l) - top	14-27	23-50	98
Algae [as Chlorophyll (ug/l)]	<10	5-22	101
Chlorophyll - max (ug/l)	<15	7-37	169
Secchi disc (ft)	8-15	4.9-10.5	4
Conductivity (umhos/cm)	50-250	300-400	150

These comparisons indicate that the water quality of Big Round Lake are out of range compared to the North Central Hardwood Forest ecoregion water quality values. The challenge will be to bring water quality values within ecoregion ranges.

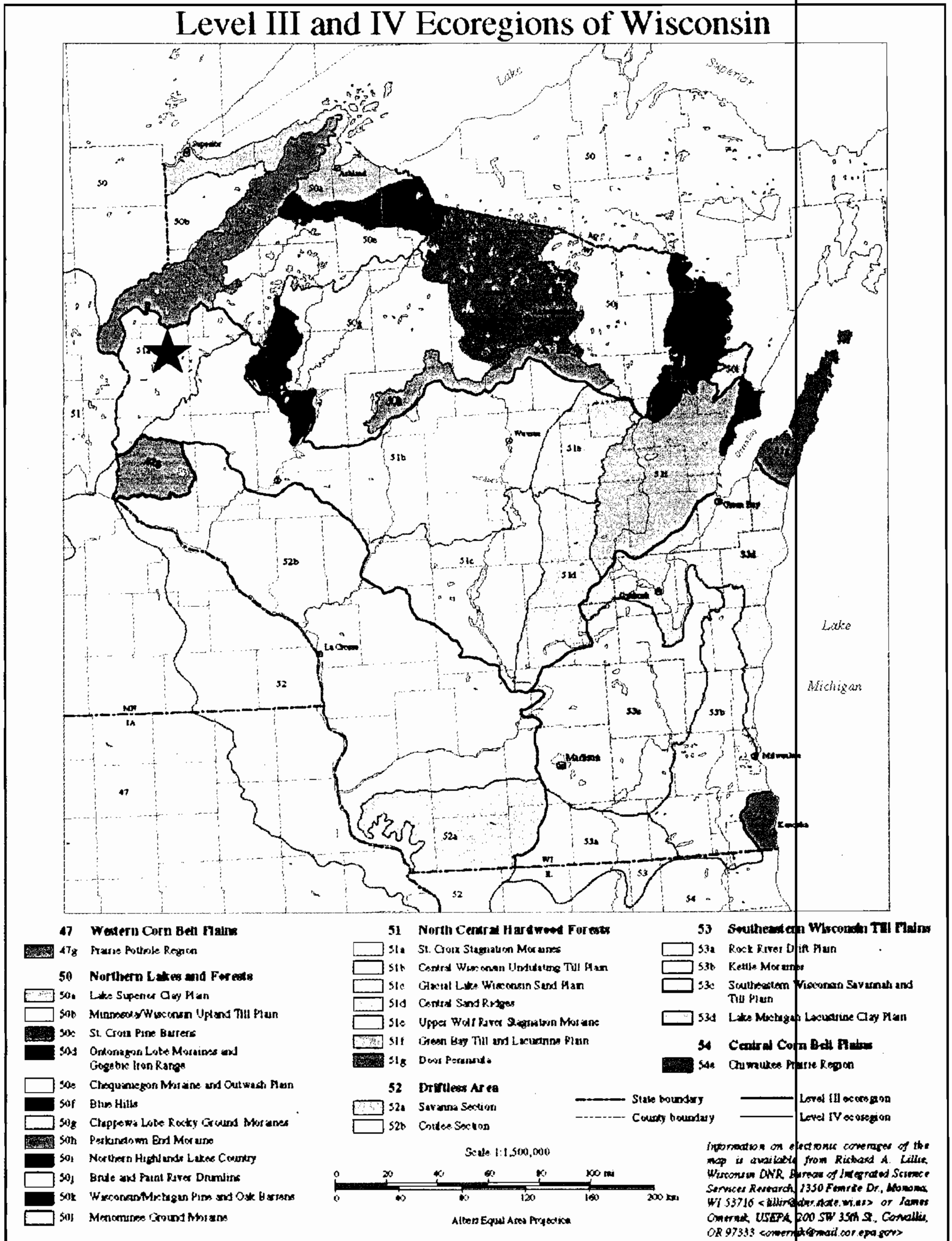


Figure 22. Ecoregion map for Wisconsin. Areas that are labeled with a "50" are within the Northern Lakes and Forest Ecoregion. Areas labeled with a "51" are in the Central Hardwood Forest Ecoregion. Big Round Lake, located in central Polk County is officially in the Central Hardwood Forest Ecoregion but close to the Northern Lakes and Forest Ecoregion.

5.3. Nutrient Inputs to Big Round Lake

Based on North Central Hardwood Forest Ecoregion ranges, Big Round Lake has been found to have phosphorus levels higher than expected for a lake in this ecoregion.

The reason for the high lake phosphorus concentration is due to the amount of phosphorus coming into Big Round Lake. A summary of estimated phosphorus loads is shown in Figure 23. A total annual phosphorus load of 8,000 pounds of phosphorus is estimated based on a lake phosphorus concentration of 98 ppb. The lake sediments appear to be the biggest nutrient contributor.

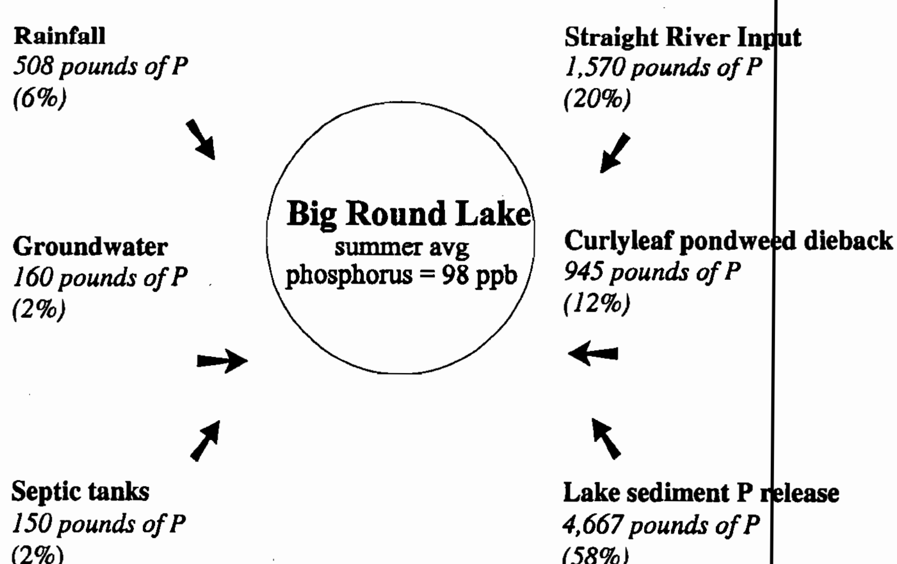


Figure 23. Estimated annual phosphorus loads to Big Round Lake.

5.4. Setting Water Quality Goals for Big Round Lake

Water quality in Big Round Lake has the potential to improve. Lake models were run to help determine feasible water quality goals for Big Round Lake. A lake model is a mathematical equation that uses phosphorus inputs along with lake and watershed characteristics to predict what a lake phosphorus concentration should be. Once a lake phosphorus concentration is determined, then seasonal water clarity and algae concentrations can be calculated as well.

Lake models were run for the following conditions and then compared to existing observed conditions.

1. Phosphorus loading from the Straight River (80 ppb).
2. Phosphorus loading from a Central Hardwood Forest river that averages 150 ppb.
3. Phosphorus loading from a Northern Lakes and Forest river that averages 50 ppb.

