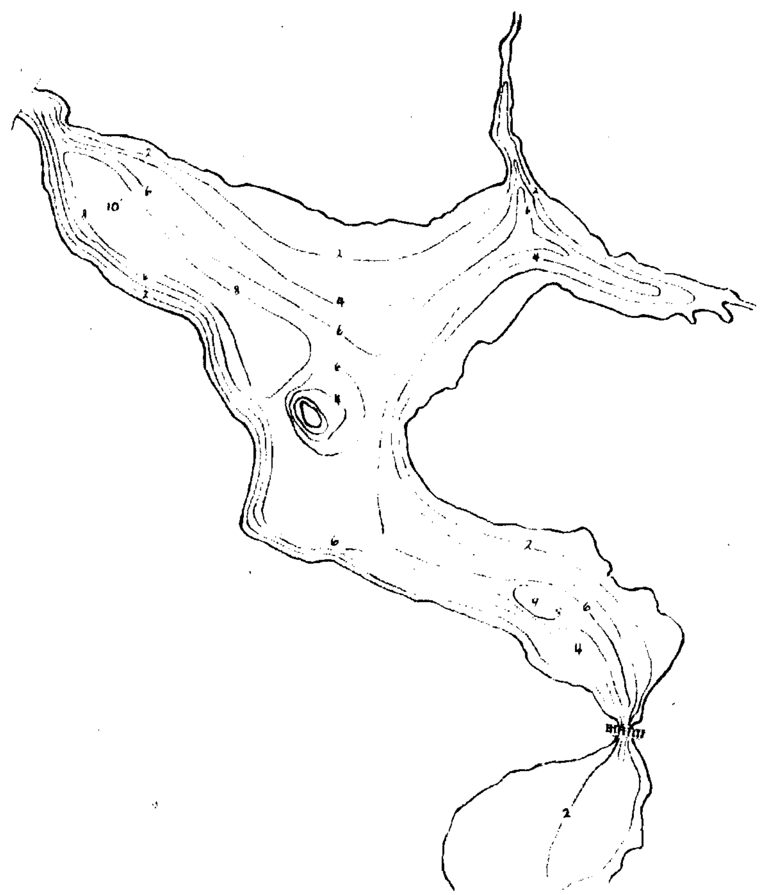
Black Otter Lake

Comprehensive Survey Results and Management Plan

January 24, 2003



Prepared by:

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Chad Cason

Aquatic Biologists, Inc.
N4828 Hwy 45
Fond du Lac, WI 54935
920-361-4088

Sponsored by:

The Black Otter Lake District and the Wisconsin Department of Natural Resources

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Contributors:

Jim Nicholson - project coordination, data collection
Andy Chikowski - data collection and analysis, literature review

1.0 Abstract

A comprehensive survey was conducted on Black Otter Lake during 2002. this survey focused on lake ecology, physical and chemical characteristics, and watershed influences. The purpose of the survey was to assess lake management efforts and to provide information for an updated lake management plan. The survey found an aquatic plant community dominated by exotic species; predominantly curly-leaf pondweed. Duckweed and algae also reached nuisance levels and negatively affected lake ecology and water quality. Submergent plant diversity had declined since the previous survey. The highest diversity of emergent plants was found along the undeveloped east shore. This area contained important fish spawning habitat as well as excellent wildlife habitat. Water quality data collected during the survey generally ranked Black Otter Lake in the "poor" range. Despite an operating aeration system, much of the lake became anoxic during warmer months. Most water chemistry values were similar to those found in the previous survey, except nitrate + nitrite and chloride, which were much higher. Black Otter Lake was found to be phosphorus-limited. Its volume was 384 acre-ft. Lake residence time was 4.32 days. Phosphorus imports exceeded exports, thus the lake acted as a nutrient sink. Soil conservation and nutrient management programs enacted in the watershed appear to have been very effective. Phosphorus loading from the south inlet, the lake's main water source, was relatively low. However, phosphorus loading from the north inlet was very high. Lake mapping efforts found that significant sedimentation had not reoccurred since the last dredging effort. Black Otter Lake's watershed area was determined to be 10,193 acres. Land uses were 62% agricultural, 15% upland forest, 12% residential, 8% swamp forest, and 3% CRP. The watershed was composed of three drainage basins. The upper basin, which was predominantly residential / commercial, was identified as having the greatest negative influence on lake water quality.

-How??

Management recommendations indicated by the survey results included controlling curly-leaf pondweed and Eurasian watermilfoil with herbicides, treating algae and duckweed with herbicides if nuisance levels are reached, controlling nuisance native plants by mechanical harvesting, and retrofitting and upgrading the aeration system to achieve water quality improvements. Property owners with direct drainage into the lake were encouraged to use zero-phosphorus fertilizers. The Lake District was encouraged to work with local governments in implementing new construction site BMPs, developing stormwater management projects that limit direct runoff into the lake, and improving erosion control on waterways.

2.0 Excerpt:

A Year in the Life of Black Otter Lake (an interpretation of data)

Winter is a time of calmness and stability for Black Otter Lake. Few things affect the lake underneath its protective layer of ice. An aeration system provides life-giving oxygen for fish and other aquatic organisms. The fish attract predators: mink and otters who find easy access beneath the ice through the aeration holes, and humans, who set up shanties on the thicker ice and fish through augered holes for the lake's good-sized bluegills and crappies.

Things changed drastically with the spring thaw, however. Melting snow sent rivulets of water over plowed fields, forests and pasture. Rivulets gathered in low areas and moved as sheets of water through forests of cedar and ash. Gaining momentum, these waters became fast-moving creeks that rushed into Black Otter Lake. These flowing watercourses were laden with sediments, and nutrients that would fertilize plant growth. In the lower and middle watersheds, much of the sediments and nutrients were captured in swamps and marshes, and in porous soils. In the upper watershed though, waters flowed quickly over mowed lawns, parking lots and roadways, bringing a heavy load of silt and fertilizer, as well as road salts and other pollutants, directly into the lake.

As waters warmed and sediments flushed downstream, when aquatic plants thrived, particularly curly-leaf pondweed. This new arrival to the lake prefers cool water and began growing well before native plants, giving it a competitive advantage. In the warm shallows, plants became dense and quickly grew to the surface. Largemouth bass, black crappie, then bluegill migrated through these dense beds of vegetation in search of hard-bottomed areas where they could fan out a spawning nest. A June heat wave warmed waters quickly. This both increased biological oxygen demands and decreased the oxygen saturation concentration of water. The dense plant beds further prevented mixing of oxygenated waters from other parts of the lake. During the day this was not a problem, as plants produced oxygen as a byproduct of photosynthesis. At night however, oxygen reserves were quickly depleted. The spawning fish were trapped and became stressed. Fish began to die, perhaps from becoming susceptible to natural toxins released from floating pine pollen, or perhaps directly from oxygen deprivation. Within a matter of days thousands of fish were floating, dead and bloated, in the shallows.

By July the water flow entering the lake had diminished considerably. Warm, stagnant waters developed in the protected bays, creating ideal environments for several opportunistic plants. The most ubiquitous of these were tiny free-floating plants called duckweed and watermeal. Filamentous algae, such as *Pithophora* and *Spirogyra*, filled in the voids. The entire surface of these bays became blanketed in a floating carpet of vibrant green. These floating plants became so effective in competing for sunlight that the rooted plants below were starved to death. Bacterial decomposition of the dead plant matter quickly depleted oxygen reserves, once again creating a toxic environment for many organisms. More mobile life forms, such as fish, migrated down the lake to more favorable environments. The less mobile creatures, such as aquatic insects, mollusks and crustaceans, perished in the darkness beneath the carpet of green. Only mother mallards with flocks of ducklings in tow, who found the duckweed and watermeal to be a floating smorgasbord, and painted turtles, who feasted on the carcasses of fish that did not escape, seemed to thrive in these conditions.

During July, curly-leaf pondweed dominated the rooted aquatic plant community. By August however, 80° water temperatures ended the seasonal life cycle of this cold-adapted plant. Curly-leaf pondweed died en masse. The decaying plant matter released a massive load of nutrients into the water column. Duckweeds and algae, the floating army of green, responded and advanced down the lake. The encroaching green blanket killed even more plants. All of the decaying plant matter turned the water in Black Otter Lake to a dirty brown color. In a self-perpetuating cascade of plant carnage, the darkened water starved rooted plants of light throughout the lake.

Despite the operating aeration system, the lake became so depleted of oxygen that fish were forced into the upper water column over the deepest portions of the lake. Black Otter Lake had truly become a hostile environment. The only life that seemed to thrive were duckweeds and algae. Lakeshore homeowners though, looked upon these floating mats in disgust. Recreational use on the lake had nearly ground to a halt. Only a handful of neighborhood boys armed with fishing rods and big red and white bobbers were able to capitalize on these conditions. The big schools of bluegills that were forced to crowd above the spillway made easy prey for the young anglers.

But life persisted in Black Otter Lake. Fall rains helped to flush out the turbid water. Cooling temperatures reduced metabolisms and oxygen demands in the lake. The mats of free-floating plants were most susceptible to these sudden temperature changes and died off almost as quickly as they formed. By November, dissolved oxygen was once again replenished in the lake and fish were able to disperse. Soon the fast-paced, feast or famine, boom or bust, cycle of life would come to halt. Beneath a protective layer of ice, order and stability would be restored – until the spring thaw, when once again the results of activities throughout a ten thousand acre watershed would find their way to a little 75-acre lake called Black Otter.

3.0 Introduction

3.1 Description of Study Area

Black Otter Lake is a shallow, 75-acre impoundment located within the village of Hortonville in the southwest corner of Outagamie County, Wisconsin. Outagamie County has the distinction of having the fewest lakes of any county in the state. Black Otter Lake is the only named lake with public access in the county. The lake was constructed in the late 1840's to provide hydraulic power for a sawmill. It is connected to the Wolf River via Black Otter Creek. Black Otter Lake is fed by two intermittent tributaries that drain an area of rolling farmland and swamp forest. The south shore of the lake is a heavily developed residential area. The north shore of the lake is lightly developed parkland and residential area. The entire eastern shore of the lake is a forested reserve that remains in an undeveloped state. The lake has two public boat launches, a county park and a village park on its shores. As the only lake in Outagamie County having public access, Black Otter Lake receives substantial recreational use. The Black Otter Lake District was formed in 1976 to help restore and protect the lake.

Due to its shallowness and the nutrient inputs from the watershed, Black Otter Lake has had history of management concerns. The concerns have included nuisance weed growth, nuisance algae and duckweed growth, poor water quality, and sedimentation.

3.2 History of Management Activities

In 1977-78 Aqua Tech, Inc. of Port Washington, Wisconsin, conducted a feasibility study on Black Otter Lake. This study found poor water quality, dense macrophyte growth, heavy sediment accumulations near the inlets, and anoxic conditions during winter. A management plan was developed in 1982 based on the results of this study. Resultant management activities included installation of an aeration system (1982), dredging and removal of soft sediment from 55 acres of the lake (1989), construction of five sediment basins and re-routing of Black Otter Creek through a wetland upstream of the lake (1989-91).

In 1992 Coastal Planning and Design of Green Bay, Wisconsin developed a comprehensive management plan for Back Otter Lake. This report analyzed water quality data collected as part of the DNR's Self-Help Monitoring Program. Water chemistry results were similar to those found in the earlier survey. However, dissolved oxygen profiles had improved to the point where the lake was considered capable of sustaining a warmwater fishery. Management recommendations from this report included curtailing several identified nutrient discharges into the lake, implementing a weed harvesting program, developing water level management guidelines, lobbying for improved construction site erosion control practices and enforcement, increasing public involvement, involving state and county agencies in lake management, and researching alternative aeration systems. To date, virtually all of these recommendations have been carried out.

3.3 Purpose of Work

The impacts and effectiveness management techniques that have been employed on the lake during the last ten years have not been accurately assessed. Further, new threats to the lake have arisen since the last study, particularly the invasion of two exotic aquatic plants Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*). Therefore the Black Otter Lake District voted to pursue a study of the lake that would lead to the development of a more timely and up to date comprehensive management plan.

Aquatic Biologists, Inc. was retained by the Lake District to perform this study and to develop the comprehensive management plan. The goal of this project was to review past management efforts, identify and prioritize present management needs, establish definable goals, and recommend and design strategies for lake improvement.

3.4 Supporting Partners

The Black Otter Lake Comprehensive Survey and Management Plan was sponsored by the Black Otter Lake District and the Wisconsin Department of Natural Resources through the Lake Management Planning Grant Program. The project was recommended by the Outagamie County Land Conservation Department. Supporting partners included The Village of Hortonville, Outagamie County, and the Townships of Dale and Hortonia.

4.0 Methods

The lake study encompassed three main areas: 1) lake ecology, 2) physical and chemical characteristics, and 3) watershed influences.

4.1 Lake Ecology

Studies of lake ecology included conducting line-transect surveys of both submergent and emergent aquatic plants throughout the lake, correlating plant distribution with depth, mapping the distribution of nuisance exotic species, compiling information on the ecological value of aquatic plants found, identification and documentation of important fish and wildlife habitats, and identification of shoreline habitat protection and enhancement needs. Other work elements pertaining to lake ecology included: a review of the effectiveness of past plant management activities and research into other applicable plant management techniques.

The methods used for the submergent plant survey were as follows: Line transects were established at 400 foot intervals, and ran north - south (**Figure 1**). Sampling plots were established along each transect at 200 foot intervals. Sampling plots were developed by estimating a 10-foot diameter circle around the anchored boat. The circular plot was then divided into four quarters, with each quarter representing a quadrant. Plants were collected in each quadrant with a tethered short-toothed rake. A total of 132 quadrants were sampled. From each rake haul, all plants collected were identified to *genus*, and to *species* whenever possible. Depths, bottom substrates and the presence or absence of human disturbance were recorded for each sample plot. Data were recorded separately for sample plot. Transect tracking was facilitated with a hand held GPS unit.

The methods used for the emergent plant survey involved establishing twenty five additional transects (labeled I, II ……XXV) that ran parallel to shore between the starting points of the submergent transects (**Figure 2**). For each transect, all emergent and floating-leaf plants encountered were identified and recorded. Each species encountered was then given a relative abundance ranking based on the following criteria:

0	*Absent*	not found along transect
1	*Rare*	found along less than 5% of transect
2	*Present*	found along 5 – 25% of transect
3	*Common*	found along 25 – 50% of transect
4	*Abundant*	found along more than 50% of transect

From this data, percent frequency and percent composition were calculated.

4.2 Physical and Chemical Characteristics

The study of physical and chemical parameters included mapping depth contours, conducting limnological profiles, and water chemistry analyses throughout the season. Water chemistry and flow analyses were also performed on the two inflowing tributaries and at the outflow into Black Otter Creek in order to develop nutrient budgets and water budgets for the lake. In-lake water chemistry data was used to calculate trophic state indicators. The effectiveness of management efforts directed at improving water quality and reducing sediment accumulation were also be assessed.

In-lake water sampling and monitoring was done from a single site – at the deepest point in the middle of the lake (**Figure 3**). Testing was done five times in 2002: April, June, July and August and November. All water samples not analyzed in the field were sent to the State Lab of Hygiene for analysis.

The following parameters were monitored on each sampling date:

total phosphorus	dissolved oxygen profile
chlorophyll *a*	temperature profile
pH	secchi depth
nitrate + nitrite	

During the spring turnover the following additional parameters were monitored:

dissolved phosphorus	Kjeldahl nitrogen
ammonia	total hardness
turbidity	calcium
magnesium	sodium
potassium	manganese
iron	chloride
alkalinity	total dissolved solids
total suspended solids	total volatile solids

At both inlets and below the spillway, the following parameters were monitored on each sampling date:

total phosphorus	temperature
nitrate + nitrite	dissolved oxygen
pH	

Lake mapping was done using the aquatic plant survey transects (**Figure 1**). At each sampling plot a depth sounding was taken with a weighted tape measure. Data was then plotted onto a map to create depth contours. Transect grid measurements were used to determine lake area and volume.

Dissolved oxygen and temperature profiles were measured with a YSI electronic meter. Flow rates were determined with a Global Waters electronic flow meter. Volume was determined by multiplying flow rate by the cross-sectional area where the reading was taken. Gauge height was measured from the base of the iron railroad bridge to the water's surface.

4.3 Watershed Influences

Analyses included delineation of watershed boundaries, determinations of acreage and drainage patterns, identification of land uses and cover types, and identification of specific areas having potential to affect water quality. How The effectiveness of soil conservation practices and best management practices in the watershed were also evaluated. Boundaries, area and drainage patterns were extrapolated from USGS topographical maps. Land use patterns and cover types were identified via ground surveys and aerial photos. A literature review was conducted to determine best management practices, as well as state and federal conservation programs available.

Figure 1. Black Otter Lake 2002 submergent plant survey transects.