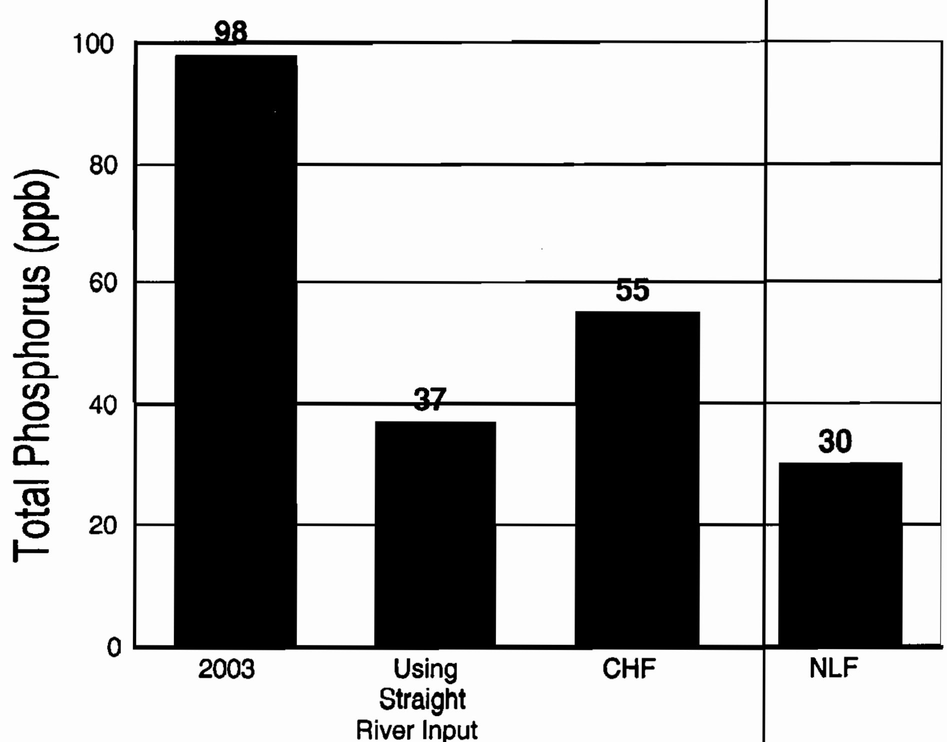


Figure 24. Comparison of total phosphorus conditions for Big Round Lake in 2003 to predicted conditions for a lake the size of Big Round Lake situated in the Central Hardwood Forest (CHF) or the Northern Lakes and Forest (NLF) ecoregion.

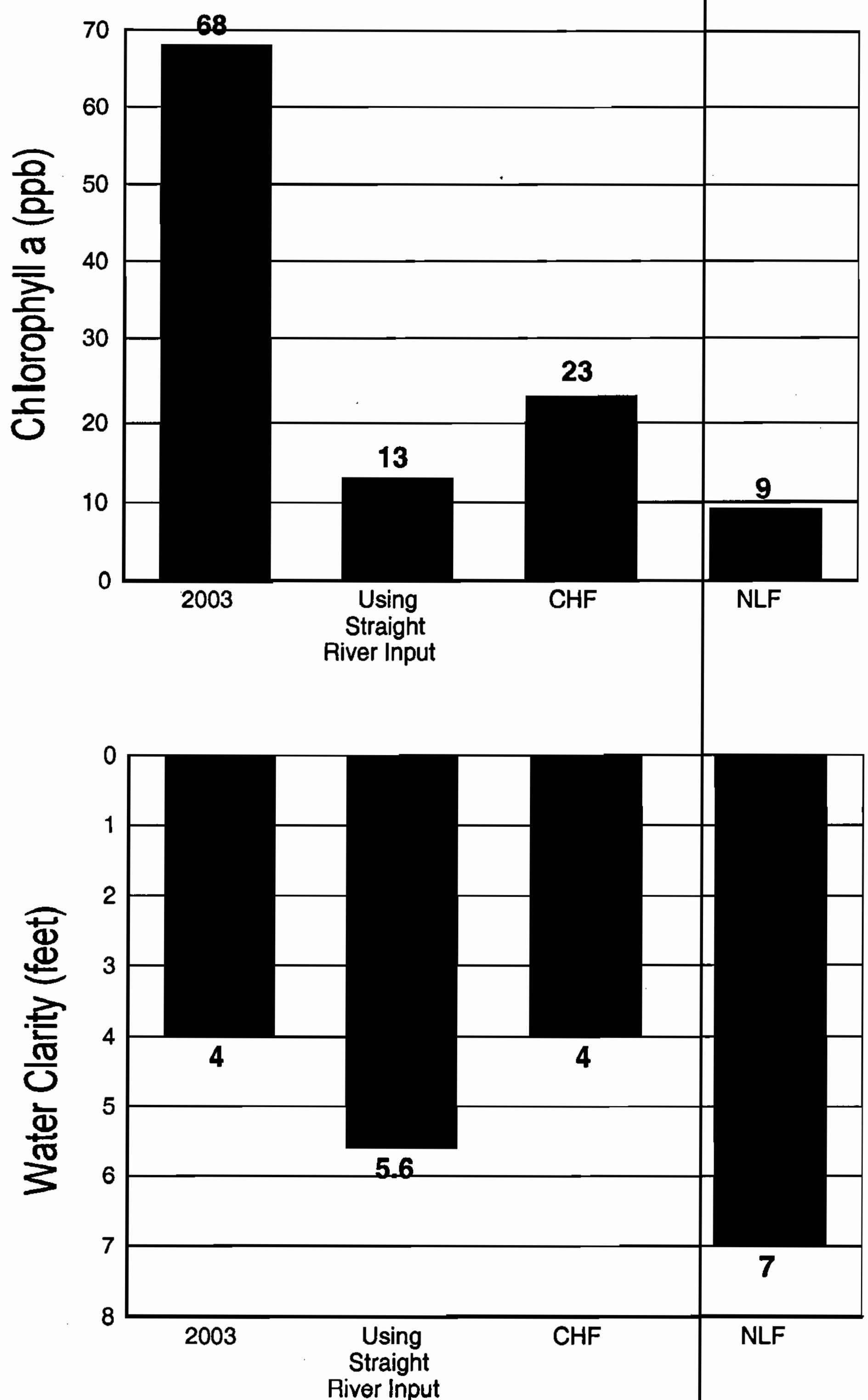


Figure 24. Comparison of chlorophyll a and water clarity conditions for Big Round Lake in 2003 to predicted conditions for a lake the size of Big Round Lake situated in the Central Hardwood Forest (CHF) or the Northern Lakes and Forest (NLF) ecoregion.

Lake Goals: Based on lake modeling considerations it appears Big Round Lake has the potential for better water quality conditions.

The proposed water quality goal for lake phosphorus is 45 ppb this is slightly better than the estimated NCHF ecoregion model of 55 ppb but that is because the Straight River is known to have lower phosphorus concentrations than typical NCHF ecoregion streams.

The key to reaching this lake phosphorus goal will be to reduce internal lake loading.

Because it is expensive and risky to implement a sediment phosphorus release control project, other programs will be considered first.

5.5. Water Quality Improvement Strategy

Big Round Lake is a drainage lake, meaning that there is significant stream inflow into the lake. The watershed to lake surface ratio of 19 to 1 is higher than glacial seepage lakes (seepage lakes have no major streams and generally have a watershed to lake surface ratio of 10 to 1 or less). Although the Big Round Lake watershed is moderately large, the water quality of the Straight River is very good. Using the phosphorus loading associated with just the Straight River in a lake model indicated Big Round Lake should have lower phosphorus concentrations and better water clarity than what has been observed.

It appears there is an additional phosphorus source that is impacting Big Round Lake and elevating the phosphorus concentration. The phosphorus source is likely from the lake itself. Lake water quality probably will not improve unless the in-lake phosphorus sources are reduced.

Two sources of excessive lake generated phosphorus are from curlyleaf pondweed dieback and from lake phosphorus release from the sediments.

The first choice to reduce in-lake phosphorus levels is by manipulating the lake biology by way of reducing the curlyleaf pondweed distribution. Reducing nuisance curlyleaf pondweed growth would address two issues: reduce early summer nuisance growth of an exotic plant and reduce phosphorus inputs from curlyleaf dieback. It is predicted water quality would improve, but at this time there is not enough information available to determine the benefit on water quality improvement with a curlyleaf program. A recommended project is to collect data on nuisance curlyleaf distribution and sample tissue and sediment concentrations which will help to determine the long term likelihood of nuisance growth. Then implementation of a long term curlyleaf control program is recommended.

For reducing phosphorus release from lake sediments there are two good techniques to choose from: summer aeration or alum. Lakes in Polk County have examples of each technique. Cedar Lake has had aeration for several years and Lake Wapagasset had an alum treatment in 2001. In each case, water quality improvements have been modest. There is no guarantee that either technique will solve the nutrient release problem.

The most common technique to reduce sediment phosphorus release from lakes and a potential project for Big Round is alum, but it would be expensive, costing around $900,000. If the alum treatment was 100% effective in reducing the excessive phosphorus release from lake sediments, lake phosphorus levels would drop significantly in the lake but transparency would increase only about 1.6 feet as a seasonal average. Also there is no guarantee the effect would last longer than several years. It is recommended that an alum treatment be delayed until it can be determined if controlling curlyleaf pondweed can have a beneficial water quality impact. Based on this strategy, a project list was developed and is shown below:

Project List of Lake Improvement Projects for Big Round Lake

1. Watershed projects.
2. On-site system maintenance.
3. Landscaping projects.
4. Aquatic plant projects
    a. curlyleaf delineation and analysis.
    b. conduct a lake soil fertility survey to determine potential long-term nuisance growth of exotic plants.
    c. curlyleaf pondweed control demonstration.
5. Fish management options.
6. Education program.
7. Watershed and lake monitoring program.

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

Project ideas for Big Round Lake are geared toward long-term protection of water quality.

A list of projects has seven main components:

1. Watershed projects.
2. On-site system maintenance.
3. Landscaping projects.
4. Aquatic plant projects.
5. Fish management options.
6. Ongoing education program.
7. Watershed and lake monitoring program.

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

Project 1. Watershed Projects

The main goal of the watershed projects program is to protect the natural character of the watershed which helps maintain good runoff water quality.

Currently, a majority of the watershed is forested. However there is some agricultural land use in the watershed as well. Polk County Soil and Water Conservation Department recommends that when farmers grow row crops, the following three practices be used: conservation tillage, including either no-till or reduced till, grass waterways, and nutrient management. Contour farming also is a valuable tool, however most of the topography of the Big Round watershed does not lend itself to contour farming. At this time, agriculture does not appear to contribute excessive amounts of nutrients to Big Round Lake.

Project 2. On-site System Maintenance

The septic tank/soil absorption field has been one of the most popular forms of on-site wastewater treatment for years. When soil conditions are proper and the system is well maintained, this is a very good system for wastewater treatment. The on-site system is the dominant type of wastewater treatment found around Big Round Lake today.

However, problems can develop if the on-site system has not been designed properly or well-maintained. Around Big Round Lake there are probably some on-site systems that need maintenance and upgrades. At the same time, it is good practice to ensure that systems that are functioning adequately now will continue to do so in the future.

This project calls for an organized program to be developed that makes homeowners aware of all they can do to maintain their on-site systems.

A description of possible activities associated with the on-site maintenance program are described below:

- **Workshop**
  A workshop should be scheduled for Big Round Lake Watershed residents to demonstrate the installation of a conforming septic system and the proper care and maintenance of a septic tank and septic system.

- **Septic Tank Pumping Campaign**
  Polk County requires every septic tank associated with a permanent residence pumped 2-3 years in the shoreland area to help reduce phosphorous loading to the septic system drainfield. This is the law.

- **Ordinance Implementation**
  Work to maintain enforcement of the county ordinance, where septic systems must be "evaluated" at the time a property is transferred. The seller would obtain a septic system evaluation from Polk County at the time of property transfer. The evaluation would determine if the septic system was "failing", "non-conforming", or "conforming". A "failing" septic system includes septic systems that discharge onto the ground surface, discharges into tiles and surface waters, and systems found to be contaminating a well. The county would require a "failing" system to be brought into compliance with the Polk County ordinance within 90 days of property transfer.

Project 3. Landscaping Projects

Controls are in place at the county level to guide new shoreland development. An excellent reference publication is the Shoreland Property Owner Handbook that was published by Polk County. However for existing properties, it is important to either maintain or to improve the natural vegetative buffer.

The shoreland area is valuable for promoting a natural lake environment and a natural lake experience for lake users. The shoreland is defined as the upland area about 300 to 1,000 feet back from the shoreline, and out into the lake to about the end of your dock (Figure 25). A shoreland with native vegetation offers more wildlife and water quality benefits than a lawn that extends to the lake's edge. A summary of attributes and functions of native plants in the shoreland area is shown in Table 15.

Figure 25. Cross section of the lake shoreland habitat.

Table 15. Attributes and functions of native plants in the shoreland area (Source: Henderson and others, 1999. Lakescaping for Wildlife and Water Quality. MnDNR)).

Important functions of plants in and around lakes
Submergent and emergent plants

- Plants produce leaves and stems (carbohydrates) that fuel an immense food web.
- Aquatic plants produce oxygen through photosynthesis. The oxygen is released into lake water.
- Submerged and emergent plants provide underwater cover for fish, amphibians, birds, insects, and many other organisms.
- Underwater plants provide a surface for algae and bacteria to adhere to. These important microorganisms break down polluting nutrients and chemicals in lake water and are an important source of food for organisms higher in the food chain.
- Emergent plants break the energy of waves with their multitude of flexible stems, lessening the water's impact on bank and thus preventing erosion.
- Plants stabilize bottom sediments, which otherwise can be resuspended by currents and wave action. This reduces turbidity and nutrient cycling in the lake.

Shoreline and upland plants

- Shoreline and upland plants provide food and cover for a variety of birds, amphibians, insects, and mammals above the water.
- The extensive root systems of shoreline plants stabilize lake-bank soils against pounding waves.
- Plants growing on upland slopes that reach down to lake hold soil in place against the eroding forces of water running over the ground, and help to keep lake water clean.
- Upland plants absorb nutrients, like phosphorus and nitrogen, found in fertilizers and animal waste, which in excessive concentrations are lake pollutants.

Improving Upland Native Landscape Conditions: In the glacial lake states, three broad vegetative groups occur: pine forests with a variety of ground cover species including shrubs and sedges: hardwood forests with a variety of understory species, including ferns: and tallgrass prairie with a variety of grasses as well as bur oaks and willow trees. Residences around Big Round Lake are in the hardwood forest group.

Reestablishing native conditions in the shoreland area not only improves stormwater runoff quality, it also attracts a variety of wildlife and waterfowl to the shoreland area. Benefits multiply when other neighbors naturalize because the effects are cumulative and significant for water quality and wildlife habitat.

When installing native vegetation close to the shoreline residents are actually installing a buffer. A buffer is a strip of native vegetation wideenough to produce water quality and wildlife improvements. Much of the natural vegetative buffer has been lost in shoreland areas with development where lawns have been extended right down to the shore.

Lawns are not necessarily bad for a lake. However they can be over fertilized and then runoff carries phosphorus to the lake. Also, lawns function as a low grade open prairie, with poor cover for wildlife and a food supply that is generally poor, except for geese who may find it attractive. Replacing lawn areas with native landscaping projects reduces the need for fertilizer, reduces the time it takes to mow, increases the natural beauty of a shoreland area, and attracts wildlife.

Lawns do not make very good upland buffers. With runoff, short grass blades bend and do not serve as a very effective filter. Tall grass that remains upright with runoff is a better filter. Kentucky bluegrass (which actually is an exotic grass) is shallow-rooted and does not protect soil near shorelines as well as deep-rooted native prairie grasses, shrubs, or other perennials. Grass up to the shoreline offers poor cover, so predators visit other hiding areas more frequently reducing the prey food base and limiting predator populations in the long run. Also with short ground cover, ground temperatures increase in summer, evapotranspiration increases and results in drying conditions, reducing habitat for frogs and shoreline dependent animals.