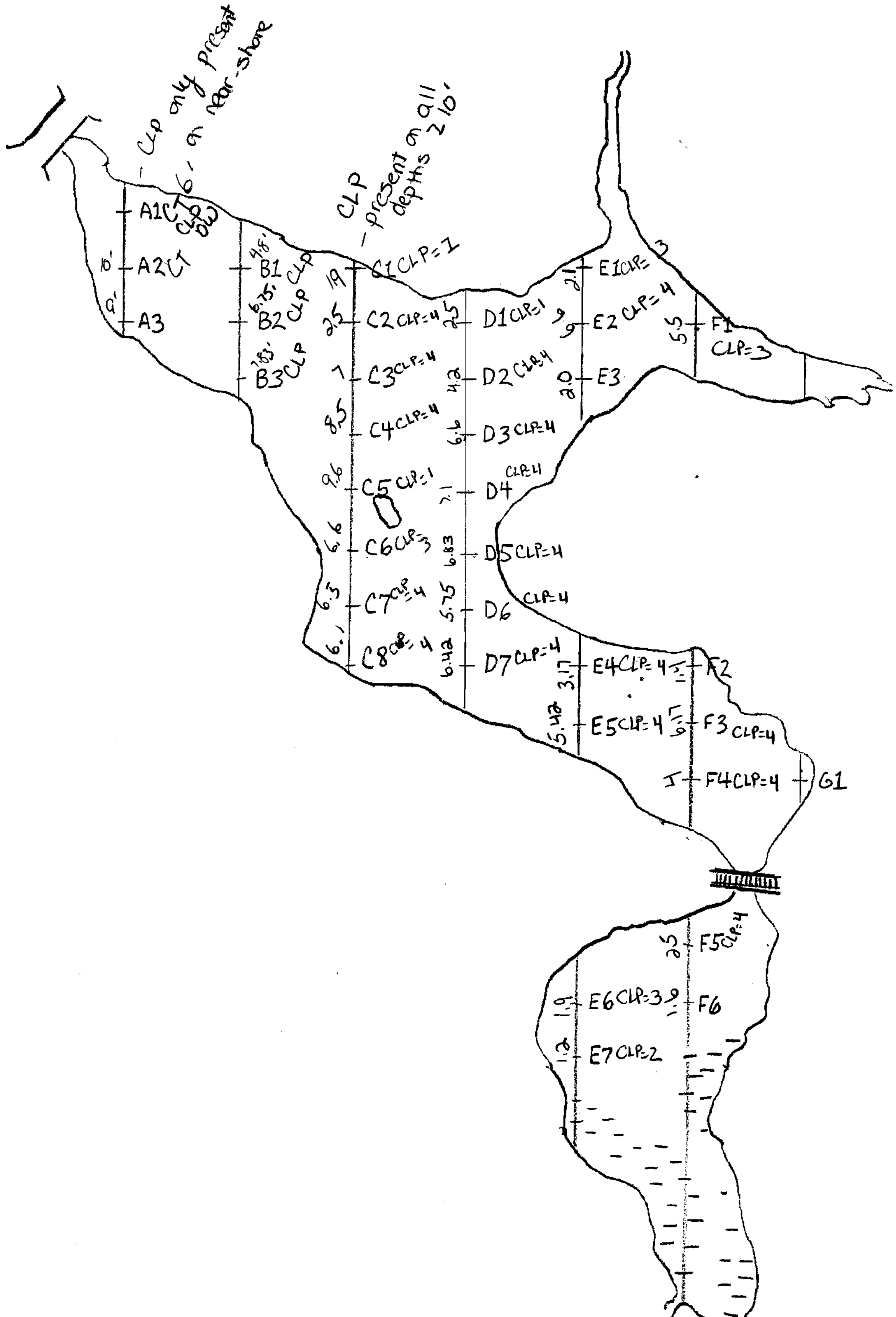


Figure 2. Black Otter Lake 2002 emergent plant survey transects.

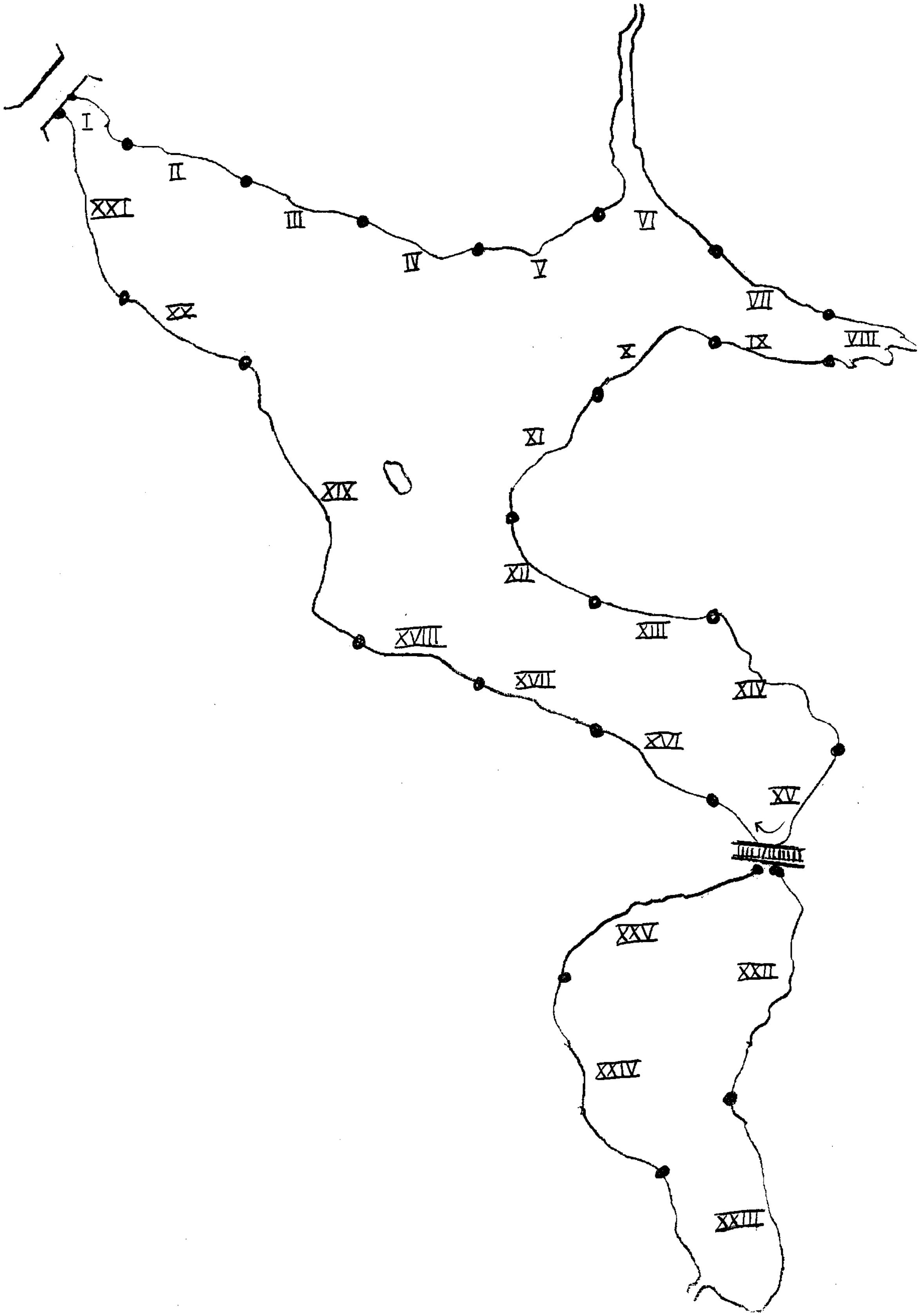
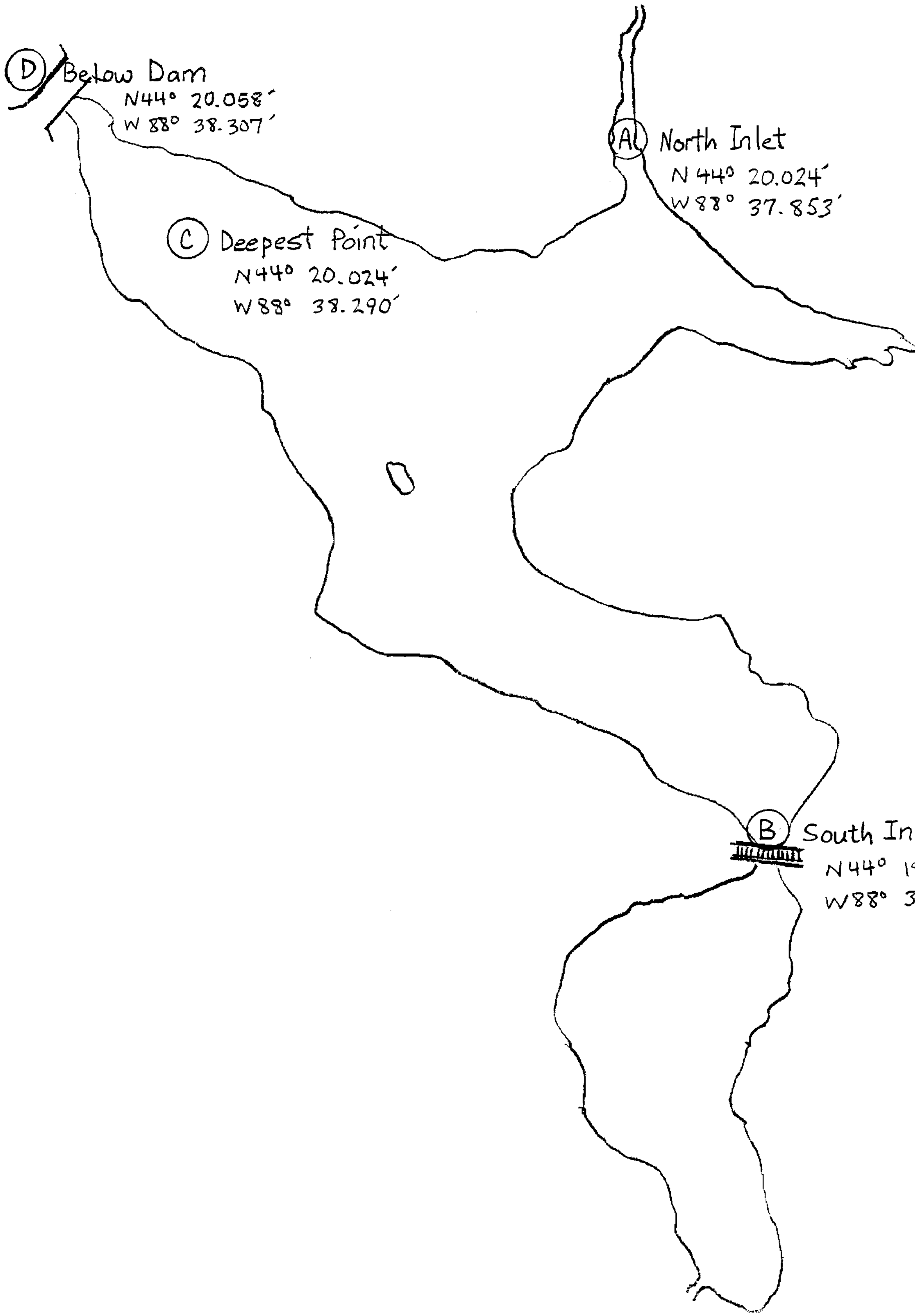


Figure 3. Black Otter Lake 2002 water sample collection points.



5.0 Results and Discussion

5.1 Aquatic Plant Communities

5.11 Submergent plant survey results

The submergent plant survey found 12 species of rooted plants, four genera of filamentous and colonial algae, and three species of free-floating plants (**Table 1**). The exotic curly-leaf pondweed was the most commonly found plant, occurring at 74.3% of sample points. Coontail (*Ceratophyllum demersum*) was next most abundant at 60.7% frequency. Horsehair algae (*Pithophora spp.*) and lesser duckweed (*Lemna minor*) followed in abundance at 38.6% and 34.3% frequency, respectively.

not sure ??

Native macrophytes, plants generally associated with good water quality, comprised only 40% of the total species composition. Algae and free-floating plants, such as duckweed (*Lemna spp.*) and watermeal (*Wolffia columbiana*), made up 32.2% of the species composition. As the season progressed, these plants became dominant at the upstream portions of the lake. This resulted in serious environmental consequences. As water flow decreased and temperatures increased, duckweed and algae formed solid floating mats that covered large areas of the lake. Anoxic conditions occurred under these mats, forcing fish to the downstream parts of the lake. These dense surface mats also blocked sunlight from rooted plants, causing them to die and decompose. The resultant suspended dead plant matter gradually drifted down the lake, increasing the biological oxygen demand and producing more anoxic conditions in the rest of the lake. The dead plant matter also reduced light penetration, causing further die-off of rooted plants and worsening the situation. Along with the decomposition dead plant matter came a nutrient release that fueled further algae growth.

The die-off of curly-leaf pondweed greatly magnified the problems caused by algae and duckweed. Curly-leaf pondweed gains a competitive advantage over other species by growing rapidly in cold water. As water temps approach 80° F though, the plant begins to die. Just as algae and duckweed were reaching problem levels in Black Otter Lake, curly-leaf pondweed experienced a massive die-off. The resultant suspended plant matter and nutrient release created very turbid conditions and fueled an even heavier algae bloom. Oxygen became so depleted that fish could only survive in the top two feet of the water column over the deepest portions of the lake.

Check WQ data

5.12 Historical data comparisons

A comparison of 2002 survey data with past aquatic plant surveys suggests that environmental conditions in the lake have deteriorated considerably (**Table 2**). Four species of macrophytes that were found in 1978 were completely absent in 2002. These species, flatstem pondweed (*P. zosteriformis*), small pondweed (*P. pusillus*), elodea (*Anacharis canadensis*) and water stargrass (*Zosterella dubia*), are often found in lakes with good water quality. While most of these species are able to tolerate somewhat turbid conditions, water quality may have become too poor in Black Otter Lake for their continued survival. Perhaps the most important difference in the 1978 data is that exotic plants were not identified.

make point bk no EWM or CLP State-wide 1960's

5.13 Submergent plant distribution

Submergent plant distribution correlated closely with depth (**Table 3**). The two exotic species found, curly-leaf pondweed and Eurasian watermilfoil, were most abundant in waters greater than four feet deep. Both of these species grow rapidly in cooler water, giving them a head start over native species. Early growth may also allow them to reach the surface before turbidity inhibits other plants. Native macrophytes were most commonly found in less than four feet of water. In fact the greatest percent frequency for many of these species was found in less than two feet of water.

bk survey in June-CLP still dominated

Eurasian watermilfoil was not found in dense beds during the survey. This and the fact that Eurasian watermilfoil was only found at 19.3% of sample points suggests that the large-scale milfoil treatment conducted in 2000 provided some long-term control. Curly-leaf pondweed was found in dense beds primarily along the south shore, which drops off quickly. It was also found along the deeper channels and surrounding the deeper hole in the center of the lake. The distribution of curly-leaf pondweed is shown in **Figure 4**. The area of this monotypic plant stand was about 20 acres.

5.14 Emergent plant survey results

In contrast to the submergent plant survey, and incredible diversity of emergent plants was found. A total of 28 species were encountered (**Table 4**). Most abundant were Kentucky bluegrass (*Poa pratensis*), floating-leaf pondweed (*Potamogeton natans*), bottlebrush sedge (*Carex comosa*), soft rush (*Juncus effusus*) and narrow-leaved cattail (*Typha angustifolia*). Emergent species were not as affected by turbidity or competition from exotic species, things that limited submergent plants in Black Otter Lake. The primary reason for the wealth of emergent plants found though, lies in the fact that substantial areas of shoreline remained undeveloped. Conversely, the heavily developed south shore contained very few emergents. – In-lake native restoration

5.15 Exotic species

Invasion of exotic aquatic plants has become one of the main problems facing Wisconsin lakes. Exotic species can affect recreation uses, lake ecology and aesthetics. Lake management groups spend millions of dollars annually toward management of nuisance exotic plants.

The most significant of these exotic invaders has undoubtedly been Eurasian watermilfoil. Eurasian watermilfoil was first introduced into U.S. waters in 1940. It had reached Wisconsin's lakes by 1960. Since then, its expansion has been exponential (Brakken, 2000). Eurasian watermilfoil can be identified by its long, spaghetti-like stems and reddish-tinged, feather-like leaves. It can be easily confused with several of the seven native milfoils. Distinguishing characteristics are the finely divided leaflets that occur in 14-20 pairs (Borman, et.al., 1997). Perhaps its most distinguishing characteristics though, is the plant's ability to form dense, impenetrable beds that grow to the water's surface, inhibiting boating, swimming and fishing.

As mentioned earlier in this report, Eurasian watermilfoil begins growing earlier than native plants, giving it a competitive advantage. The dense surface mats formed by the plant block sunlight and have been found to displace nearly all native submergent plants. Over 200 studies link declines in native plants with increases in Eurasian watermilfoil (Madsen, 2001). Dense growths of Eurasian watermilfoil have been associated with declines in fishery quality, invertebrate abundance and water quality (Pullman, 1993).

Curly-leaf pondweed has been found in the U.S. since at least 1910. A native of Europe, Asia, Africa and Australia, this plant is now found throughout much of U.S. (Baumann, et.al., 2000). Curly-leaf pondweed has oblong leaves that are 2-4 inches long and attach to a flattened stem in an alternate pattern. The most distinguishing characteristics of this plant are the crenellated appearance of the leaves, and the serrated leaf margins. Curly-leaf pondweed is a cold-adapted plant. It can begin growing under the ice while other plants are dormant. By mid-summer when water temperatures reach the upper 70° F range however, the plant begins to die off (Borman, et.al, 1997).

As with Eurasian watermilfoil, curly-leaf pondweeds aggressive early season growth allows it to out compete native species and grow to nuisance levels. Because the plant dies back during the peak of the growing season for other plants though, it is better able to coexist with native species than Eurasian watermilfoil. Perhaps the most significant problem associated with curly-leaf pondweed involves internal nutrient cycling. The die-off and decomposition of the plant during the warmest time of year leads to a sudden nutrient release in the water. This often leads to nuisance algae blooms and poor water quality.