Buffer Strip Considerations: A functional upland buffer should be at least 15 feet deep. With this you start getting water quality and wildlife habitat benefits. But a 35 foot deep buffer is recommended. In the past, before lakeshore development, buffers ringed the entire lake. For lakeshore residents it is recommended the length of the buffer extend for 75% of the shoreline, although 50% would produce buffer benefits.

A buffer strip can address two problem areas right away. Geese are shy about walking through tall grass because of the threat of predators. There will always be a few who charge right through but it is a deterrent for most of them. Also, muskrats shouldn't be a problem. They may burrow into the bank, but generally not more then 10 feet. With a buffer going back 15 to 25 feet, you won't be mowing over their dens. An occasional den shouldn't produce muskrat densities that limit desirable aquatic vegetation.

Several types of buffers can be installed or propagated that offer nutrient removal as well as wildlife benefits. Examples include:

Tall grass, sedge, flower buffer: Provides nesting cover for mallards, blue-winged teal and Canada geese. Provides above ground nesting habitat for sedge wrens, common yellow throat and others.

Shrub and brush buffer: Provides nesting habitat for lakeside songbirds such as yellow warblers, common yellowthroat, swamp sparrows, and flycatchers. It also provides significant cover during migration.

Forested buffers: Provides habitat for nesting warblers and yellow-throated vireo, Diamond herons, woodducks, hocked mergansers, and others. Upland birds such as red-winged blackbirds, orioles, and woodpeckers use the forest edge for nesting and feeding habitat.

Even standing dead trees, which are referred to as snags, have a critical role. When they are left standing they serve as perching sites for kingfishers and provide nesting sites for herons, egrets, eagles, and ospreys. In the midwest over 40 bird species and 25 mammal species use snags. To be useful, they should be at least 15 feet tall and 6-inches in diameter.

The initial step for lake residents to get started is to simply make a commitment to try something. Just what the final commitment is evolves as they go through a selection process. The next step in the process is to conduct a site inventory. On a map with lot boundaries, house and buildings, driveway, turf areas, trees, shrubs, and other features are drawn. If there is a chance, the property is checked during a rainstorm. Look for sources of runoff and even flag the routes. Find out where the water from the roof goes, and see if there are temporary ponding and infiltration areas. Are the paths down to the lake eroding? Then the next step is to consider a planting approach.

Native Landscaping for Buffers: Three Approaches: Native landscaping efforts can be put into three categories:

1. Naturalization
2. Accelerated Naturalization
3. Reconstruction

1. Naturalization: With this approach, the resident is going to allow an area to go natural. Whatever is present in the seedbank is what will grow. If they want to install a buffer along the shoreline, let a band of vegetation grow at least 15 feet deep from the shoreline back and preferably 25 feet or deeper. Just by not mowing will do the trick. Residents can check how it looks at the end of the summer. It will take up to three years for flowers and native grasses to grow up and be noticed. Residents can also select other spots on their property to "naturalize".

2. Accelerated Naturalization: After developing a plant list of species from the area, residents may want to mimic some features right away. They can lay out a planting scheme and plant right into existing vegetation. Several Minnesota nurseries can supply native plant stock and seeds. The nurseries can also help select plants and offer planting tips. Wildflowers can be interspersed with wild grasses and sedges. Mulch around the new seedlings. With this approach lake residents can accelerate the naturalization process.

3. Reconstruction: To reestablish a native landscape with the resident's input and vision, another option is to reconstruct the site with all new plants. Again plant selection should be based on plants growing in the area. Site preparation is a key factor. Residents will want to eliminate invasive weeds and eliminate turf. This can be done with either herbicides or by laying down newsprint or other types of paper followed by 4 to 6 inches of hardwood mulch. Plantings are made through the mulch. This is the most expensive of the three native landscaping categories. Residents can do the reconstruction all at once, or phase it in over 3 to 5 years. This allows them to budget annually and continue evolving the plan as time goes by.

Also mixing and matching the level-of-effort categories allows planting flexibility. Maybe a homeowner employs naturalization along the sides of the lot and reconstruction for half of the shoreline and accelerated naturalization for the other half. Examples of the three approaches are shown in Figure 26.

A book that covers the shoreland improvements is "Lakescaping for Wildlife and Water Quality" by Carrol Henderson and others and is available from the Minnesota Department of Natural Resources for $21 (651.296.6157).

1. Naturalization: The easiest way to implement a natural shoreline setting is to select an area and leave it grow back naturally.

2. Accelerated Naturalization: To accelerate the naturalization, plant shrubs, wild flowers, or grasses into a shoreland area.

3. Restoration: This involves removing existing vegetation through the use of paper mats and/or mulching and planting a variety of native grasses, flowers, and shrubs into the shoreland area.

Figure 26. Examples of three shoreland management options.

Project 4. Aquatic Plant Projects

A high priority lake improvement recommendation is to decrease the extent of the exotic curlyleaf pondweed and to maintain healthy native aquatic plant communities in Big Round Lake. Currently, Big Round 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. However, curlyleaf pondweed contributes to detrimental lake conditions.

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

1. Maintaining good shoreland conditions can promote improved plant distribution. Ongoing aquatic plant monitoring and delineation will be important.

2. Conduct a lake soil fertility survey to determine if soils can support plant growth. Sample areas with plants and areas without plants. If soil fertility is similar, then something other than nutrients are inhibiting plant growth. The cost is $2,500.

3. Conduct curlyleaf pondweed control demonstrations to evaluate the best way to control curlyleaf pondweed in Big Round Lake. Details of this program are given on the next two pages.

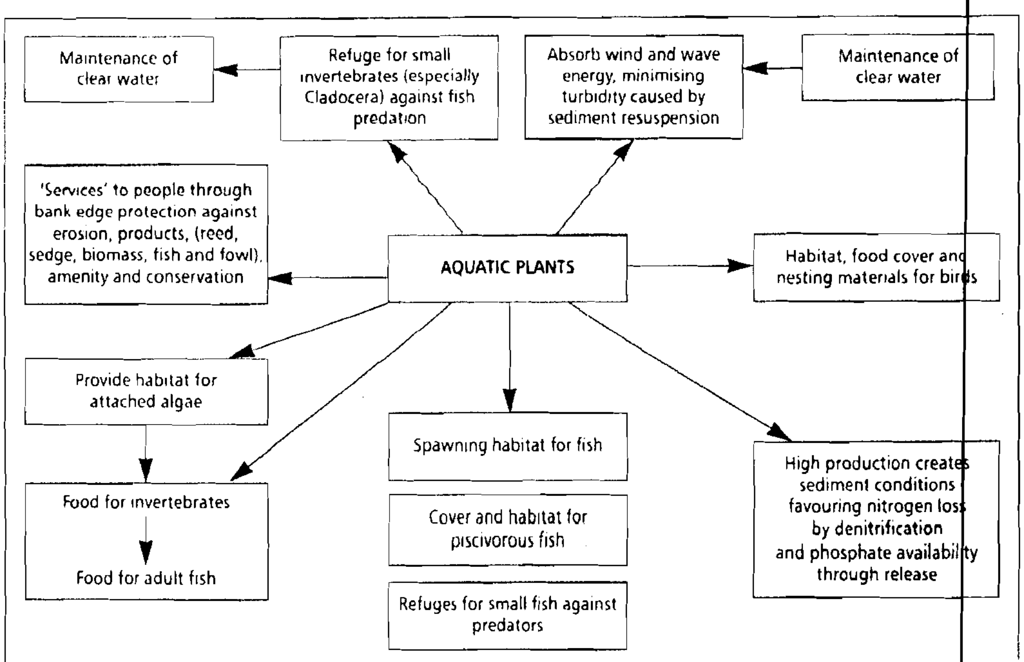


Figure 27. Links between aquatic plants and other organisms, including ourselves (source: Moss and others. 1996. A guide to the restoration of nutrient-enriched shallow lakes. Broads Authority Norwich, England).

Conduct Ongoing Macrophyte Survey and Curlyleaf Evaluations: Early summer aquatic plant surveys will be conducted in 2005 and 2006 to examine, in detail, the abundance of curlyleaf pondweed as well as the type of plants and coverage of plants found in Big Round Lake using Wisconsin DNR guidelines (Lowrance X-16 sonar tracings, and a minimum of 25 transects). Results from this survey will allow a calculation of percent of lake surface coverage, maximum depth colonized, and species distribution.

Conduct a Demonstration Harvesting and Iron Treatment Program for Curlyleaf Pondweed Control:
Harvesting; Ongoing efforts are involved for long-term control of curlyleaf pondweed. Mechanical harvesting has been a standard option for annual nuisance curlyleaf control. The question is can custom harvesting be employed to develop long-term control. Results in other lakes have been mixed. Pre-emptive cutting has shown signs of controlling curlyleaf (McComas and Stuckert 2000) but additional observations have shown that curlyleaf does not always respond to repeated cutting or harvesting (McComas 2004 -Bald Eagle). The question is why? Research results from 2003 indicate that at extremely high stem densities and biomass, curlyleaf is somewhat resistant to long term control efforts (McComas - in prep).

Therefore the harvesting program for Big Round involves initial curlyleaf evaluation and then harvesting action in two one-acre plots in May or June of 2005. Sites will be delineated with GPS coordinates. Follow-up curlyleaf evaluation will determine if there is significant curlyleaf reduction in terms of stem density and biomass.

Iron Treatments: Results from an iron-treated pond in Minnesota in 1998 give some indication that elemental iron has an inhibitory effect on nuisance curlyleaf growth (McComas 2004 - Heine Pond). The addition of iron filings in Heine Pond apparently worked primarily as a sediment treatment and had an effect on sediment pH, which in turn, regulated the availability of iron and subsequently affected micro and macro-nutrient availability in the plants. We propose to set-up two half-acre plots that will be treated with iron filings at a rate of 30 grams per square foot. The iron will be added in the fall of 2004 and sites will be delineated with GPS coordinates. Follow-up curlyleaf evaluation will determine if there is significant curlyleaf reduction. Curlyleaf status will be evaluated by collecting stem counts and plant biomass.

? Technical team review.

A map showing demonstration locations is shown in Figure 28.

Figure 28. Site locations for demonstration projects are shown above. The squares indicate harvesting locations and circles indicate iron treatment locations. The overall distribution of curlyleaf is shown with the green shading.

Project 5. Fish Management Options

[Management recommendations are based on WDNR management plans]

1. Big Round Lake as a desirable, well balanced fish community, and currently fishing regulations are appropriate.

2. Past surveys have indicated that walleye fingerling stocking is beneficial, so the current management scenario of stocking walleye fingerlings at the rate of 50 per acre on alternate years should continue.

3. Walleye natural reproduction is significant, and a walleye spawning reef is to be installed in the winter of 2005. Similarly, wetland areas and shallow, heavily vegetated bays where northern pike spawn should not be altered.

Project 6. Ongoing Education Program

Lake residents get an important amount of lake protection information from the lake newsletter. Each issue should offer tips on lake protection techniques. There is abundant material available. An example of an informational piece is shown below.

Reduce Waste *If not you, who?*

YOUR LAWN AND THE ENVIRONMENT

New phosphorus lawn fertilizer law aims to protect Minnesota lakes and rivers

Minnesota has recently passed a law that restricts the use of lawn fertilizers containing phosphorus, the primary nutrient that turns lakes green with algae.

New Phosphorus Law

Starting January 1, 2004, **fertilizers containing phosphorus cannot be used on lawns in the Twin Cities metro area** (Anoka, Carver, Dakota, Hennepin, Ramsey, Scott and Washington counties). Greater Minnesota is restricted to lawn fertilizers with 3 percent or less phosphate content (with fertilizer, phosphorus is measured as *phosphate*). Look for the middle number on a bag of fertilizer. For the metro area, it should be zero (0) and in Greater Minnesota it should be three (3).

Keep fertilizer off paved surfaces: It's illegal to spread any fertilizer on hard surfaces such as streets, sidewalks, and driveways. Rain can wash the fertilizer into nearby storm drains or road ditches, eventually getting into a lake or river near you. If you accidentally spill or spread fertilizer on a hard surface, clean it up immediately.

Exemptions

Fertilizers containing phosphorus may be used on lawns if a soil test indicates that it is needed or if you are establishing a new lawn.

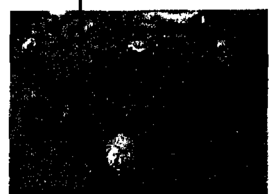
These restrictions do not apply to fertilizers used for agricultural crops, *flower and vegetable* gardening, or on golf courses by trained staff.

DO THE GREEN THING: FERTILIZE RESPONSIBLY Many garden centers and hardware stores now carry phosphorus-free lawn fertilizers.

Will phosphorus-free fertilizer keep my lawn healthy?

While phosphorus is necessary to grow healthy lawns, soils in many parts of Minnesota already have an adequate amount. In these instances, adding more phosphorus in fertilizer is not needed and will not benefit your lawn. Healthy lawns can be maintained with phosphorus-free fertilizers.

THE PROBLEM: TOO GREEN

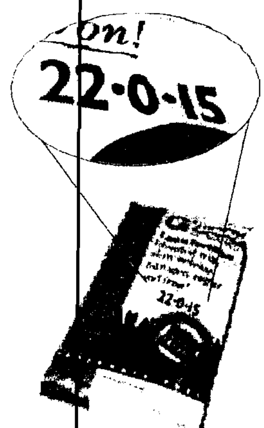


GREEN AND MUCKY Excess algae and weed growth is a major problem in many Minnesota lakes and waterways.

MORE PHOSPHORUS, LESS FISH Too much algae lowers oxygen levels and darkens the water. This can have a devastating effect on fish populations.

What to look for

On any bag or box of fertilizer, there is a string of three numbers. The middle number indicates phosphorus content and should read "0" in the Twin Cities seven-county metropolitan area, and "3" or less in Greater Minnesota.



What can you do to protect water quality?

Fertilizers, leaves, grass clippings, eroded soil, and animal waste are all sources of phosphorus. When they are swept or washed into the nearest street or storm drain, they end up in your local lake or river. You can do your part to protect water quality by doing the following:

- Follow Minnesota's new phosphorus lawn fertilizer law.
- Keep leaves and lawn clippings out of your gutters, streets, and ditches.
- Clean lawn and garden equipment on the grass, not on hard surfaces. Never wash or blow soil or grass clippings into the street.
- Pick up pet waste promptly. Pet waste can contain harmful bacteria as well as nutrients. Never drop pet waste in the street or ditches.

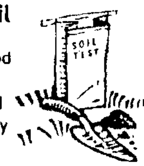
- Control soil erosion around your house. When left bare, soil is easily washed away with rain, carrying phosphorus with it. Soil erosion can be prevented by keeping soil covered with vegetation or mulch.

SWEEP IT UP Grass clippings and leaves left on streets and sidewalks are a major source of phosphorus.

To obtain additional copies of this fact sheet

contact Office of Environmental Assistance's **Education Clearinghouse** at 1-800-877-6300, 651-215-0232 or e-mail: clearinghouse@moea.state.mn.us.

Find out what you need: Test your soil



A soil test is a good idea, especially if you are concerned that your lawn may need phosphorus.

Instructions on soil testing are available through the University of Minnesota Extension Service's INFO-U by calling 612-624-2200 (metro) or 1-800-525-8636 and requesting message 468.