Table 1. Results of the submergent aquatic plant survey conducted on Black Otter Lake during June 2002.

Species common name	scientific name	Percent Frequency	Percent Composition
Curly Leaf Pondweed	*Potamogeton crispus*	74.3	22.1
Coontail	*Ceratophyllum demersum*	60.7	18.1
Horsehair algae	*Pithophora spp.*	38.6	11.5
Lesser Duckweed	*Lemna Minor*	34.3	10.2
Eurasian Watermilfoil	*Myriophyllum spicatum*	19.3	5.7
Sago Pondweed	*Potamogeton pectinatus*	15.0	4.5
Watermeal	*Wolffia columbiana*	14.3	4.3
Filamentous Green Algae	*Spirogyra spp.*	14.3	4.3
Northern Watermilfoil	*Myriophyllum sibericum*	12.9	3.8
White Water Crowfoot	*Ranunculus longirostris*	12.1	3.6
Whorled Watermilfoil	*Myriophyllum verticillatum*	10.7	3.2
Floating Leaf Pondweed	*Potamogeton natans*	9.3	2.8
Musk Grass	*Chara spp.*	7.1	2.1
Star Duckwed	*Lemna trisulca*	5.7	1.7
Water Moss	*Drepanoclaclus spp.*	2.9	0.9
Colonial BlueGreen Algae	*Oscillatoria*	1.4	0.4
Stonewort	*Nitella spp.*	1.4	0.4
Various-Leaved Watermilfoil	*Myriophyllum heterophyllum*	0.7	0.2
Filamentous Green Algae	*Cladophora spp.*	0.7	0.2
No Plants Found		0.7	

Table 2. A comparison of Black Otter Lake suubmergent plant survey data from 1978 and 2002.

Species common name	scientific name	Percent Frequency 2002	1978
Curly Leaf Pondweed	*Potamogeton crispus*	74.3	
Coontail	*Ceratophyllum demersum*	60.7	88
Horsehair algae	*Pithophora spp.*	38.6	
Watermilfoil	*Myriophyllum spp.*	*	76
Lesser Duckweed	*Lemna Minor*	34.3	
Eurasian Watermilfoil	*Myriophyllum spicatum*	19.3	
Sago Pondweed	*Potamogeton pectinatus*	15.0	11
Watermeal	*Wolffia columbiana*	14.3	
Filamentous Green Algae	*Spirogyra spp.*	14.3	
Northern Watermilfoil	*Myriophyllum sibericum*	12.9	
White Water Crowfoot	*Ranunculus longirostris*	12.1	16
Whorled Watermilfoil	*Myriophyllum verticillatum*	10.7	
Floating Leaf Pondweed	*Potamogeton natans*	9.3	30
Musk Grass	*Chara spp.*	7.1	1
Star Duckwed	*Lemna trisulca*	5.7	
Spadderdock	*Nuphar variegata*	4	1
Water Moss	*Drepanoclaclus spp.*	2.9	
Colonial BlueGreen Algae	*Oscillatoria*	1.4	
Stonewort	*Nitella spp.*	1.4	
Various-Leaved Watermilfoil	*Myriophyllum heterophyllum*	0.7	
Filamentous Green Algae	*Cladophora spp.*	0.7	
No Plants Found		0.7	
Flatstem Pondweed	*Potamogeton zosteriformis*	0	75
Small Pondweed	*Potamogeton pusillus*	0	63
Elodea	*Anacharis canadensis*	0	13
Water Stargrass	*Heterathera dubia*	0	3

* sorted to genus

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Stonewort	*Nitella spp.*	1.4	0.4
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Filamentous Green Algae	*Cladophora spp.*	0.7	0.2
No Plants Found		0.7	

Table 3. Aquatic plant frequency of occurrence by depth from 2002 Black Otter Lake survey.

Species		Precent Frequency / Depth (ft.)				
common name	**scientific name**	**0-1.9**	**2.0-3.9**	**4.0-5.9**	**6.0-7.9**	**8+**
Curly Leaf Pondweed	*Potamogeton crispus*	45.8	66.7	95.8	90.4	37.5
Coontail	*Ceratophyllum demersum*	95.8	62.5	79.2	44.2	37.5
Horsehair algae	*Pithophora spp.*	70.8	25.0	8.3	38.5	50.0
Lesser Duckweed	*Lemna Minor*	70.8	50.0	37.5	13.5	18.8
Eurasian Watermilfoil	*Myriophyllum spicatum*	12.5	0.0	50.0	23.1	0.0
Sago Pondweed	*Potamogeton pectinatus*	79.2	8.3	0.0	0.0	0.0
Watermeal	*Wolffia columbiana*	37.5	20.8	25.0	0.0	0.0
Filamentous Green Algae	*Spirogyra spp.*	37.5	16.7	8.3	5.8	12.5
Northern Watermilfoil	*Myriophyllum sibericum*	37.5	8.3	4.2	1.9	0.0
White Water Crowfoot	*Ranunculus longirostris*	41.7	25.0	4.2	0.0	0.0
Whorled Watermilfoil	*Myriophyllum verticillatum*	16.7	12.5	16.7	3.8	12.5
Floating Leaf Pondweed	*Potamogeton natans*	12.5	37.5	4.2	0.0	0.0
Musk Grass	*Chara spp.*	12.5	29.2	0.0	0.0	0.0
Star Duckweed	*Lemna trisulca*	20.8	16.7	0.0	3.8	6.8
Water Moss	*Drepanocladus spp.*	0.0	0.0	0.0	1.9	18.8
Colonial BlueGreen Algae	*Oscillatoria*	8.3	0.0	0.0	0.0	0.0
Stonewort	*Nitella spp.*	0.0	8.3	0.0	0.0	0.0
Various-Leaved Watermilfoil	*Myriophyllum heterophyllum*	0.0	4.2	0.0	0.0	0.0
Filamentous Green Algae	*Cladophora spp.*	0.0	0.0	4.2	0.0	0.0
No Plants Found		0.0	0.0	0.0	0.0	6.3

Figure 4. 2002 distribution of curly-leaf pondweed in Black Otter Lake.

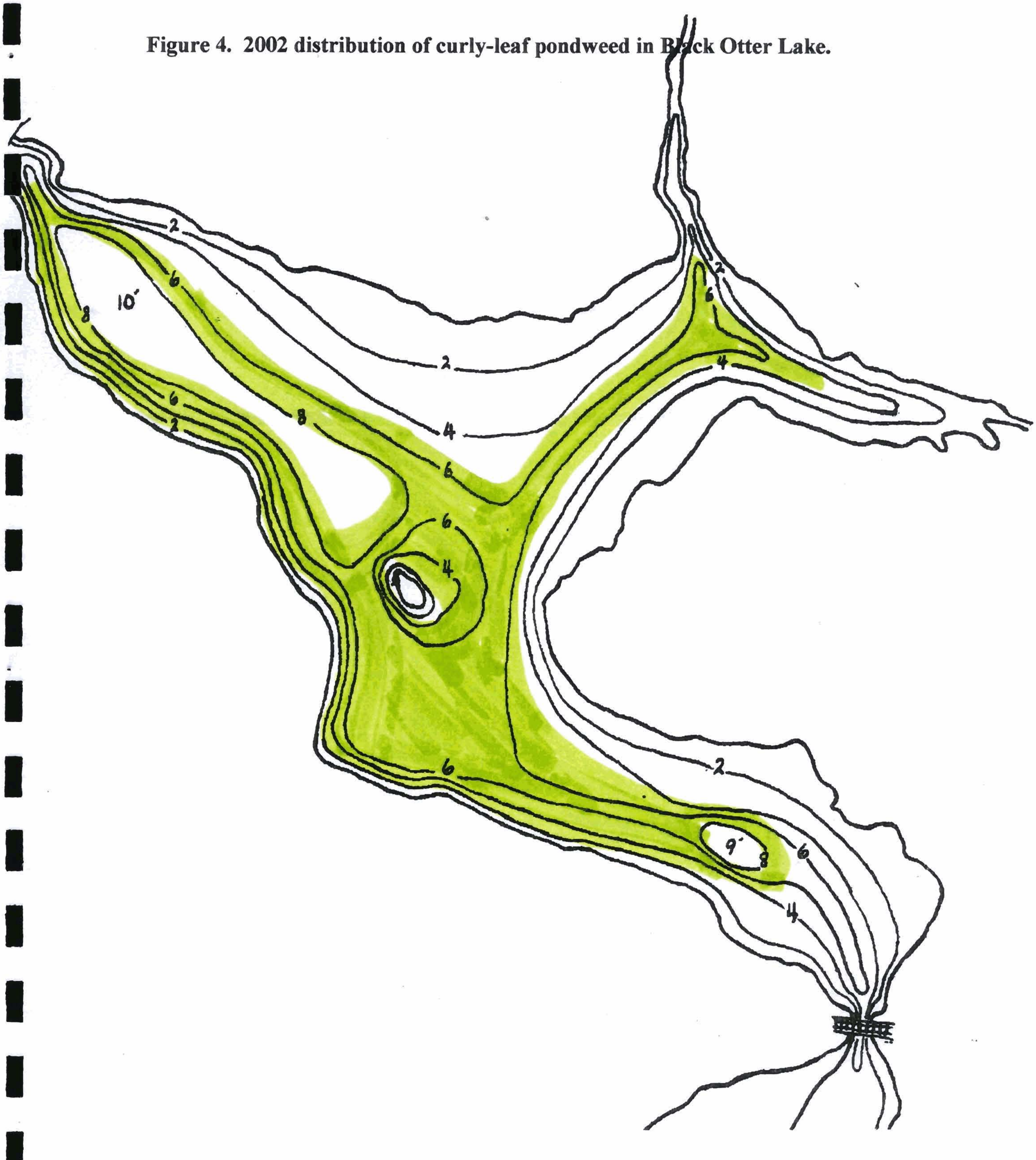


Table 4. Description and ecological value of aquatic plants found in Black Otter Lake.

Species	Description	Ecological Value
Bottlebrush Sedge *(Carex comosa)*	Stems emerge bundle-like and are triangular; leaves are roughly veined and grow to waist high; spiklets have bristly appearance	Help trap sediment and stabilize ground against erosion; provide food and habitat for an array of wildlife
Broad-leaved Cattail *(Typha latifolia)*	Green, sword-like leaves grow 3-10 ft tall and emerge from a large, tough rhizome; leaves are bundle-like at base and split off into single leaves; flowers appear as a large cigar on a stick and don't have a space between the male and female flower	Serve as nesting habitat for many birds including (red-winged blackbirds, marsh wrens, and coots); muskrat communities rely heavily on cattails for food and shelter; whitetail deer and raccoon utilize cattails for protection; provide spawning habitat for sunfish, pike, and musky; one of the most important species for utilizing excessive amounts of nutrients
Coontail *(Ceratophyllum demersum)*	As its name implies, it produces whorls of narrow, toothed leaves on a long trailing stem that often resembles the tail of a raccoon	Provide shelter for young fish and is home to insects which provide food for fish and waterfowl; captures a large amount of sediment and phosphorus which greatly helps water quality
Floating-Leaf Pondweed *(Potamogeton natans)*	Stems emerge from red-spotted rhizomes; leaves are heart shaped at base and rest flat on the waters surface	Provides food for ducks, geese, muskrats, beaver, deer, and moose; offer shade and cover for fish
Jewelweed *(Impatiens capensis)*	An annual with smooth stems; leaves are alternate and finely toothed; flowers are orange-yellow with red and brown spots	Serve as wildlife habitat; help stabilize soil against erosion, especially along trout streams; help uptake excessive amounts of nutrients; flower provides a source for insect food and pollination
Kentucky Bluegrass *(Poa pratensis)*	A perennial grass that forms many rhizomes; stems are round to slightly flat; leaf blades are flat to slightly folded and are shaped like a boat at the tip	Provides habitat including nesting cover for many species of birds; serves as important soil stabilizer against erosion; helps utilize nutrients before they enter a water source
Musk Grass *(Chara spp.)*	A complex algae that resembles a higher plant; its is identified by its pungent, musk-like odor and whorls of toothed branched leaves	Provides shelter for young fish and is associated to Black Crappie spawning sites; helps stabilize bottom sediments and contributes to better water quality
Narrow-leaved Cattail *(Typha angustifolia)*	Green, sword-like leaves grow 3-10 ft tall and emerge from a large, tough rhizome; leaves are bundle-like at base and split off into single leaves; flowers appear as a large cigar on a stick and have a space between the male and female flowers	Serve as nesting habitat for many birds including (red-winged blackbirds, marsh wrens, and coots); muskrat communities rely heavily on cattails for food and shelter; whitetail deer and raccoon utilize cattails for protection; provide spawning habitat for sunfish, pike, and musky; one of the most important species for utilizing excessive amounts of nutrients
Northern Water milfoil *(Myriophyllum heterophyllum)*	Light colored stems with leaves divided like a feather; flower spike emerges above water level and is made up of whorls of red tinted flowers	Offers excellent foraging habitat for fish; food for waterfowl and provides a home for invertebrates
Soft Rush *(Juncus effuses)*	Stems are smooth, cylindrical and grow 3ft. or more; leave sheaths are reddish-brown at the stem base; flower cluster appears to grow off the side of the leaf blade, but actually a flower leaf extends past the flower cluster	Serve as cover for birds; seeds provide food for a variety of birds; muskrats feast on new shoots; fish, especially rock bass utilize the stem base for spawning; aid in stabilizing sediments and preventing erosion

Table 4 continued. Description and ecological value of aquatic plants found in Black Otter Lake.

Sago Pondweed *(Potamogeton pectinatus)*	Stems emerge from slender rhizomes with many starchy tubers; leaves are sharp, thin, and resemble a pine needle; flowers emerge in small whorls	One of the most important foods for migrating waterfowl; important habitat for juvenile trout and other young fish
White Water Crowfoot *(Ranunculus longirostris)*	Branched stems emerge from buried rhizomes; leaves are alternate and are made up of many thread-like divisions; white flowers emerge just above the waters surface and contain 5 petals	Home for many invertebrates which serve as fish forage; food for ducks and upland game birds
Whorled Water milfoil *(Myriophyllum verticillatum)*	Leaves are feather-like and attach directly to a greenish-brown stem; flower bracts tend to be lobed	Provides invertebrate habitat and is utilized by fish for foraging and cover

5.2 Aquatic Plant Control

Given the depths, shape and watershed characteristics of Black Otter Lake, management of aquatic plants will continue to be a primary concern for the Lake District. Aquatic plant management needs can be broken down into four main areas: 1) control of Eurasian watermilfoil, 2) control of curly-leaf pondweed, 3) control of duckweed and algae, and 4) management of nuisance native species.

5.21 Eurasian watermilfoil

A wide variety of methods have been employed to control Eurasian watermilfoil on a large scale in lakes. These have included mechanical harvesting, introduction of biological vectors, lake drawdown, herbicide treatments, even rotovation of bottom sediments.

5.211 mechanical harvesting

Boat-mounted mechanical weed harvesters are usually used in lakes that have historically used harvesters, and is situations where lake management units have done insufficient planning to receive permits for herbicide use.

In accurate - Some choose not to spray

Mechanical harvest is not a recommended control method for Eurasian watermilfoil, however. Eurasian watermilfoil can reproduce by fragmentation (Borman, et. al. 1997), and the free-floating plant matter left from cutting operations can accelerate dispersal of the plant – both within the lake and to nearby lakes. Mechanical harvest does offer several distinct advantages, though. Harvested plant matter can be removed from the lake system, reducing the possibility of low dissolved oxygen due to bacterial decomposition. The possibility of algae blooms due to a sudden nutrient release is also greatly reduced. There are no water use restrictions following mechanical harvest either. A disadvantage of mechanical harvest is that it is not species selective. While cutting does not typically kill plants, there is little evidence to suggest that cutting can induce a shift back to native species (Shardt, 1999).

So are some chemicals?

Can chemical ??

5.212 milfoil weevils

There has been considerable research on biological vectors, such as insects, and their ability to affect a decline in Eurasian watermilfoil populations. Of these, the milfoil weevil has received the most attention. Native milfoil weevil populations have been associated with declines in Eurasian watermilfoil in natural lakes in Vermont (Creed and Sheldon, 1995), New York (Johnson, et. al., 2000) and Wisconsin (Lilie, 2000). However there is scant evidence that *stocked* weevils can produce a decline in Eurasian watermilfoil density. A twelve-lake study called "The Wisconsin Milfoil Weevil Project" (Jester, et. al. 1999) conducted by the University of

Wisconsin, Stevens Point in conjunction with the Wisconsin Department of Natural Resources researched the efficacy of weevil stocking. This report concluded that milfoil weevil densities were not elevated, and that Eurasian watermilfoil was unaffected by weevil stocking in any of the study lakes.

There have been numerous reasons given for the lack of success of weevil stocking as a management option, including calcium carbonate deposits on plants (Jester, et. al. 1999), poor over-wintering habitat (Newman, et, al. 2001), high pH (C. Kendziorski, 2001) and sunfish predation (Newman, pers. comm.). Perhaps the most compelling reason why weevil stocking has been unsuccessful may be that weevil populations are already at carrying capacity in many lakes. Recent studies indicate that milfoil weevils are widely distributed throughout Wisconsin's lakes (Jester, et. al. 1997.