Soil testing information can also be obtained through the Internet by visiting www.extension.umn.edu and searching for "Lawn Soil Testing."

A list of laboratories certified for soil testing by the Minnesota Department of Agriculture can be found at www.mda.state.mn.us/appd/soilabs.htm.

Visit **www.reduce.org** for lots of ideas about reducing waste and toxic chemicals in your day-to-day life.

reduce.org

For more information on lawn care

- The **Yard & Garden Line** is the University of Minnesota Extension Service's one-stop telephone link to information about plants and insects in the home landscape. Call 612-624-4771, or (toll free) 1-888-624-4771 in Greater Minnesota.
- University of Minnesota **Extension Service's web site**: www.extension.umn.edu. From the home page click on "Garden" then on "Lawns."
- University of Minnesota Extension Service - **Sustainable Urban Landscape Information Series** (SULIS): www.sustland.umn.edu. From the home page, click on "Maintenance" then on "Lawn care."
- **Minnesota Department of Agriculture**: www.mda.state.mn.us. From the home page, click on "Water & Land," then on "Lawn Care & Water Quality."

AGRICULTURE Metro WaterShed Partners Extension Minnesota Office of Environmental Assistance

Project 7. Watershed and Lake Monitoring Program

A lake monitoring program is outlined in Table 16. It is designed to be flexible to accommodate the volunteer work force and a fluctuating budget.

Table 16. Big Round Lake Water Quality Monitoring Program

Category	Level	Alternative	Labor Needed	Cost/Year
A. Dissolved oxygen	1	Check dissolved oxygen in Big Round Lake every two weeks in January, February, and March depending on winter conditions.	Moderate	$0
	2	Check dissolved oxygen in Big Round Lake every one to two weeks in December, January, February, and March, depending on winter conditions and collect phosphorus samples.	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.	--	$100-$3,000

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 2004, a recommended program consists of Level B2 and Level C3 annually. An aquatic plant survey (Level D1) should be conducted every three years.

7. References

Saad, D.A. and D.M. Robertson. 2000. Water-resources related information for the St. Croix Reservation and vicinity, Wisconsin. US Geol. Survey, Water Resources Invest. Rep 00-4133, Middleton, Wisconsin.

WDNR. 1980. Big Round Lake, Polk County: Feasibility study; management alternatives. WDNR, Office of Inland Lake Renewal.

Appendix

Wisconsin Department of Natural Resources

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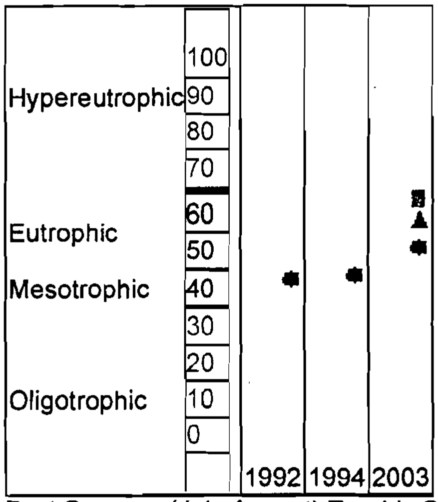
Trophic State Index Graph for BIG ROUND LAKE, DEEP HOLE, Polk County



Past Summer (July-August) Trophic State Index (TSI) averages.

◆ = Secchi ■ = Chlorophyll ▲ = Total Phosphorus

TSI(Chl) = TSI(TP) = TSI (Sec)	It is likely that algae dominate light attenuation.
TSI(Chl) > TSI(Sec)	Large particulates, such as Aphanizomenon flakes dominate
TSI(TP) = TSI(Sec) > TSI (Chl)	Non-algal particulate or color dominate light attenuation
TSI(Sec) = TSI(Chl) >= TSI (TP)	The algae biomass in your lake is limited by phosphorus
TSI(TP) > TSI(Chl) = TSI (Sec)	Zooplankton grazing, nitrogen, or some factor other than phosphorus is limiting algae biomass

TSI	TSI Description
TSI < 30	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
TSI 30-40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
TSI 40-50	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
TSI 50-60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
TSI 60-70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
TSI 70-80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
TSI > 80	Algal scums, summer fishkills, few plants, rough fish dominant. Very poor water quality.

Trophic state index (TSI) is then determined using a mathematical formula (Wisconsin has its own version). The TSI is a score from 0 to 110, with lakes that are less fertile having a low TSI. We base the overall TSI on the Chlorophyll TSI when we have Chlorophyll data. If we don't have chemistry data, we use TSI Secchi. We do this rather than averaging, because the TSI is used to predict biomass. This makes chlorophyll the best indicator. Visit Bob Carlson's website, dipin.kent.edu/tsi.htm, for more info.

Report Printed Data Last Updated: 3/26/04. Storet: 493145

Lake Monitoring 2003 Annual Report

Big Round Lake
Polk County
Waterbody Number: 2627400

Lake Type:
DNR Region:
GEO Region: NW

Site Name	Storet #
Deep Hole	493145

Group	Date	SD (ft)	SD (m)	CHL	TP	TSI (SD)	TSI (CHL)	TSI (TP)	Lake Level	Clarity	Color	Perception
57654	05/06/2003				15			49				
57653	05/07/2003	15.33	5			38			Normal	Clear	Blue	
57653	05/24/2003	11.25	3			42			Normal	Clear	Brown	
57653	06/13/2003	9	3			45			Normal	Clear	Brown	
57653	06/17/2003				26			53				
57653	06/18/2003	8.75	3			46			Normal	Clear	Brown	
57653	07/04/2003	8	2			47			Normal	Clear	Brown	
57653	07/16/2003				35			56				
57653	07/21/2003	5.25	2			53			Normal	Murky	Green	
57653	08/05/2003	2.33	1			65			Normal	Murky	Green	
57653	08/20/2003				104			64				
57653	08/20/2003	1.75	1			69			Normal	Murky	Green	
57653	09/06/2003	1.33	0			73			Low	Murky	Green	
57653	09/16/2003				179			68				
57653	09/22/2003	3.5	1			59			Low	Murky	Green	
57653	10/08/2003	5.33	2			53			Low	Murky	Brown	

Date	Collector Comments
05/07/2003	Partially cloudy, light wind. Rained for 2 days.
05/24/2003	Clear, calm, last rain 2 days ago.
06/13/2003	Small fish kill on 7th and 8th of June about 5 fish per foot of shore on North side. 11(?) panfish.
06/18/2003	Partially cloudy, slight breeze.
07/04/2003	Partially cloudy, slight breeze. 2.5 inches of rain 2 days ago.
07/21/2003	Overcast, slight breeze. No rain for 4 days.
08/05/2003	Overcast, calm, no rain for 5 days
08/20/2003	Clear, windy. .75" rain 5:30 AM to 7:30 AM.
09/06/2003	Clear, no wind. No rain for 2 weeks. Algae, muck out 30' from shore.
09/22/2003	Cloudy, overcast, windy for 3 days.
10/08/2003	Clear, windy

Date	Lab Comments
05/06/2003	Temp at lab - iced.
06/17/2003	Sample received with ice melted- result approximate
07/16/2003	Sample received with ice melted- result approximate
08/20/2003	Temp at lab - iced. Assumed surface sample depth of 6 ft. Sample depth not indicated.
09/16/2003	Sample received with ice melted- result approximate. Assumed surface sample depth of 6ft. Sample depth not indicated.

Group - Data Collectors - Source of Data
57654 - McComas -
57653 - Dan Bergeron -

SD = Secchi depth measured in feet converted to meters; Chl = Chlorophyll a in micrograms per liter(ug/l); TP = Total phosphorus in ug/l, surface sample only; TSI(SD), TSI(CHL), TSI(TP) = Trophic state index based on SD, CHL, TP respectively; Depth measured in feet; Temp = Temperature in degrees Fahrenheit; D.O. = Dissolved Oxygen in parts per million.

Wisconsin Department of Natural Resources **Wisconsin Lakes Partnership**

Big Round Lake - Deep Hole 2003 Results

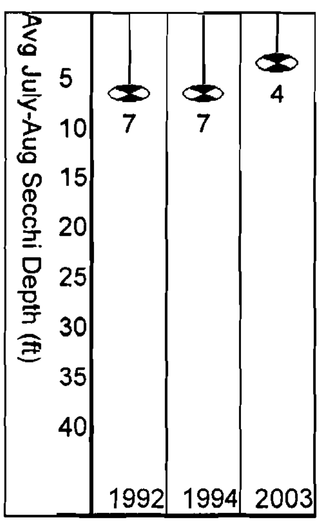
Eutrophic **Mesotrophic** **Oligotrophic**

Self-Help Lake Monitoring just completed its 18th year! A total of 569 lakes, and 657 individual sites, were monitored in 2003. **Big Round Lake, Deep Hole** was sampled **16** different days during the 2003 season. Parameters sampled included

- water clarity
- total phosphorus

The average summer (July-Aug) secchi disk reading for Big Round Lake (Polk County, WBIC: 2627400) - Deep Hole was 4 feet. The average for the NW Georegion was 9 feet. Typically the summer water was reported as **Murky** and **Green**. This suggests that the secchi depth may be mostly impacted by algae. Algal blooms are generally considered to decrease the aesthetic appeal of a lake because people prefer clearer water to swim in and look at. Algae are always present in a balanced lake ecosystem. They are the photosynthetic basis of the food web. Algae are eaten by zooplankton, which are in turn eaten by fish. You will know algae are causing reduced Secchi depth if the water generally appears green when you assess the color against the white background of the secchi disc.

The overall Trophic State Index (based on secchi) for Big Round Lake - Deep Hole is 56. The TSI suggests that Big Round Lake is **eutrophic**. This TSI usually suggests decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.



Past secchi averages in feet.
Data Last Updated: 3/26/04. Storet: 493145

Water-Resources-Related Information for the St. Croix Reservation and Vicinity, Wisconsin

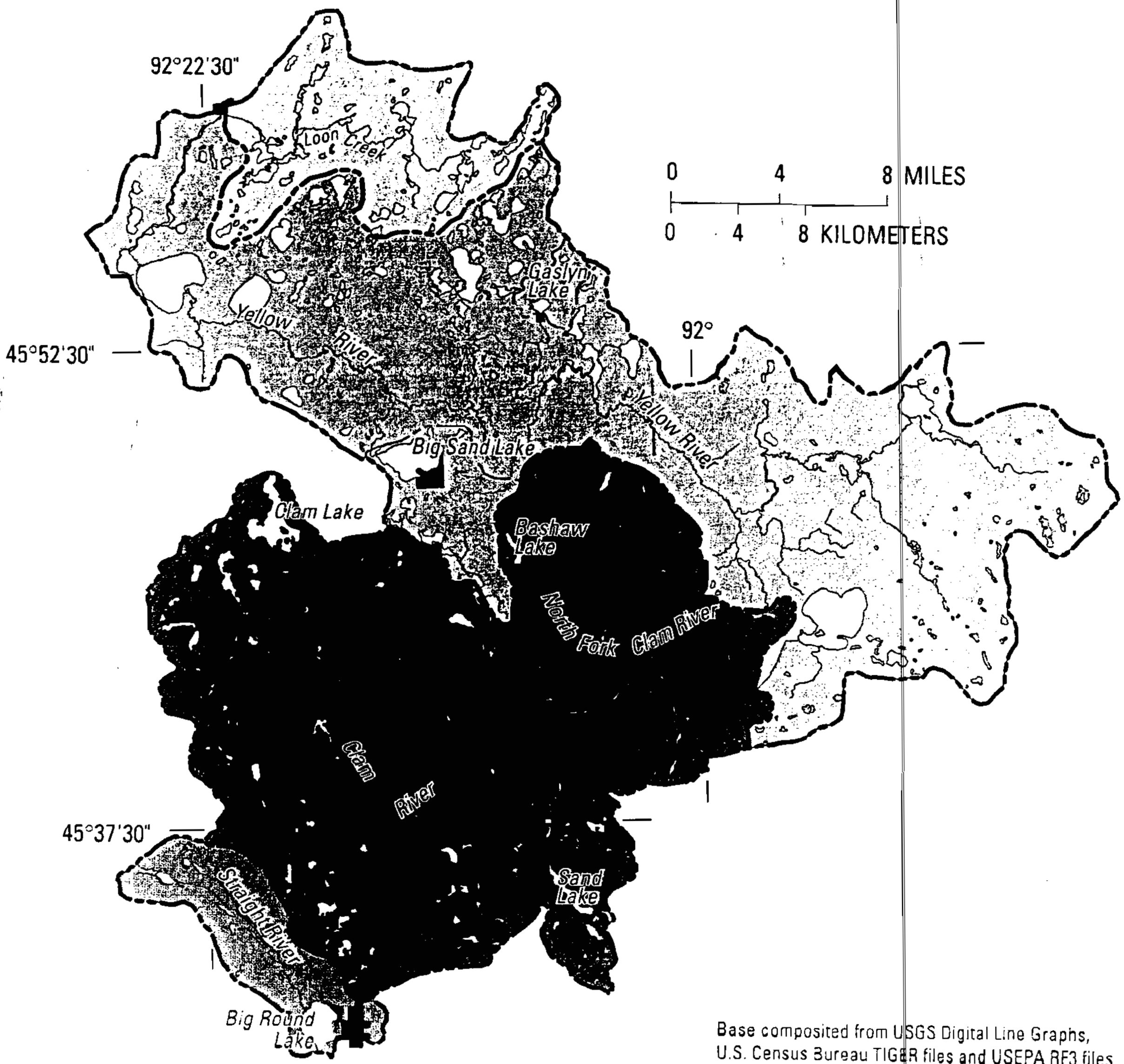
By David A. Saad and Dale M. Robertson

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 00–4133

Prepared in cooperation with the
St. Croix Chippewa Indians of Wisconsin

Middleton, Wisconsin
2000

USGS
science for a changing world



Base composited from USGS Digital Line Graphs, U.S. Census Bureau TIGER files and USEPA RF3 files

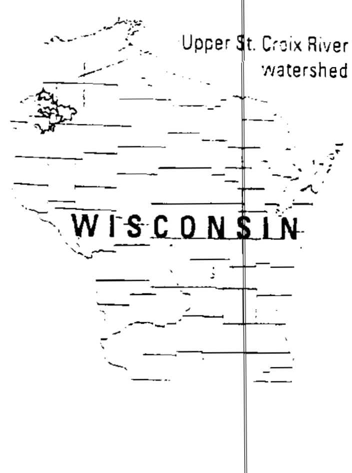


Figure 2. Main watersheds and subwatersheds in the study area.