One reason that native weevil populations may be able to impact Eurasian watermilfoil in some lakes but not others may have to do with a lake's surface are and its wind fetch. Recent studies conducted by Aquatic Biologists, Inc. staff (as yet unpublished) concluded that a relationship might exist between wind energy and the ability of milfoil weevils to affect a decline in Eurasian watermilfoil. It appears that lakes must be large enough (300 acres +) to generate sufficient wave action before milfoil stems burrowed by weevils will collapse.

define successful

5.213 herbicides

Herbicides have been the most widely used and most successful tools for controlling Eurasian watermilfoil. The two herbicide groups most commonly employed are fluridone (Avast®, Sonar®) and 2,4D (Aquacide®, Aquakleen®, Navigate®, Weedar 64®). Fluridone treatments have shown considerable promise for providing both good control and species selectivity for Eurasian watermilfoil (Welling, et al., 1997). Whole-lake Sonar® treatments have been done on several Wisconsin Lakes. While initial results were encouraging (species selectivity, 95-100% initial control), continued monitoring found that desired long-term control was not achieved (Cason, 2002). Because fluridone is a very slow-acting herbicide that requires maintaining specific concentrations for extended periods of time, it may also be less effective on lakes such as Black Otter that have a short residence time.

2,4D herbicides, on the other hand, have been used on hundreds of Wisconsin Lakes with good success. The E.P.A. lists 2,4D as a Class D herbicide, which means that there is no data to support that it is harmful to humans. The E.P.A. product label lists no water use restrictions for swimming or fish consumption following treatment with 2,4D either. 2,4D is a biodegradable organic herbicide that does not persist in the environment in any form. Applied correctly at prescribed rates, 2,4D is highly selective to Eurasian watermilfoil. 2,4D has been used on thousands of lakes throughout North America. To date 2,4D treatments have been the single most effective Eurasian watermilfoil control program. In fact, the number of lakes in Michigan having Eurasian watermilfoil problems has actually declined as a result of 2,4D use (Pullman, 1993). show the long-term results

The greatest disadvantage of 2,4D treatments is that they rarely produce 100% control. As a granular formulation, the product tends to work only where applied. Unnoticed and untreated plants may eventually grow to dense beds if left unchecked. Factors such as pH and plant maturity may also reduce treatment efficacy. Several follow-up treatments, in-season or on subsequent years, may be needed to reduce Eurasian watermilfoil to target levels.

5.214 lake drawdown

Drawing down lake levels to expose aquatic plants is an option for impoundments such as Black Otter Lake. Drawdowns kill plants directly through desiccation. Overwinter drawdowns may provide some long-term control of plants by freezing root systems. Drawdowns are clearly a low-cost option, they may also aid in reduction in bottom sediments through oxidation. They have several significant disadvantages though. Drawdowns are not species-selective. They may also lead to partial or complete loss of the fishery, requiring re-stocking. The biggest disadvantage to lake users is that they have to do without their lake for a period of time.

so!

Definitely an option

Recent efforts to control Eurasian watermilfoil by drawdown in Big Muskego Lake in Wisconsin were extensively studied. Eurasian watermilfoil composition went from 90% one year prior to drawdown to 10% two years after drawdown. Water clarity also increased ten-fold, and native aquatic plants increased in abundance. It was concluded that periodic drawdowns (every 10 years) as well as annual water level fluctuations would be required to maintain long-term milfoil control (Madsen, 2002).

5.215 rotovation

The use of rotovators to control Eurasian watermilfoil has been used in the Pacific Northwest but is seldom used in other parts of the country. This technique involves churning bottom sediments with rototiller-like blades to uproot aquatic plants. Rotovators are typically attached to a hydraulic boom that is mounted on a boat. The boat is also equipped with a weed rake or harvester to capture and remove uprooted plant fragments.

Studies have shown that rotovation can produce a high level of milfoil control for up to two years. Eurasian watermilfoil from adjacent uncleared areas then gradually reinvaded the cleared sites (State of Washington, 2001). Rotovation has numerous disadvantages though, including temporary turbidity increase, nutrient and sediment resuspension, impacts to fish and other organisms and high cost. Rotovation cannot be used in areas submerged utility or aeration lines.

5.22 Curly-leaf pondweed

Both mechanical harvesting and herbicide treatments are commonly used to control curly-leaf pondweed. The herbicide most often used is endothol (Aquathol®). While endothol is effective on a broad range of aquatic monocots, at low rates it is highly selective to curly-leaf pondweed. Both mechanical harvesting and herbicide treatments are very effective in providing short-term control. However neither method, as they are commonly applied, tend to provide any long-term control of the plant. Curly-leaf pondweed produces a vegetative reproductive structure in early summer that is called a turion. While herbicides effectively kill the parent plant, the turions are resistant to herbicides. This allows curly-leaf pondweed to regenerate annually.

for a short-term

Recent studies conducted by the Army Corps of Engineers however, have found that conducting treatments of curly-leaf pondweed using Aquathol when water temperatures are in the 50° F range will kill plants before turions form, thus providing long-term control. These treatments conducted over time were able to significantly reduce curly-leaf pondweed populations (Skogerboe, 2002). These findings may make Aquathol® the tool of choice for controlling curly-leaf pondweed.

5.23 Duckweed and algae

No-destroy shoreline buffers

Members of the duckweed family thrive in warm, stagnant, nutrient rich waters. Under favorable conditions, duckweed can spread very quickly. Common methods for providing long-term control involve increasing surface agitation. This is accomplished by installing flow generators or aeration systems and /or by cutting of trees along banks to increase wave action. The most common short-term control method is herbicide treatment. Recommended herbicides are a mixture of copper chelate (Cutrine®) and diquat (Schmidt and Kannenberg, 1976).

Long-term algae control is best accomplished through control of nutrient inputs. Short-term control is generally provided by algaecide treatments. Most algaecides have copper formulations as their active ingredients (Cutrine®, Captain®, K-Tea®). Diquat (Reward®) is often mixed with algaecides to control more resistant strains of algae that develop in warmer water. Duckweed and algae can often be treated simultaneously.

There has been considerable interest in the use of barely straw for algae control. Submersion of barley straw bales had reportedly been effective in controlling algae in England. This phenomenon was studied by Lembi (2000). It was found that barley straw did indeed contain a chemical that killed algae. However it was only effective on planktonic algae, and did not work on mat-forming species. Further, the bales had to be removed rather quickly or else they would decompose and release nutrient that could lead to further algae growth. Since this chemical had not been isolated, and therefore its environmental fate and toxicology could not be studied, it was recommended that this method not be used until such information is available.

5.24 Nuisance native plants

Native macrophytes play a vital role in the health of lake ecosystems. They improve water clarity by preventing shore erosion and resuspension of bottom sediments by wave action. Macrophytes store nutrients that would otherwise be utilized by algae. They also provide food and shelter for fish, invertebrates and water birds.

The two methods most commonly used to control native aquatic plants are mechanical harvesting and non-selective herbicide treatments. Both methods have the potential to reduce water quality, degrade habitats, increase algae production, and cause shifts in the plant community (WDNR, 1970). Nonetheless, both mechanical harvesting and herbicide treatments can be valuable tools if used wisely.

Herbicide treatments are generally much less costly than weed harvesting programs. They also tend to produce better long-term control. A primary disadvantage is that they are more likely to cause shifts in the plant community. These shifts generally favor less desirable species. Herbicide treatments are also more likely to lead to nuisance algae growth.

In contrast, mechanical harvest only mows plants, allowing them to survive at a reduced height. This is less likely to cause plant community shifts. Mechanical harvest also allows for removal of plant matter, reducing the likelihood of nuisance algae blooms. Theoretically, mechanical harvesting should remove substantial amounts of nitrogen and phosphorus from lake systems. Actual studies however, found that lake nutrient budgets were not significantly affected even after intensive harvest (Nichols, 1974). None-the-less, mechanical harvesting offers distinct advantages when preserving the values of native plants is important.

5.3 Lake Habitats

Despite the water quality problems found in Black Otter Lake, the submergent and emergent plants found there provide a wealth of fish and wildlife habitat. A description of the commonly found aquatic plants and their habitat value is presented in **Table 4**.

5.31 Fish habitat

The shallow, warm waters and abundant rooted vegetation found in Black Otter Lake create an environment best suited to a fishery containing largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), black crappie (*Pomoxis nigromaculatus*), northern pike (*Esox lucius*), bullheads (*Ictalurus spp.),* golden shiner (*Notomegonus crysoluecas*) and other minnow species.

Centrarchids (bass, bluegill, pumkinseed and crappie) were observed spawning over hard-bottomed areas adjacent to undeveloped shores. These areas contained the highest diversity of submergent and emergent plants as well. Yellow perch spawning habitat was found amongst the areas of flooded brush (shrub carr), and the submerged stumps and logs near the middle inlet. Preferred northern pike spawning habitat includes flooded emergent vegetation such as cattails. This type of habitat was found north of the railroad bridge and at the creek inlet south of the railroad bridge.

No plant removal

The locations of fish spawning habitats are shown in **Figure 5**. This information is not intended to be used as a fishing guide. Instead, it is to be used for guidance in lake management and development activities in hopes that these habitats will be protected.

5.32 Wildlife habitat

The undeveloped eastern shore of the lake contained a wealth of habitat types including deep marsh, shallow marsh, shrub carr, hardwood swamp, and floodplain forest. These habitats provide homes for a variety of reptiles, amphibians, mammals and birds. Wood ducks, mallards, teal and Canada geese find feeding and nesting areas in the lake. The bay upstream of the railroad bridge provides excellent waterfowl forage as well as refuge from nuisance species

disturbance by boaters. Mowed lawns along the residential areas provide excellent grazing opportunities for Canada geese.

The quality of wildlife habitat relates directly to the diversity of aquatic plants. The diversity of emergent plants was recorded during the shoreline aquatic plant survey (**Table 5**). Emergent plant diversity correlated strongly with riparian land use. The undeveloped east shore and the lightly developed north shore, which had a buffer strip of natural vegetation, both had excellent plant diversity. The undeveloped shoreline (transects VII - XVI and XXII – XXV) had and average of 13.5 species / transect, and the lightly developed shoreline (transects I – VI) had and average of 14.3 species / transect. In contrast, the heavily developed south shore (transects XVII – XXI) averaged only 2.0 species / transect.

In-lake restorati

Figure 5. Black Otter Lake habitat map.

Table 5. Shoreline aquatic plant transect data from Black Otter Lake, June 2002.

Collectors: C. Cason
J. Nicholson

Species		Transect/Abundance Ranking								
common name	**scientific name**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**
Blue Flag Iris	*Iris versicolor*			1	1			1	2	
Bottlebrush Sedge	*Carex comosa*		1	1	1	2	2	1	1	2
Broad Leaved Arrowhead	*Sagittaria latifolia*						1			1
Broad Leaved Cattail	*Typha latifolia*				2	2	4	2		
Canada Bluejoint Grass	*Calamagrostis canadensis*				1	3				
Creeping Spikerush	*Eleocharis palustris*			1						
Curly Dock	*Rumex Crispus*								1	1
Dogwood	*Cornus spp.*									
Floating Leaf Pondweed	*Potamogeton natans*		2	3	3	4	4	3		
Hardstem Bulrush	*Scripus acutus*	1								
Jewelweed	*Impatiens capensis*		4	4				2		
Kentucky Bluegrass	*Poa pratensis*	3	4	4	4	4	2	4	4	4
Lake Sedge	*Carex lacustris*					2				
Marsh Marigold	*Caltha Palustris*							1		
Marsh Milkweed	*Asclepias incarnata*				1					
Narrow Leaved Cattail	*Typha angustifolia*					2				
Needle Rush	*Eleocharis acicularis*									
Reed Canary Grass	*Phalaris arundinacea*				2			1		
River Bulrush	*Scripus fluviatilis*				2					
Sage Willow	*Salix canadensis*									
Soft Rush	*Juncus effusus*		1	2	1	2		1	1	
Softstem Bulrush	*Scripus validus*									
Spadderdock	*Nuphar variegata*									
Stalk Grained Sedge	*Carex stipata*			1						
Tag Alder	*Alnus*							1	2	3
Tussock Sedge	*Carex*					1		1		
Water Smartweed	*Polygonum amphibium*								2	
Water Smartweed spp.	*Polygonum longistylum*								1	
Willow	*Salix spp.*							1	1	
total per transect		**4**	**12**	**17**	**18**	**22**	**13**	**19**	**15**	**11**

Relative abundance Ranking
- 1 Rare — found along less than 5% of transect
- 2 Present — foung along 5-25% of transect
- 3 Common — found along 25-50% of transect
- 4 Abundant — found along more than 50% of transect

Table 5, continued. Shoreline aquatic plant transect data from Black Otter Lake, June 2002.

Collectors: C. Cason
J. Nicholson

Species		Transect/Abundance Ranking							
common name	**scientific name**	**X**	**XI**	**XII**	**XIII**	**XIV**	**XV**	**XVI**	**XVII**
Blue Flag Iris	*Iris versicolor*	1		1				1	
Bottlebrush Sedge	*Carex comosa*	2	3	2	2	1			
Broad Leaved Arrowhead	*Sagittaria latifolia*								
Broad Leaved Cattail	*Typha latifolia*				2				
Canada Bluejoint Grass	*Calamagrostis canadensis*		1	3			1		
Creeping Spikerush	*Eleocharis palustris*		2			1		2	
Curly Dock	*Rumex Crispus*				1	1		1	
Dogwood	*Cornus spp.*							2	1
Floating Leaf Pondweed	*Potamogeton natans*	4	3	4					
Hardstem Bulrush	*Scripus acutus*								
Jewelweed	*Impatiens capensis*		2		2				
Kentucky Bluegrass	*Poa pratensis*	4	4	4	3	3	4	4	
Lake Sedge	*Carex lacustris*								
Marsh Marigold	*Caltha Palustris*								
Marsh Milkweed	*Asclepias incarnata*								
Narrow Leaved Cattail	*Typha angustifolia*				4	4		1	
Needle Rush	*Eleocharis acicularis*		1						
Reed Canary Grass	*Phalaris arundinacea*								
River Bulrush	*Scripus fluviatilis*			1		1			
Sage Willow	*Salix canadensis*		4			2			
Soft Rush	*Juncus effusus*	3	2		2	2			
Softstem Bulrush	*Scripus validus*								
Spadderdock	*Nuphar variegata*								
Stalk Grained Sedge	*Carex stipata*								
Tag Alder	*Alnus*	1							
Tussock Sedge	*Carex*			2					
Water Smartweed	*Polygonum amphibium*								
Water Smartweed spp.	*Polygonum longistylum*		2						
Willow	*Salix spp.*							2	1
total per transect		**15**	**24**	**17**	**16**	**15**	**5**	**13**	**2**

Relative abundance Ranking	1 Rare	found along less than 5% of transect
	2 Present	foung along 5-25% of transect
	3 Common	found along 25-50% of transect
	4 Abundant	found along more than 50% of transect

Table 5, continued. Shoreline aquatic plant transect data from Black Otter Lake, June 2002.

Collectors: C. Cason
J. Nicholson

Species common name	scientific name	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	Total
		Transect/Abundance Ranking								
Blue Flag Iris	*Iris versicolor*							1		9
Bottlebrush Sedge	*Carex comosa*	1							2	24
Broad Leaved Arrowhead	*Sagittaria latifolia*									2
Broad Leaved Cattail	*Typha latifolia*									12
Canada Bluejoint Grass	*Calamagrostis canadensis*									9
Creeping Spikerush	*Eleocharis palustris*									6
Curly Dock	*Rumex Crispus*					1				6
Dogwood	*Cornus spp.*									3
Floating Leaf Pondweed	*Potamogeton natans*					2				32
Hardstem Bulrush	*Scripus acutus*									1
Jewelweed	*Impatiens capensis*									14
Kentucky Bluegrass	*Poa pratensis*	1			2	4	4	4	4	78
Lake Sedge	*Carex lacustris*									2
Marsh Marigold	*Caltha Palustris*									1
Marsh Milkweed	*Asclepias incarnata*									1
Narrow Leaved Cattail	*Typha angustifolia*	1	1			1		3	3	20
Needle Rush	*Eleocharis acicularis*									1
Reed Canary Grass	*Phalaris arundinacea*						1			4
River Bulrush	*Scripus fluviatilis*								2	6
Sage Willow	*Salix canadensis*									6
Soft Rush	*Juncus effusus*	1							3	21
Spadderdock	*Nuphar variegata*					1	3			4
Stalk Grained Sedge	*Carex stipata*									1
Tag Alder	*Alnus*									7
Tussock Sedge	*Carex*									4
Water Smartweed	*Polygonum amphibium*									2
Water Smartweed spp.	*Polygonum longistylum*									3
Willow	*Salix spp.*				1					6
total per transect		**4**	**1**	**0**	**3**	**9**	**8**	**8**	**14**	**285**

Relative abundance Ranking		
	1 Rare	found along less than 5% of transect
	2 Present	foung along 5-25% of transect
	3 Common	found along 25-50% of transect
	4 Abundant	found along more than 50% of transect

5.4 Water Quality Indicators

While a number of parameters may be tested to evaluate the water quality and the trophic state or relative age of a lake, the three most commonly assessed parameters are chlorophyll *a* concentration, total phosphorus concentration and Secchi disc depth. Another important parameter that can be used to assess trophic state is dissolve oxygen concentration. While no single parameter can provide reliable gauge of lake water quality, taken collectively over time, these parameters form an accurate basis for comparative analysis. The results of these tests taken in the main lake through the 2002 season are shown in **Table 6**.

5.41 Chlorophyll *a*

Chlorophyll is a pigment found in all plants. It is the only pigment that can convert light to chemical energy in photosynthesis. Chlorophyll *a* concentrations are often used to gauge algal abundance. Because algal abundance is often related to nutrient inputs in a lake, chlorophyll *a* can be a good indicator of water quality. Average chlorophyll *a* readings were high for Black Otter Lake, indicating that much of the plant biomass was in the form of planktonic algae. These values rank Black Otter Lake in the "poor" range on the Chlorophyll *a* Water Quality Index shown in **Figure 6**.

5.42 Total phosphorus

Phosphorus is the most common growth-limiting element for aquatic plants. Results indicate that it is indeed the limiting factor in plant growth in Black Otter Lake. Total phosphorus is a measure of available phosphorus plus phosphorus tied up in living cells. Results indicate that ample phosphorus was available for algae growth. Black Otter Lake ranks in the "poor" range on the Total Phosphorus Water Quality Index shown in **Figure 7**. However, this ranking is typical for impoundments.

5.43 Secchi disc depth

A Secchi disc is an eight-inch diameter black and white plate that is lowered into the water on a calibrated cord. The depth at which the disc is last visible is used as the standard measure of water clarity. Water clarity is often a function of suspended solids and/or phytoplankton density, and is thus often related to water quality. Secchi disc readings on Black Otter Lake were at their lowest in August and at their highest in November. Average readings rank in the "poor" range on the Secchi Disc Depth Water Quality index shown in **Figure 8**.

5.44 Dissolved oxygen and temperature

Dissolved oxygen and temperature data are taken together, as dissolved oxygen saturation concentrations are inversely related to temperature. Seasonal profiles for these two parameters taken from Black Otter Lake are shown in **Figures 9** and **10**. This inverse relationship is apparent in the November readings when water temperatures were at their coolest and dissolved oxygen readings were at their highest. Conversely, when water temperature are at their highest in July and August, dissolved oxygen concentration were at their lowest.

In most cases, more productive lakes will have a greater oxygen deficit in the depths than less productive lakes. Therefore the productivity of a lake can often be estimated from the nature of its oxygen curve (Ruttner, 1953). There was a distinct oxycline apparent on each sampling date except during April when a high volume of water was moving through the lake. On all the other dates, the bottom layers of the water column were devoid of oxygen. The extent of this anoxic layer varied through the season. In June good oxygen levels remained in the top two feet of water. Below six feet deep the lake was devoid of oxygen. In July, following a die-off of curly-leaf pondweed, dissolved oxygen became depleted in the upper water column as well. By August, dense mats of duckweed and algae had killed off most rooted plants causing high turbidity and a high oxygen demand. Below a depth of two feet oxygen levels became too low for most fish species. By November however, cooling water temperatures slowed productivity and oxygen was once again replenished. Only a thin layer of water above the bottom was depleted in oxygen.

Aeration

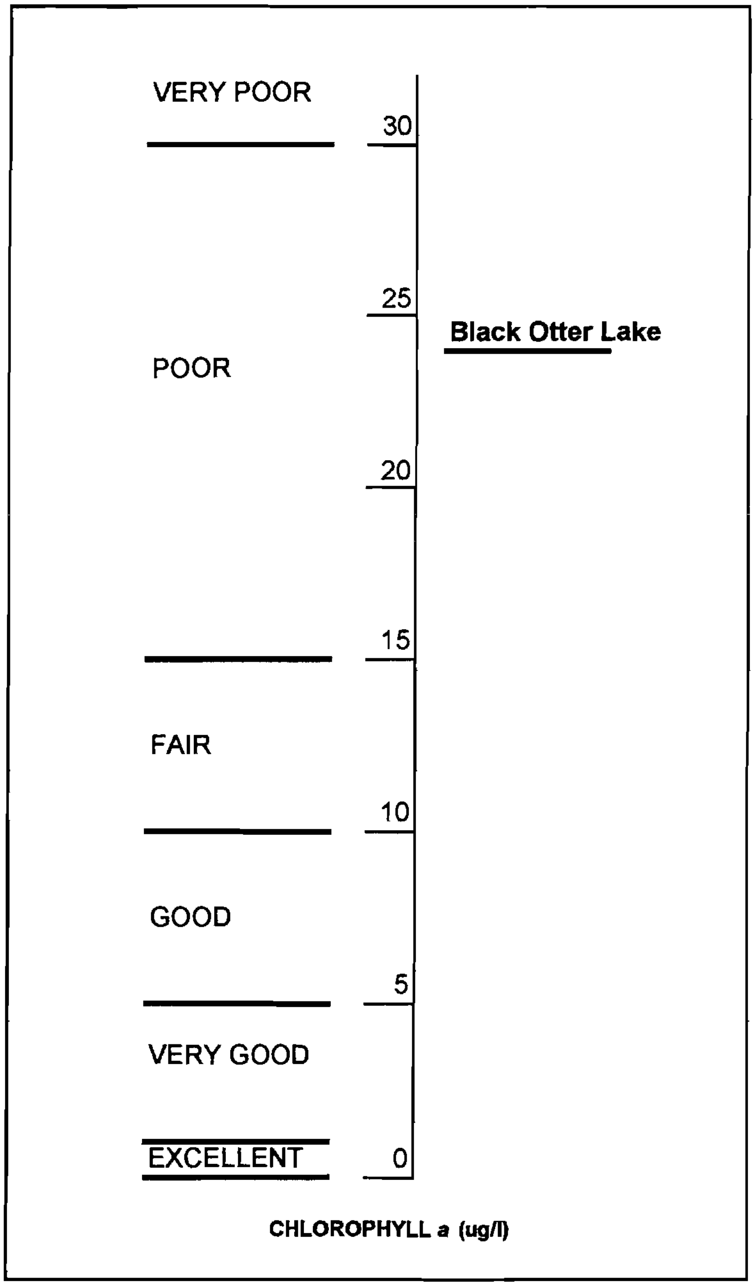
These data indicate that the existing aeration system is not performing adequately during periods of low flow in Black Otter Lake. The stratification apparent in the temperature profiles likewise indicates that the aeration system is not able to adequately mix the water column.

Table 6. Summary of 2002 Black Otter Lake water analysis data collected one foot below the surface over the deepest point of the lake (C).

		sample date					
parameter	**unit**	**24-Apr-02**	**17-Jun-02**	**12-Jul-02**	**7-Aug-02**	**4-Nov-02**	**Average Value**
alkalinity	mg/l	232					232
chloride	mg/l	31.2					31.2
chlorophyll *a*	ug/l	33	10	54.4	17	4	23.7
conductivity	um/cm	567					567
dissolved oxygen - bottom	mg/l	11.8	0.10	0.10	0.08	5.44	3.5
dissolved oxygen - surface	mg/l	12.6	11.2	5.7	5.43	13.35	9.66
ammonia as N	ug/l	34					34
Kjeldahl nitrogen	ug/l	1520					1520
nitrate + nitrite as N	ug/l	798	482	N.D.	N.D.	1480	552
total phosphorus	ug/l	60	63	89	90	31	66.6
dissolved phosphorus	ug/l	N.D.					N.D.
nitrogen / phosphorus ratio		39/1					
pH, field	s.u.	8.7	8.48	8.2	8.06	8.6	8.41
pH, lab	s.u.		8.57	7.88		8.53	8.3
secchi disc depth	ft.	3.1	3.4	3.1	2.5	6.9	3.8
temperature - bottom	C	12.2	12.3	14.2	17.7	4.7	12.22
temperature - surface	C	12.2	24.9	25.6	24	4.8	18.3
total dissolved solids	mg/l	354					354
total suspended solids	mg/l	7					7
weather conditions		rainy,windy	sunny	calm	sunny	calm	
air temperature	C		29.1	25.2	24	1.7	20
cloud cover	%	100.00	20	20	0	0	28
gauge height	ft.	2.25	2.25	2.21	2.2	3.17	2.42

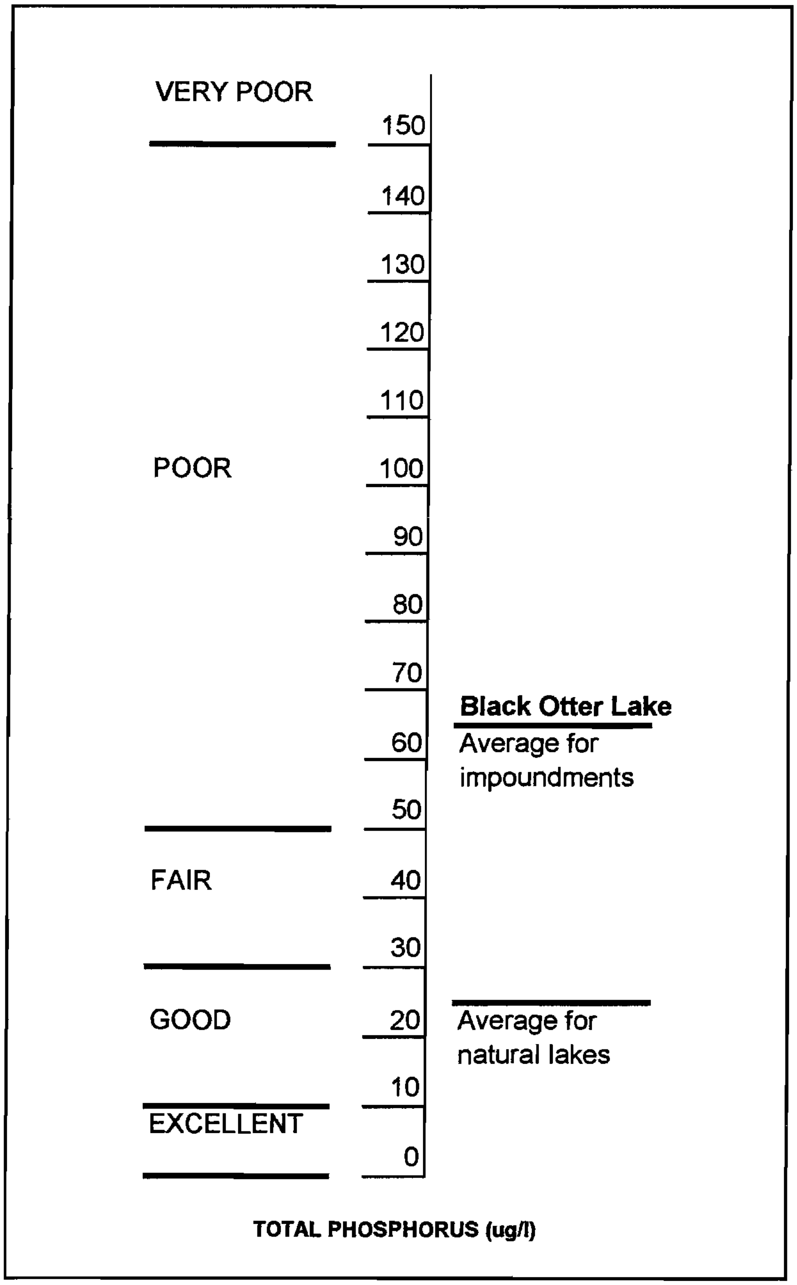
N.D. = not detected, concentration below limit of detection
Gauge height = distance between bottom of iron RR bridge and water's surface.

Figure 6. Chlorophyll *a* water quality index.



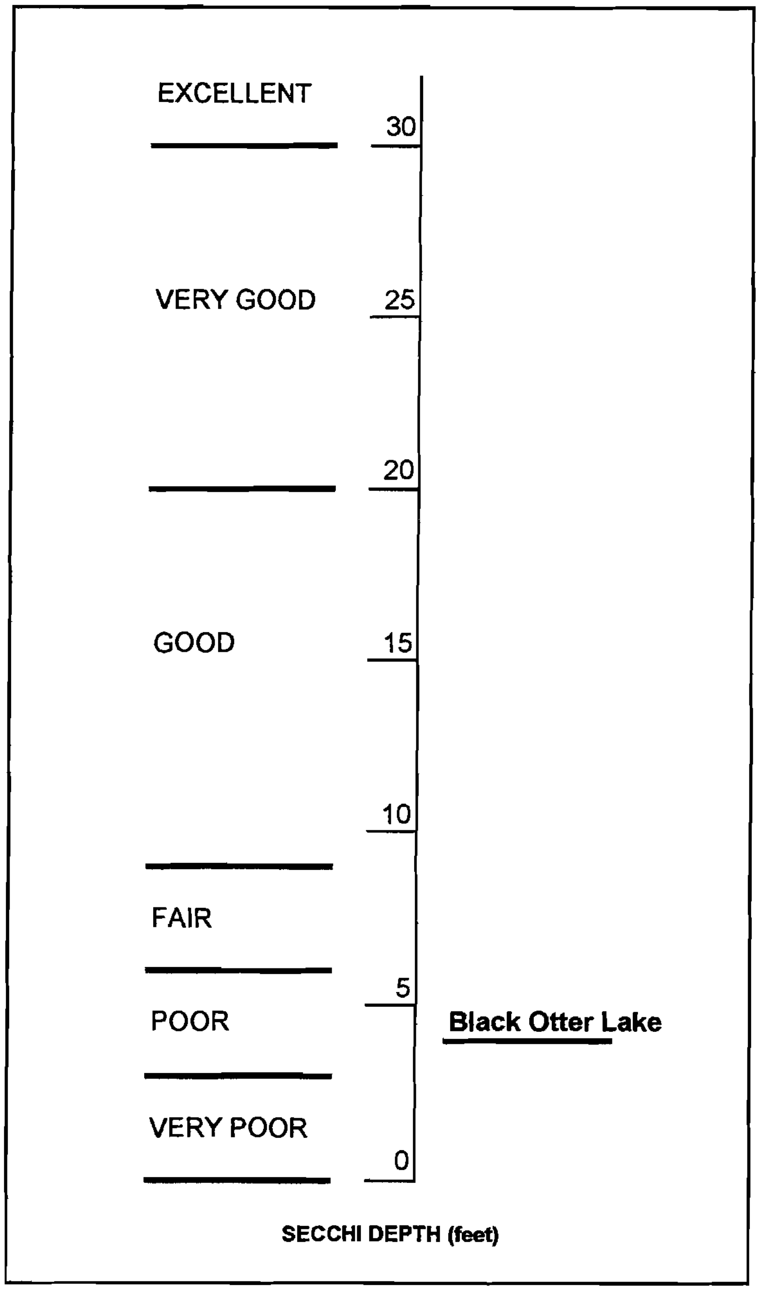
Adapted from Shaw, et. al. (2000).

Figure 7. Total phosphorus water quality index.



Adapted from Shaw, et. al. (2000).

Figure 8. Secchi disc depth water quality index.



Adapted from Shaw, et. al. (2000).

Figure 9. Black Otter Lake 2002 dissolved oxygen profiles.