Table 7. Summary of selected water-quality characteristics for samples from the lakes of interest for the St. Croix Reservation and vicinity, Wisconsin—Continued

Parameter code	Characteristic	Bashaw Lake		Big Round Lake		Big Sand Lake		Clam Lake		Gaslyn Lake		Sand Lake	
		N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
00668	Phosphorus, bottom material, mg/kg as P	3	660	---	---	---	---	3	650	3	1,200	---	---
00671	Phosphorus, dissolved orthophosphate, mg/L as P	3	<DL	2	<DL	3	.01	3	<DL	4	.01	2	<DL
00681	Carbon, organic, dissolved, mg/L as C	---	---	1	4.1	---	---	---	---	---	---	---	---
00691	Carbon, inorganic, dissolved mg/L as C	---	---	1	22	---	---	---	---	---	---	---	---
00900	Hardness, total, mg/L as $CaCO_3$	3	93	2	87	---	---	3	99	3	66	---	---
00910	Calcium, mg/L as $CaCO_3$ GW	---	---	1	23	---	---	---	---	---	---	---	---
00915	Calcium, dissolved, mg/L as Ca	3	24	2	21	2	9.7	3	26	3	18	2	22
00916	Calcium, total, mg/L as Ca	---	---	---	---	2	8.5	---	---	1	19	---	---
00925	Magnesium, dissolved, mg/L as Mg	3	8	3	8.4	2	3.4	3	9	3	4.9	2	7
00927	Magnesium, total, mg/L as Mg	---	---	---	---	2	3	---	---	1	5	---	---
00929	Sodium, total, mg/L as Na	---	---	---	---	2	5	---	---	1	2	---	---
00930	Sodium, dissolved, mg/L as Na	3	2.8	3	2.7	2	1.8	3	2.9	3	2.3	2	2.5
00931	Sodium adsorption ratio	1	.1	---	---	---	---	1	.1	1	.1	---	---
00932	Sodium, percent	1	6	---	---	---	---	1	6	1	7	---	---
00935	Potassium, dissolved, mg/L as K	3	.93	3	.85	2	.4	3	.7	3	.67	2	.95
00937	Potassium, total, mg/L as K	---	---	---	---	2	.55	---	---	1	1.1	---	---
00940	Chloride, dissolved, mg/L as Cl	3	2.8	2	3	4	1.3	3	2.1	4	1.6	2	1.6
00941	Chloride, total, mg/L as Cl	---	---	1	2.8	---	---	---	---	---	---	---	---
00945	Sulfate, dissolved, mg/L as SO_4	3	5.8	2	3.8	2	3.1	3	4.7	3	5.3	2	4.5
00950	Fluoride, dissolved, mg/L as F	3	.1	3	.09	2	.1	3	.1	3	<DL	2	<DL
00955	Silica, dissolved, mg/L as SiO_2 GW	3	14	3	22	2	2	3	16	3	17	2	9.8
01002	Arsenic, total, µg/L as As	2	<DL	1	<DL	1	<DL	2	<DL	2	<DL	1	<DL
01005	Barium, dissolved, µg/L as Ba	1	23	1	25	1	25	1	28	1	62	1	21
01007	Barium, total, µg/L as Ba	2	<DL	1	<DL	1	<DL	2	<DL	2	<DL	1	<DL
01010	Beryllium, dissolved, µg/L as Be	1	<DL	1	<DL	1	<DL	1	<DL	1	<DL	1	<DL
01012	Beryllium, total, µg/L as Be	2	<DL	1	<DL	1	<DL	2	<DL	2	<DL	1	<DL
01027	Cadmium, total, µg/L as Cd	2	<DL	1	<DL	1	<DL	2	<DL	2	<DL	1	<DL
01034	Chromium, total, µg/L as Cr	2	6.5	1	2	1	4	2	2.5	2	4	1	4
01037	Cobalt, total, µg/L as Co	2	<DL	1	<DL	1	<DL	2	<DL	2	<DL	1	<DL
01042	Copper, total, µg/L as Cu	2	2.5	1	5	1	3	2	5	2	4	1	2
	, suspended, µg/L as Fe	2	250	1	100	1	170	2	290	2	1,000	---	---
	, total, µg/L as Fe	3	500	2	300	2	280	3	440	3	1,900	2	140
	dissolved, µg/L as Fe	3	88	2	17	2	49	3	130	3	950	2	4.5

Table 7. Summary of selected water-quality characteristics for samples from the lakes of interest for the St. Croix Reservation and vicinity, Wisconsin

[N, number; ---, no data; <DL, less than the detection limit; °C, degrees Celsius; μS/cm, microsiemens per centimeter; mg/L, milligrams per liter; mg/kg, milligrams per kilogram; μg/L, micrograms per liter; NTU, nephelometric turbidity unit]

Parameter code	Characteristic	Bashaw Lake		Big Round Lake		Big Sand Lake		Clam Lake		Gaslyn Lake		Sand Lake	
		N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
00010	Water temperature, field, °C	3	20	3	16	2	22	3	20	3	21	2	21
00076	Turbidity, Hach, FTU	---	---	---	---	2	2.3	---	---	1	7.8	---	---
00078	Transparency, Secchi disk, meters	1	0.9	1	2	1	4.3	4	1.3	1	0.6	---	---
00080	Color, platinum cobalt scale	---	---	1	13	---	---	---	---	---	---	---	---
00095	Specific conductance, μS/cm at 25°C	3	205	3	219	4	111	3	214	4	157	2	188
00154	Sulfate, total, mg/L as S	---	---	1	4.3	---	---	---	---	---	---	---	---
00300	Oxygen, dissolved, mg/L	3	6.9	2	8.3	3	5.8	3	8.6	4	7.1	2	9.1
00400	pH, field	3	7.9	2	9	2	8.5	3	8.2	2	7.1	2	8.7
00403	pH, whole water, lab	2	7.8	3	8.1	4	7.7	2	8.4	3	7.5	2	8.3
00409	Alkalinity, total, gran titration, μeq/L	---	---	1	1,900	---	---	---	---	---	---	---	---
00410	Alkalinity, total, mg/L as $CaCO_3$	1	84	---	---	2	42	---	---	1	75	1	75
00496	Loss on ignition, bottom material, mg/kg	2	420,000	---	---	---	---	2	480,000	2	460,000	---	---
00530	Residue, total, nonfiltered, mg/L	1	7	1	12	1	2	1	6	1	7	1	3
00600	Nitrogen, total, mg/L as N	---	---	---	---	2	.78	---	---	1	1.4	---	---
00605	Nitrogen, organic, mg/L as N	2	1.2	---	---	2	.44	2	.78	2	.81	---	---
00608	Nitrogen, ammonia, dissolved, mg/L as N	3	.05	2	0.09	4	.15	3	.03	4	.10	2	<DL
00610	Nitrogen, ammonia, total, mg/L as N	2	.08	1	.25	1	<DL	2	.03	2	.02	1	<DL
00611	Nitrogen, ammonia, bottom material, mg/kg as N	3	200	---	---	---	---	3	130	3	300	---	---
00613	Nitrogen, nitrite, dissolved, mg/L as N	---	---	---	---	2	.01	---	---	1	.01	---	---
00615	Nitrogen, nitrite, total, mg/L as N	2	<DL	1	<DL	1	<DL	2	<DL	2	<DL	1	<DL
00618	Nitrogen, nitrate, dissolved, mg/L as N	---	---	---	---	2	.07	---	---	1	.29	---	---
00623	Nitrogen, kjeldahl, dissolved, mg/L	---	---	1	.3	1	.6	---	---	---	---	1	.2
00624	Nitrogen, kjeldahl, suspended, mg/L as N	---	---	1	.50	1	.2	---	---	---	---	1	.2
00625	Nitrogen, kjeldahl, total, mg/L as N	2	1.3	2	1.8	2	.8	3	.8	2	1.1	2	.65
00626	Nitrogen, ammonia plus organic, bottom material, mg/kg as N	3	36,000	---	---	---	---	3	45,000	3	42,000	---	---
~~00630~~	~~Nitrogen, nitrite plus nitrate, total, mg/L as N~~	~~2~~	~~<DL~~	~~1~~	~~<DL~~	~~1~~	~~<DL~~	~~2~~	~~<DL~~	~~2~~	~~<DL~~	~~1~~	~~<DL~~
00631	Nitrogen, nitrite plus nitrate, dissolved, mg/L as N	3	.11	2	<DL	2	<DL	3	<DL	3	2.23	2	<DL
00633	Nitrogen, nitrite plus nitrate, bottom material, mg/kg as N	3	83	---	---	---	---	3	89	3	98	---	---
00662	Phosphorus, total recoverable, μg/L as P	---	---	1	27	---	---	---	---	---	---	---	---
00665	Phosphorus, total, mg/L as P	2	.09	2	.13	4	.02	3	.05	3	.03	2	.03
00666	Phosphorus, dissolved, mg/L as P	3	.02	2	.03	2	.04	3	.03	3	.02	2	.03