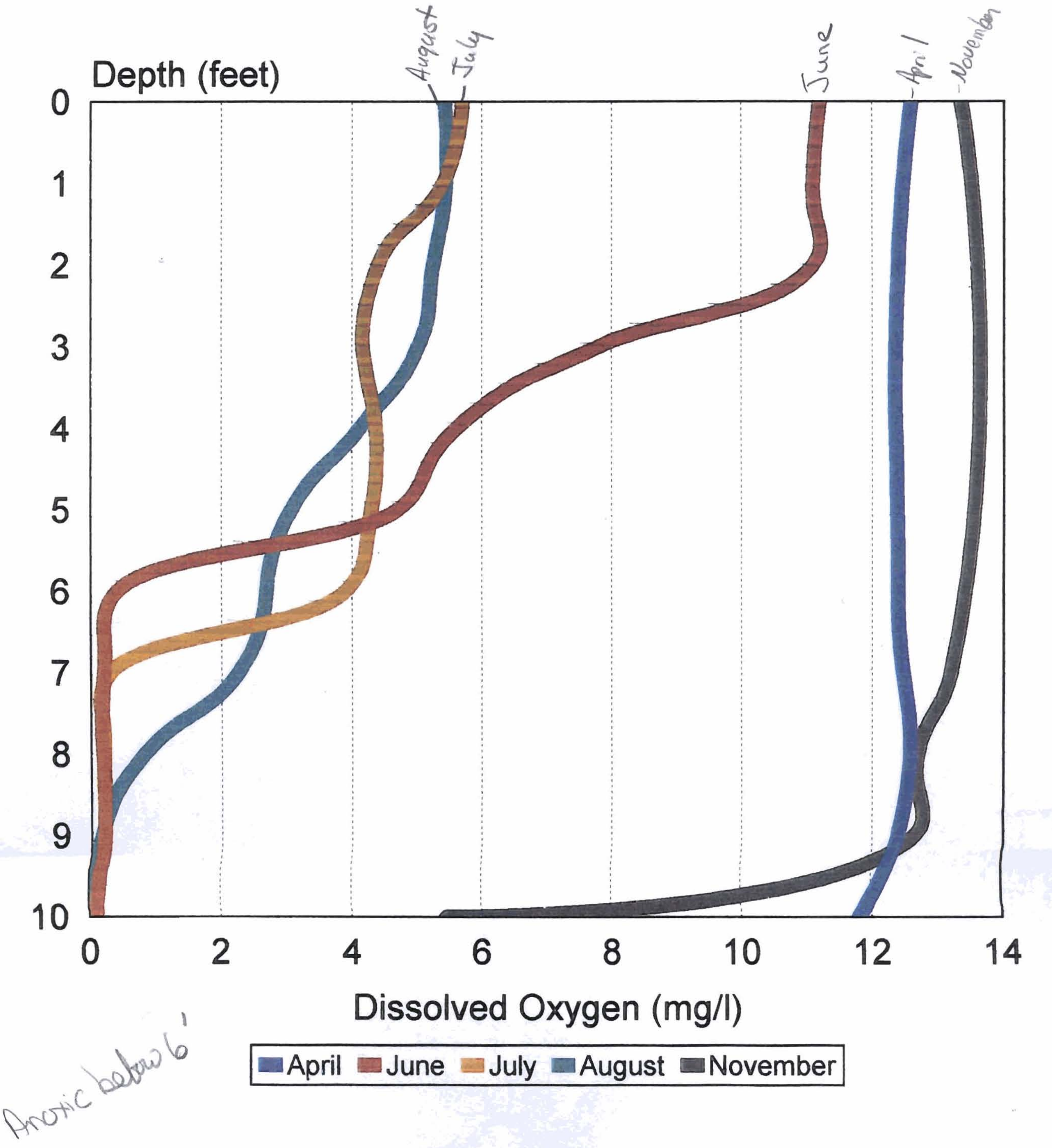
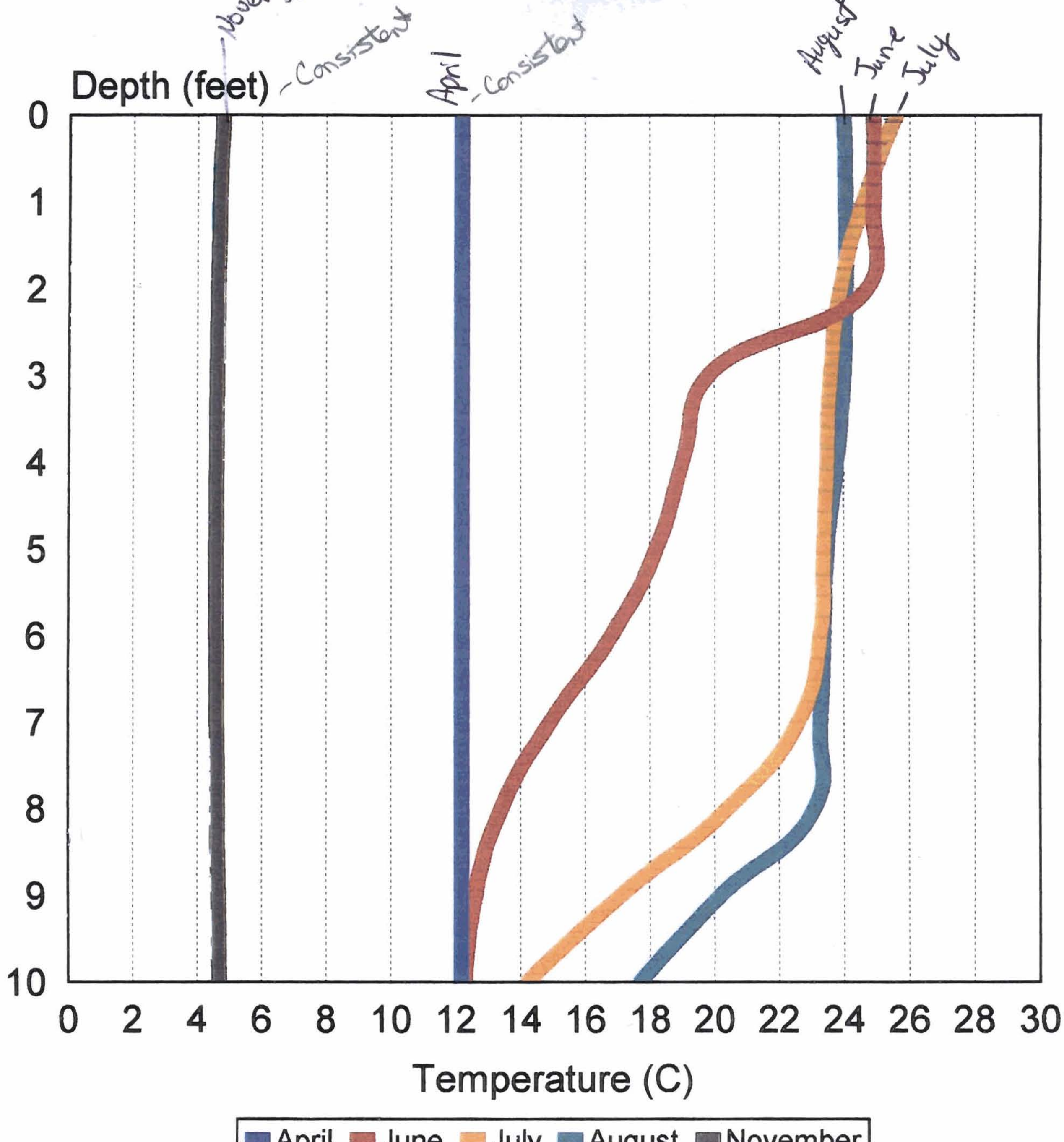


Figure 10. Black Otter Lake 2002 temperature profiles.



5.5 Water chemistry analysis

Along with the parameters discussed in section 5.4, eleven additional water chemistry parameters were tested on the lake during April after the spring turnover. The results of these analyses are given in **Table 6**. Averaged results from the 2002 survey are compared to water chemistry analysis results from the 1991 and 1978 surveys in **Tables 7.** A description of each parameter and the implications of the results found for Black Otter Lake are discussed in the following paragraphs.

5.51 Phosphorus

Phosphorus has been found to be the nutrient that limits plant and algae growth in more than 80% of Wisconsin lakes. As phosphorus levels increase, so does plant productivity. Failing septic systems, detergents, lawn and crop fertilizers soil erosion and feedlot runoff are all major sources of phosphorus found in lakes. Phosphorus analysis done in Black Otter Lake included total phosphorus and dissolved phosphorus. Dissolved phosphorus is phosphorus that is in solution in the water column that is readily available for plant growth. Total phosphorus is dissolved phosphorus plus the phosphorus found in living cells, such as algae, that are suspended in the water column. Total phosphorus therefore, is more often a better estimator of lake productivity.

Dissolved phosphorus concentrations were not detectable in 2002. This indicates that available phosphorus was tied up in living cells. Total phosphorus concentrations were high but typical for impoundments during April and June. Total phosphorus concentrations were highest during July and August when little stream flow entered the lake. These high concentrations are likely the result of nutrient release from decaying plant matter caused by the massive die-offs of rooted plants that occurred then. These findings also suggest that internal nutrient cycling may be more influential of Black Otter Lake's water quality than the watershed.

2002 concentrations were similar to those found in 1978, but much lower that those found in the 1991 survey.

5.52 Nitrogen

Next to phosphorus, nitrogen is the nutrient most likely to contribute to excessive weed and algae growth. Nitrogen can enter lakes from groundwater, surface runoff and precipitation. In drainage lakes though, nitrogen concentrations most often correspond to local land uses. Nitrogen analyses for Black Otter Lake included ammonia, nitrate + nitrite and Kjeldahl nitrogen, which is organic nitrogen plus ammonia. Total nitrogen is determined by adding nitrate + nitrite to Kjeldahl nitrogen. When the ratio of total nitrogen to total phosphorus is less than 15:1, a lake is considered nitrogen limited. When this occurs, additions of nitrogen to the lake can lead to increases plant productivity.

The nitrogen : phosphorus ratio found for Black Otter Lake was 39:1 in 2002, indicating that the lake is clearly phosphorus limited. Nitrate + nitrite levels varied considerably through the season, from non-detectable to 1480 ug/l. At times concentrations were high enough to be considered a health hazard to humans. High levels of nitrate and nitrite are generally the result agricultural runoff, lawn fertilizers or failing septic systems. Highest nitrate + nitrite concentrations were found at the south inlet (**Table 9**). The non-detectable levels found in July and August correspond to low oxygen levels. Low oxygen levels facilitate de-nitrification reactions.

5.53 pH

pH is the negative logarithm of the H+ (hydrogen ion) concentration. The product of H+ and OH- (hydroxyl) ions present in water is a constant. This constant is known as the dissociation constant of water. Theoretically, pure water has equal concentrations of H+ and OH- and is neutral in reaction. Neutral water has a pH of 7. When OH- becomes greater than H+, pH rises and water is considered basic or alkaline. When H+ becomes greater than OH-, water is considered acidic. Since pH is a logarithmic scale, an increase of 1.0 in pH equals a ten-fold increase in OH- concentration. Thus water with a pH of 9 is 100 times more alkaline than water with a pH of 7.

The pH of lakes is affected by many factors. Rainwater is acidic and can lower pH. However this reaction is often buffered by calcium bicarbonate. Plant productivity will raise pH. Calcium bicarbonate is actively broken down by plants in the reactions of photosynthesis. The release of OH- from this reaction raises pH (Ruttner, 1953).

Extremes in pH can have negative effects on aquatic life. In Wisconsin, most pH –related problems with lakes are due to low pH. Low pH can inhibit fish spawning and even cause fish kills. Low pH can also lead to the precipitation of mercury, zinc and aluminum from bedrock. These metals can cause health problems for fish and animals that feed upon them, notably: loons, eagles and humans (Shaw, et.al., 2000). Fortunately the pH found for Black Otter Lake is high, and these are not concerns. The high pH found in Black Otter Lake is partly the result of local geology, as area lakes tend to be alkaline, and partly the result of plant productivity.

5.54 Alkalinity

Alkalinity is a measure of the calcium carbonate concentration of water. In reactions where acid is added to water containing calcium bicarbonate in solution, bicarbonates combine with hydrogen ions thereby limiting changes in pH. Not until additions of acids have exhausted available carbonates will pH values drop sharply. This buffering capacity is very important for organisms in aquatic environments in its ability to prevent major fluctuations in pH. Not surprisingly, alkaline lakes tend to have a greater abundance of aquatic life than acidic lakes.

Lakes that have an alkalinity of 10 mg/l or less are considered moderately to highly susceptible to acid rain. With an alkalinity of 232 mg/l, Black Otter Lake is most certainly not sensitive to acid rain.

5.55 Chloride

While chloride ions are essential for plant photosynthesis, free chlorine is highly toxic to living cells. Chlorine kills by oxidation of cell membranes, but the process quickly converts it to harmless chloride ions. Thus chloride concentration is used to identify chlorinated waste discharges in lakes. Other sources of chloride are septic effluent, feedlot runoff, lawn fertilizers and road salts. Elevated levels of chloride indicate that these sources may be affecting the lake.

Chloride occurs naturally in the surface waters of Wisconsin. At typical concentrations it is not harmful to aquatic life. Typical values for area lakes are 3 – 10 mg/l. The chloride concentration of 31.2 mg/l further indicates that runoff-borne pollutants are contaminating Black Otter Lake.

5.56 Dissolved solids

Dissolved solids are a measure of dissolved organic compounds present in water. Sources of dissolved solids commonly include decomposing plant matter and tannins leached from bogs. Water having high concentrations of dissolved solids limits the depth at which photosynthesis can take place. Thus it is an important parameter that can affect lake ecosystems. The high concentrations of dissolved solids found in Black Otter Lake likely affects the aquatic plant community.

5.57 Suspended solids

Suspended solids are a measure of a lake's turbidity. Suspended solids can include clay particle and decaying plant matter as well as living organisms such as zooplankton and phytoplankton. More productive lakes and lakes having large watersheds with erodeable soils tend to have higher concentrations of suspended solids. Suspended solids and dissolved solids affect Secchi disc depth, and are thus determinants for a major water quality parameter. Suspended solids concentrations for Black Otter Lake were surprisingly low when the water was sampled in April. 1991 values were 68 times higher when samples were taken in August.

5.58 Conductivity

The ability of water to conduct an electrical current is called conductivity. Conductivity is dependant upon the concentration of inorganic compounds suspended in the water column. Like chloride, conductivity can be used to determine if human activities are influencing water quality. A general guideline is that conductivity should be about two times the hardness of water. Higher concentrations may indicate sources of pollution. The conductivity of Black Otter Lake exceeded this guideline in 2002 and in 1978. this provides further evidence that non-point source pollutants continue to affect the lake.

Table 7. A comparison of averaged water quality parameters from Black Otter Lake between 1978, 1991, and 2002.

parameter	Location	unit	1978	1991	2002
alkalinity	lake	mg/l	204	278	232
chloride	lake	ug/l	17	30	31.2
Chlorophyll a	lake	ug/l	34	*	23.7
dissolved oxygen - surface	lake	mg/l	9.6	10.2	9.66
conductivity	lake	um/cm	590	*	567
dissolved (reactive) phosphorus	lake	ug/l	44	14	N.D.
Kjeldahl Nitrogen	lake	ug/l	*	510	1520
Nitrate + Nitrite as N	lake	ug/l	*	32	552
pH, field	lake	s.u.	9.1	7.8	8.41
secchi disc depth	lake	ft.	3.8	4	3.8
temperature - surface	lake	C	21.7	19.3	18.3
total phosphorus	lake	ug/l	70	222	66.6
total suspended solids	lake	mg/l	*	478	7
conductivity	inlet (south)	um/cm	610	*	*
dissolved (reactive) phosphorus	inlet (south)	ug/l	16	*	*
total phosphorus	inlet (south)	ug/l	52.3	*	54.2
total suspended solids	inlet (south)	mg/l	51	*	*
conductivity	outlet (dam)	um/cm	510	*	*
discharge	outlet (dam)	cfs	10.4	*	67.8
dissolved (reactive) phosphorus	outlet (dam)	ug/l	48	*	*
total phosphorus	outlet (dam)	ug/l	90.8	*	69.4
total suspended solids	outlet (dam)	mg/l	23	*	*

* = no data available
N.D. = not detected, concentration below limit of detection

Averaged values from the water quality parameters were calculated from samples within the time period of April - November. The data was compared at the most similar times allowed for each sample year.

Table 8. 2002 Black Otter Lake water analysis data collected from the north inlet (A).

		sample date					
parameter	**unit**	**24-Apr-02**	**17-Jun-02**	**8-Jul-02**	**7-Aug-02**	**4-Nov-02**	**Average**
dissolved oxygen	mg/l	8.3	14.5	5.8	2.65	14	9.05
nitrate + nitrite as N	ug/l	172	63	10	N.D.	820	213
total phosphorus	ug/l	445	126	87	96	33	157.4
pH, field	s.u.	8.54	8.82	8.3	7.76	8.59	8.4
water temperature	C	14.2	25	26.7	22.3	5.0	18.6
weather conditions		rainy,windy	sunny	humid	sunny	calm	
air temperature	C		29.1	25.2	24	1.7	20
cloud cover	%	100	20	20	0	0	28

Table 9. 2002 Black Otter Lake water analysis data collected from the south inlet (B).

		sample date					
parameter	**unit**	**24-Apr-02**	**17-Jun-02**	**12-Jul-02**	**7-Aug-02**	**4-Nov-02**	**Average**
dissolved oxygen	mg/l	13.3	11.39	0.9	0.83	17.77	8.84
nitrate + nitrite as N	ug/l	2200	2640	3100	1080	7710	3346
total phosphorus	ug/l	32	98	44	69	28	54.2
pH, field	s.u.	8.9	7.9	7.7	7.7	8.55	8.15
water temperature	C	11.4	20.7	20.1	22.1	5.4	15.94
weather conditions		rainy,windy	sunny	calm	sunny	calm	
air temperature	C		29.1	25.2	24	1.7	20
cloud cover	%	100	20	20	0	0	28

Table 10. 2002 Black Otter Lake water analysis data collected from the outlet dam (D).

parameter	unit	sample date 24-Apr-02	17-Jun-02	12-Jul-02	7-Aug-02	4-Nov-02	Average
dissolved oxygen	mg/l	12.8	11.9	3.6	5.9	13.78	9.6
nitrate + nitrite as N	ug/l	768	493	N.D.	N.D.	155	283.2
total phosphorus	ug/l	43	70	98	106	30	69.4
pH, field	s.u.	8.6	8.45	8.1	8.06	8.6	8.36
water temperature	C	12.2	24.9	23.8	24.7	4.7	18.1
velocity	ft./s	14	7	5.18	3.92	5.95	7.21
total flow	cfs	166.1	143	14.1	6.2	9.7	67.8
weather conditions		rainy,windy	sunny	calm	sunny	calm	0
air temperature	C		29.1	25.2	24	1.7	20
cloud cover	%	100	20	20	0	0	28

Table 11. Averages from all four sample locations:

parameter	unit	North Inlet site A	South Inlet site B	Main Lake site C	Outlet (Dam) site D
dissolved oxygen	mg/l	9.05	8.84	9.66	9.6
nitrate + nitrite as N	ug/l	213	3346	552	283.2
total phosphorus	ug/l	157.4	54.2	66.6	69.4
pH, field	s.u.	8.4	8.15	8.41	8.36
water temperature	C	18.6	15.9	18.3	18.1

5.6 Water and Nutrient Budgets

Water velocity and flow data as well as nutrient concentrations for the north inlet, south inlet and the outlet to Black Otter Lake are given in **Tables 8, 9** and **10**. These data were used to estimate nutrient and water budgets for the lake. Because it is nearly impossible to account for all variables affecting the lake, and because flow rates frequently fell below limits of detection, several assumptions and estimates were made, as follows:

1) Because water levels were relatively stable, water inputs = water outputs.
2) Given the soil types, groundwater influences were considered insignificant.
3) Evaporation was considered to be equal to precipitation.
4) Water flow from the south and east inlets was estimated to occur 240 days /year. Water inputs were assumed to be proportional to sub-watershed acreage.
5) Water flow from the north inlet was estimated to occur 30 days / year.

Accordingly, the following water budget information was calculated:

Water inputs:

Source	Volume (acre-ft./year)
North Inlet	4998
East Inlet	3000
South Inlet	24,275
Precipitation	197

Water outputs:

Source	Volume (acre-ft./year)
Outlet	32,273
Evaporation	197

Lake volume: 384 acre-ft.
Residence time: 4.32 days

Using the water budget data above along with total phosphorus concentrations found in **Tables 8, 9** and **10**, and export coefficients from Holdren, et. al. (2001), the following results were obtained:

Phosphorus imports:

Source	Total annual P load (lbs.)	Phosphorus lbs./acre/year
North Inlet	2139*	6.08
East Inlet (estimated)	823	0.76
South Inlet	3568	0.41
Precipitation	19	0.25
TOTAL	6549	

Phosphorus exports:

Source	Total annual P load (lbs.)
Outlet	6100

Regional average values:

Source	Phosphorus lbs./acre/year
Agricultural	2.14
Residential	0.76
Residential/Commercial	0.60

As can be seen, phosphorus imports exceeded exports by a rate of 449 lbs. per year. Black Otter Lake is effectively acting as a nutrient sink. While this is beneficial for downstream waters, it will lead to significant declines in water quality for Black Otter Lake over time.

Management Tools

A comparison of calculated values with regional averages provides more useful management information. The south inlet phosphorus load of 0.41 lbs/acre/year is well below the average value of 2.14 lbs/acre/year. While the north inlet phosphorus load of 6.08 lbs/acre/year is more than ten times the average value of 0.60 lbs/acre/year. This suggests that the areas most in nutrient controls exist in the north subwatershed.

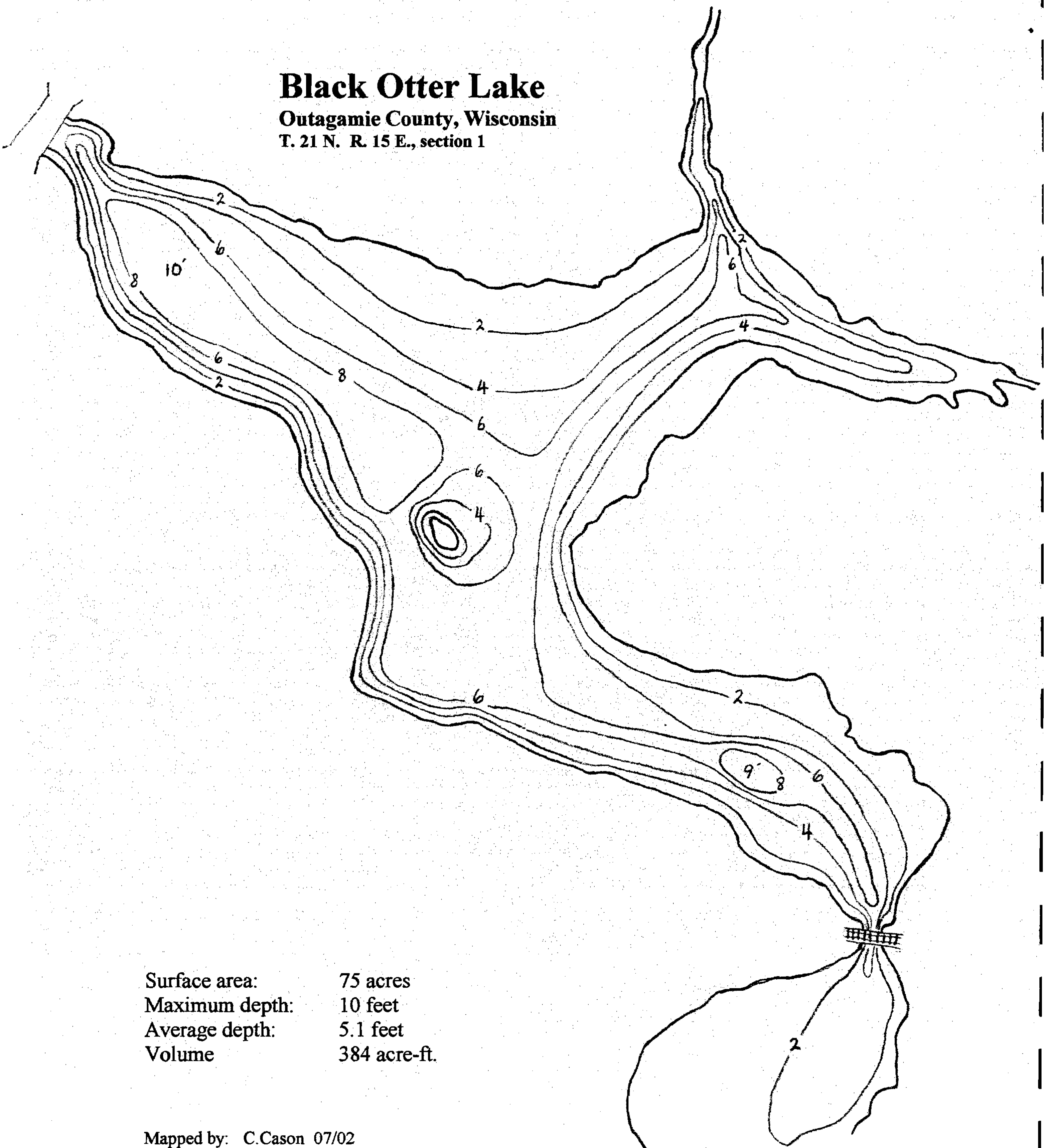
5.7 Lake Contour Mapping

The lake map that was developed from the 2002 depth soundings is shown in **Figure 11**. An average depth of 5.1 feet and a maximum depth of 10.0 feet was found. Several important conclusions can be drawn from this map. One is that lake-wide depth readings were virtually identical to those taken in 1991 and 1992 following dredging operations. This indicates that significant sedimentation had not reoccurred. The sediment trap in the south arm was also as deep as it was in 1991-92. It can be concluded that this sediment trap was totally ineffective in capturing sediments. The trap excavated near the north inlet was somewhat filled in, but given the time span since dredging, it was not effective either.

Black Otter Lake

Outagamie County, Wisconsin

T. 21 N. R. 15 E., section 1



Surface area:	75 acres
Maximum depth:	10 feet
Average depth:	5.1 feet
Volume	384 acre-ft.

Mapped by: C.Cason 07/02

Aquatic Biologists, Inc.

5.8 Watershed Analysis

5.81 Boundary delineation

The total watershed area for Black Otter Lake was determined to be 10,193 acres. The watershed is composed of three drainage basins. These were termed the upper-, mid- and lower-subwatersheds. Maps of watershed boundaries are found in **Figures 12 – 15**.

5.82 Land use patterns

The composition of land uses within the Black Otter Lake watershed was found to be 62% agricultural, 15% upland forest, 12% residential, 8% swamp forest, and 3% Conservation Reserve Program set-aside. The upper subwatershed was predominantly residential, while the mid- and lower subwatersheds were predominantly agricultural. A breakdown of subwatershed land uses is given in **Table 11**.

5.83 Site assessments

A summary of site assessments conducted in the watershed is given in **Table 12**. It appears that many of the soil conservation programs initiated in the watershed have been effective. All agricultural sites inspected had good erosion control practices and vegetative buffer zones in place. Areas of concern that were identified included runoff from roadways, and residential and commercial areas in the upper subwatershed, and runoff from residential areas adjacent to the lake in the lower subwatershed.

Residential

Table 12. Black Otter Lake watershed site assessment data summary.

<u>Upper Sub-watershed</u>

Total acres = 352

<u>Potential nutrient loading sources</u>

- Includes the inlet area in town where residential runoff is directed underground and then enters the lake; runoff is coming directly from Hwy 45 and parking lots from near-by businesses and schools

- Runoff coming from the school athletic fields and large lawns may contain fertilizers

<u>Potential sediment loading sources</u>

- Large rain events are likely to carry loose soil on hwy 45 and surrounding parking lots directly into the lake

<u>Other Observations</u>

- Much of this watershed is made up of rural cropland with many surrounding grasslands serving as buffer strips

Mid Sub-watershed
Total acres = 1,086
Potential nutrient loading sources • Includes the inlet area on the eastern finger of the lake; Approximately 8 farms with livestock pastures and 2 scattered subdivisions are contained in this watershed, both of the potential sources appear to have plenty of buffer land before lake/stream and are not considered a problem
Potential sediment loading sources • Watershed appears to be well buffered with vegetation. limited sediment loading may come from erosion along water courses

Lower Sub-watershed
Total acres = 8,755
Potential nutrient loading sources • Includes southern inlet area and western lake residential area; western residential area has approximately 29 homes boarding the lake that may contribute to lawn fertilizers and other nutrient sources entering the lake; runoff from streets and other nearby homes in the residential area is also a concern
• Surrounding cropland and pastureland all appear to have good buffer zones and are not a concern
Potential sediment loading sources • Large rain events are likely to carry loose soil on residential streets and surrounding driveways directly into the lake
Other Observations • The rural portion of this watershed appears to have good vegetated buffers (marshes, swamps, forests, grasslands) that help stop excess nutrient and sediment loading, it is the residential area that appears to be a concern

5.84 Best management practices and conservation programs

The results of a literature review of best management practice directed at enhancing lake water quality that are relevant to Black Otter Lake are given in **Table 13**. A list of state and federal conservation programs applicable to the Black Otter Lake watershed is given in **Table 14**.

Table 13. Management activities to enhance water quality.

Urban Runoff

Protection Grants

Objective:
Minimize and filter the direct runoff coming from the urban areas, especially during large rain events. The runoff coming from much of the urban area is directly flushed into Black Otter Lake; this appears to be a major contributor to poor water quality.

Methods:
Wet Detention Ponds
The most common practice used to control urban runoff. The system consists of a single pool that treats stormwater. Ponds usually hold 3 to 7 feet of standing water. The detention pond traps stormwater and allows pollutants to settle out. Past evidence shows that a majority of suspended solids, phosphorus, nitrogen, and many other elements are filtered out if stormwater is allowed to settle before being released. -sites

New stormwater regs

Stormwater Wetlands
Constructed stormwater wetlands consist of shallow pools that contain aquatic plants. The artificial wetland removes pollutants through infiltration, absorption, microbial interactions, and uptake by aquatic plants. Past evidence shows that wetland construction works for filtering a majority of stormwater pollutants. - should show sites

Infiltration Basins
Basins are large open depressions that catch and store urban runoff. Infiltration basins allow runoff to percolate into the soil, which filters the water. Infiltration basins require correct soil conditions and annual maintenance. -sites

Vegetative Buffer Zones
A buffer zone consists of an area of native vegetation that filters urban runoff before it reaches a main water source. Vegetative buffer zones play an important role in utilizing excess nutrients, trapping loose sediment and stabilizing soil. Large areas of vegetative buffers are needed to handle high flow runoff events. → Shoreline restorations

Lawn Fertilizer Use
Avoid using lawn fertilizers near the lake, if you feel it necessary to fertilize your lawn use a fertilizer with 0 phosphorus levels. Most standard fertilizers contain high levels of phosphorus. Phosphorus is the main cause for algae blooms and excessive weed growth in most lakes. - Ordinance revisions

Rural Runoff

Objective:
Prevent sources of nutrient rich contaminants from entering into rural inlet tributaries. Past evidence (1991) shows direct sources of pollutants coming from rural runoff. However our studies found no readily identifiable pollutant sources coming from the rural inlets.

Methods:

Vegetative Buffer Zones

A buffer zone consists of an area of native vegetation that is allowed to filter rural runoff before it reaches a main water source. Vegetative buffer zones play an important role in utilizing excess nutrients, trapping loose sediment and stabilizing soil. Vegetation in these zones consists of a variety of grassland, shrub, and tree species. Large areas of vegetative buffers are needed to handle high flow runoff events.

Pasture and Cropland Runoff Diversion

Prevent any direct runoff into the inlet tributaries from cattle feedlots and cropland. Runoff from these sources is nutrient rich. Nutrient loading causes algae blooms, excessive weed growth, and high sediment loads. A vegetative buffer zone is a key component to prevent nutrient loading from pasture and cropland runoff.

Conservation Programs

Many federal and state funded programs exist that encourage conservation and nutrient management. These programs help reduce erosion, increase wildlife habitat, restore wetlands, increase vegetative buffer strips, and improve water quality.

In Lake Components

Plants

In-lake restoration

Protect native submersed and emergent aquatic plants; aquatic plants are very important in stabilizing bottom sediment, utilizing excess nutrients, providing dissolved oxygen, providing fish and wildlife habitat, and helping overall water quality.

Control exotic vegetation; exotic species tend to have aggressive growth rates and rapid dispersal, which is a threat to native plants. Exotics also tend to reach nuisance levels and become a problem for recreational activities. Exotic species like Eurasian watermilfoil, purple loosestrife, and curly-leaved pondweed have been attributed to significant declines in the habitat diversity in many Wisconsin lakes.

do other methods 1st!

Aeration

Continue future aeration; oxygenating the water is very important for speeding up sediment decomposition and better overall water quality. Aeration also helps prevent algae blooms. Adding oxygen into the water column is also important in preventing winter and summer fish kills.

Future Monitoring

Continue future water quality monitoring to help aid in proper management decisions. Annual water analysis is an important ingredient in monitoring nutrient loading and overall water quality.

Table 14. State and Federal Conservation Programs

Conservation Reserve Program (CRP)
Purpose: To reduce erosion, increase wildlife habitat, improve water quality, and increase forestland.
Practices: Tree planting, wildlife ponds, grass cover, and other environmental practices.
Eligibility: Varies by soil type and crop history. Land is accepted into program if bid qualifies. Continuous signup open for buffers, waterways and environmental practices

Wisconsin Conservation Reserve Enhancement Program (CREP)
Purpose: To protect environmentally sensitive land next to rivers, streams, lakes and other water bodies.
Practices: Installation of riparian zones, sod waterways, filter strips, and restoration of prior converted and farmed wetlands.
Eligibility: Land that has been farmed 2 of the crop years 1996-2000, marginal pastureland is also eligible.

Wisconsin Nonpoint Source Pollution Abatement Program
Purpose: To improve and protect water quality.
Practices: Landowners develop practices to prevent or reduce nonpoint source water pollution.
Eligibility: Landowner/operator located in selected priority watershed area.

Wildlife Habitat Incentives Programs (Whip)
Purpose: To develop or improve fish and wildlife habitat on privately owned land.
Practices: Seeding, fencing, instream structures, etc.
Eligibility: Almost any type of land is eligible, including Ag and non-ag land, woodlots, pastures, and stream banks.

Wetlands Reserve Program (WRP)
Purpose: To Restore wetlands previously altered for agricultural use.
Practices: Wetland restoration and wildlife habitat establishment
Eligibility: Land which has been owned for one year and can be restored to wetland conditions.

Stewardship Incentive Program (SIP)
Purpose: To provide cost-sharing to protect, manage, and enhance forest resources.
Practices: Forestry management plan, tree plantings, fish habitat improvement, wetland restoration, etc.
Eligibility: Private landowner with 10-1,000 acres of woodland.

Partners for Fish and Wildlife
Purpose: Restoration of wetlands, grasslands, and threatened and endangered species habitats.
Practices: restore wildlife habitat on private lands.
Eligibility: Land that can be restored to grassland or wetland conditions. Any land that can be restored for threatened and endangered species.

Forestry Programs
Purpose: To provide cost-share for forestry practices.
Practices: Tree planting, site preparation for natural regeneration, timber stand improvement, etc.
Eligibility: Landowner with 10 or more acres.

Grazing Lands Conservation Initiative
Purpose: To provide technical, educational and other help to conserve and improve privately owned pasture and grazing land.
Practices: Prescribed grazing, animal trails and walkways, fencing

For Further Information see: http://www.wi.nrcs.usda.gov/programs/programs.asp

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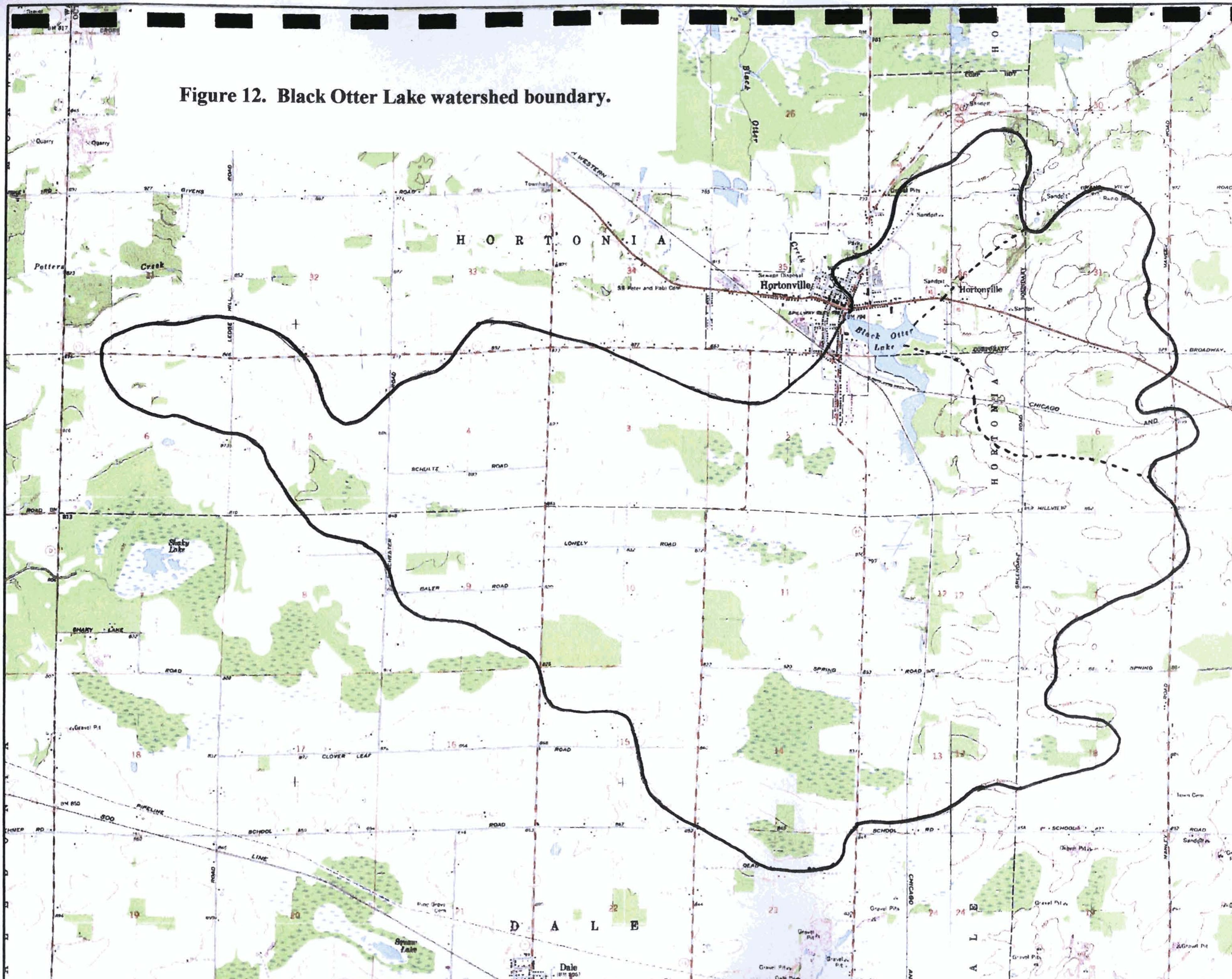

Figure 12. Black Otter Lake watershed boundary.

Figure 13. Upper – subwatershed boundary.

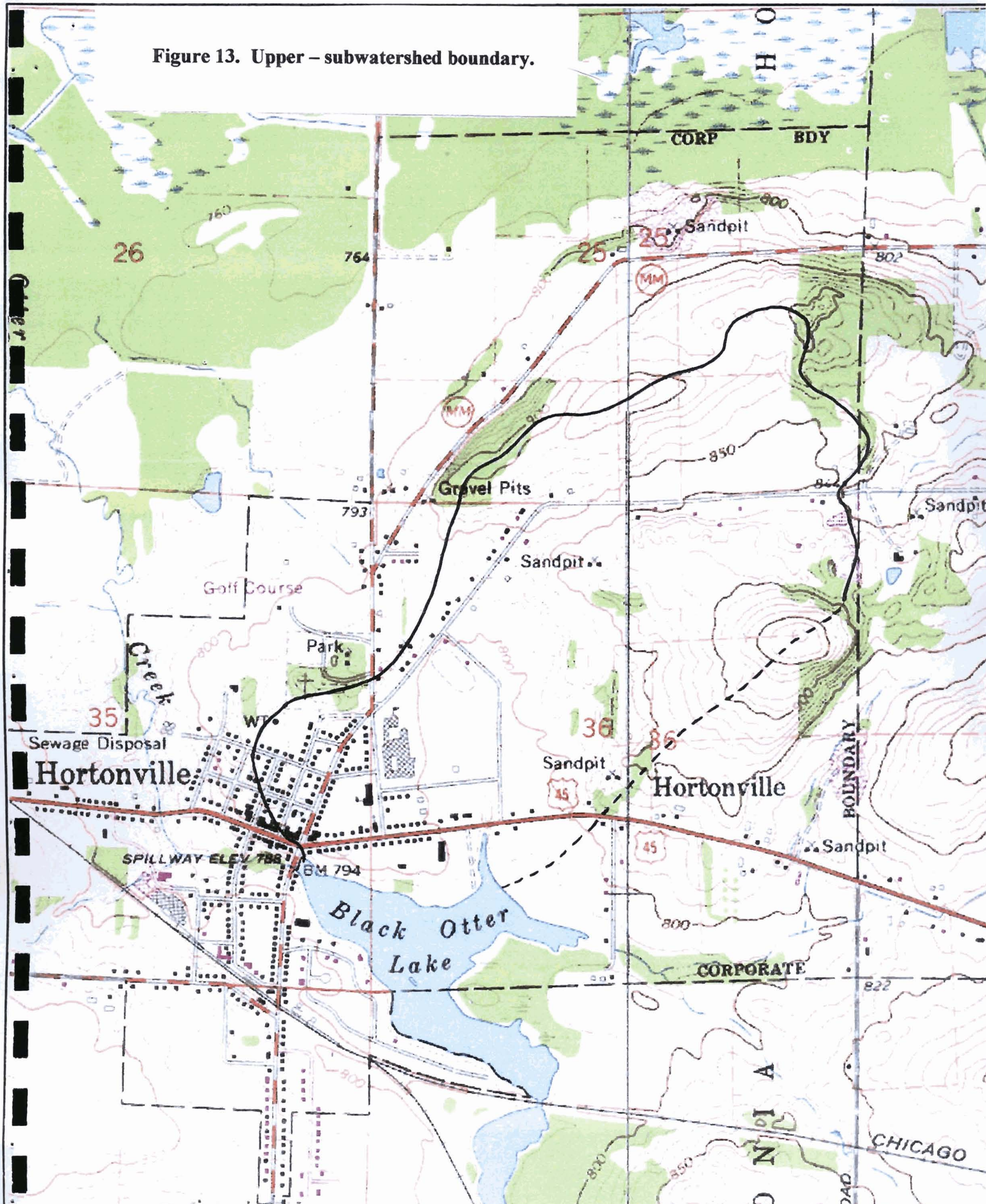

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Figure 14. Mid – subwatershed boundary.

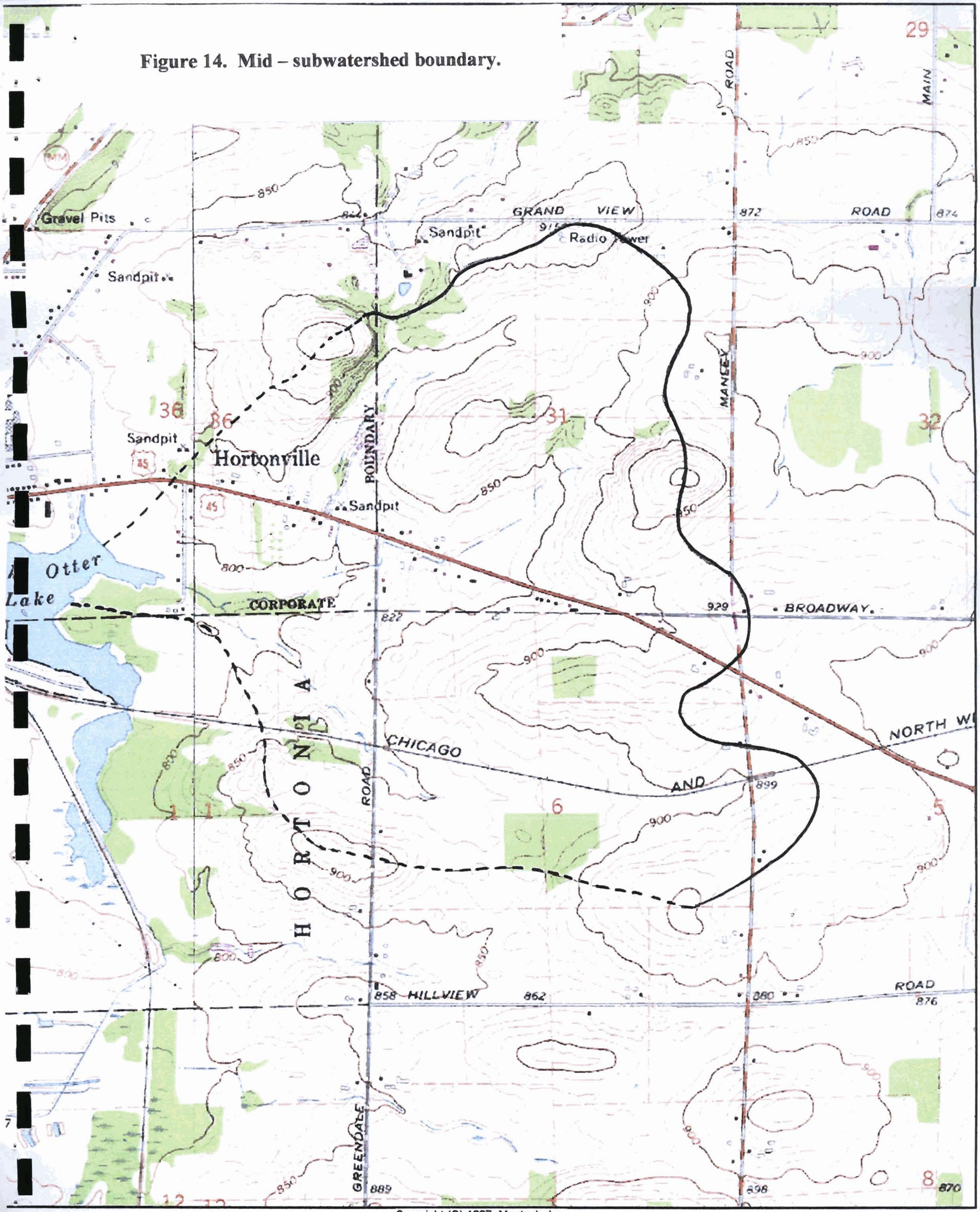
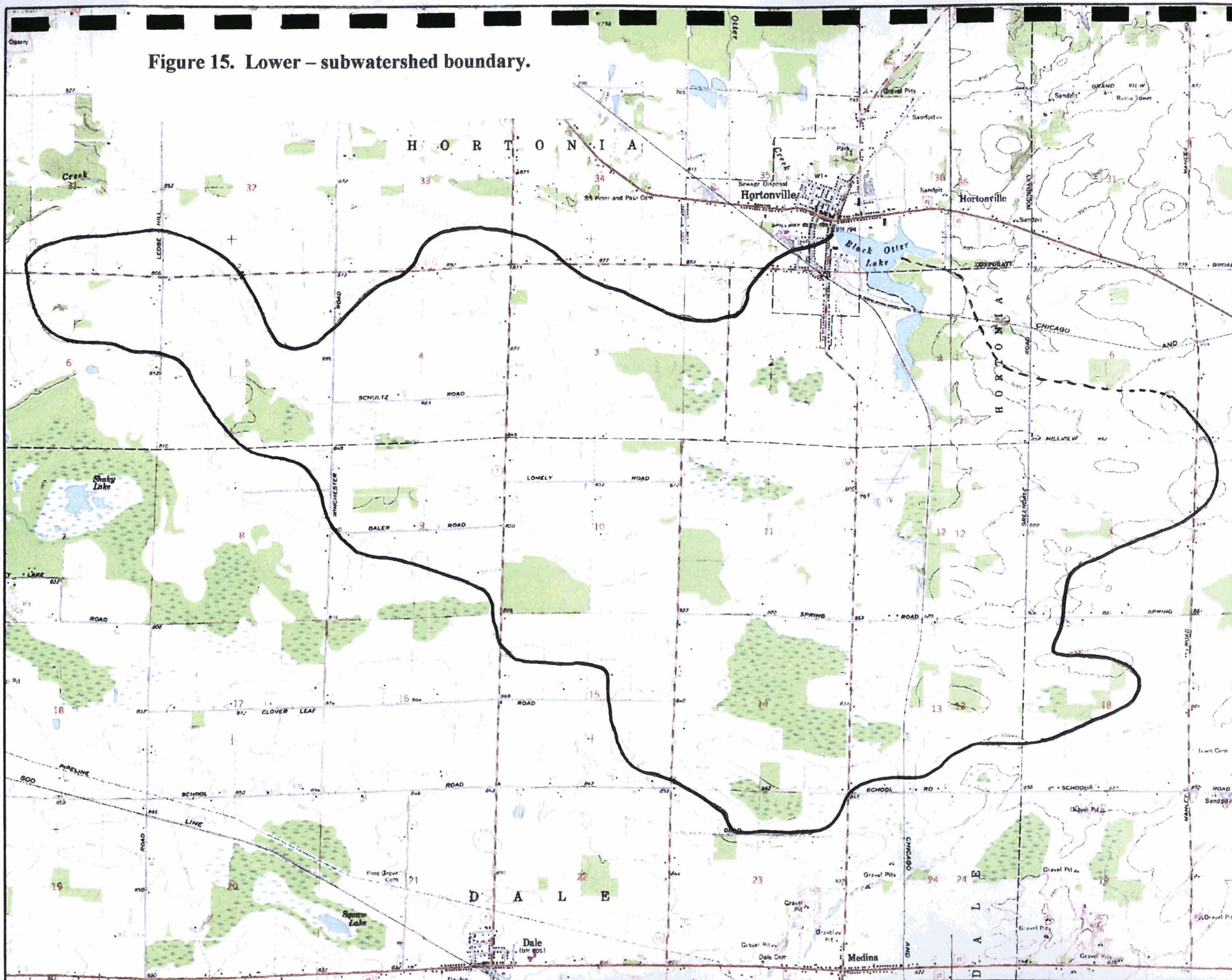


Figure 15. Lower – subwatershed boundary.



6.0 Conclusions and Recommendations

The following management recommendations have been indicated by the results of this study:

1. The Black Otter Lake District should continue to use treatments with 2,4D herbicides for control of Eurasian watermilfoil.
2. The Lake District should implement a treatment program directed a providing long-term control of curly-leaf pondweed.
3. The Lake District should contract treatment of duckweed and algae as needed.
4. The existing program of harvesting nuisance native macrophytes should be continued.
5. The existing aeration system should be retrofitted and expanded to provide lake-wide aeration.
6. The Lake District should encourage or require owners of residential properties with drainage into Black Otter Lake to discontinue use of lawn fertilizers or to use zero-phosphorus fertilizers.
7. The Lake District should continue to support implementation and enforcement of new construction site erosion control Best Management Practices.
8. The Lake District should support local units of government in improving stormwater management and enhancing erosion control measures in the upper-subwatershed.
9. The Lake District should encourage development of projects that prevent direct runoff into Black Otter Lake, such as wetland detention ponds, in the upper-subwatershed, and in new construction projects in the mid-subwatershed.
10. The Lake District should encourage awareness of conservation programs among landowners in the watershed.
11. The Lake District should enlist volunteers, school groups or consultants to annually monitor lake water quality and exotic plant distribution.
12. A future comprehensive lake survey should be scheduled after implementation of these recommendations to assess their effectiveness.

6.1 Eurasian watermilfoil control

Control of Eurasian watermilfoil will play a vital role in maintaining recreational uses, water quality and lake ecology. The treatments conducted in 2000 with granular 2,4D (Navigate®) were effective and provided long-term control. This method of controlling Eurasian watermilfoil should be continued. If dense, monotypic stands of Eurasian watermilfoil reappear in Black Otter Lake, their locations should be mapped, and acreage

inaccurate b/c EWM 19% of transects in 2002 determinations should be made. Treatment permits should be sought from the DNR, and treatments should be conducted in a timely manner. Treatment rates should not exceed 100 lbs./acre to maintain species selectivity. Ideally treatments will be done while Eurasian watermilfoil is in early growth stages to reduce water quality impacts. Mechanical harvesting should not be done in Eurasian watermilfoil beds. If adequate control of Eurasian watermilfoil cannot be achieved through herbicide treatments, the Lake District should consider conducting a lake drawdown to control the plant.

Drawdown

6.2 Curly-leaf Pondweed Control

Control of curly-leaf pondweed should be a priority item for Black Otter Lake during 2003. Control of this plant should reduce internal nutrient cycling and resultant algae blooms, improve navigation and encourage native plant recovery. Control of curly-leaf pondweed should be accomplished by large-scale treatment with the herbicide Aquathol®. Target application rates should be 0.75 – 1.5 ppm to ensure species selectivity. Treatments should be done when water temperatures are between 50 - 60° F, before turion production occurs, so that long-term control can be achieved. Regrowth should be retreated annually until curly-leaf pondweed can be maintained at les than 10% of its 2002 frequency. DNR permits for large-scale treatments will be required, and should be applied for in advance.

6.3 Duckweed and Algae Control

The extremely poor water quality conditions that occurred in Black Otter Lake during 2002 were largely the result of abundant algae and duckweed growth. Improving nutrient controls in the watershed, reducing internal nutrient cycling through control of exotic species, and improving aeration–circulation in the lake will all provide long-term solutions to the duckweed and algae problem. However if excessive growth periodically reoccurs, it will be beneficial to provide short-term control using algaecides and herbicides. In this manner, the cascading effects on water quality and lake ecology can be avoided. Growth of algae and duckweed is normal and can be expected in the shallow, remote portions of the lake. Control actions should be taken when these plants form dense mats in waters deeper than four feet, and in high-use areas along residential frontages. DNR permits will be required.

No bk treatments ineffective

6.4 Weed Harvesting

Because Black Otter Lake is a shallow impoundment~~, it will likely con~~tinue to have nuisance macrophyte growth. The best option for improving

Is this overall 7.7.

navigation and recreation while maintaining native plant diversity, habitat and water quality values will be mechanical harvesting. Therefore this program should be continued on Black Otter Lake. Weed harvesting will also play a vital role in maintaining the efficiency of the aeration system. Dense macrophyte growth around diffusers severely limits water circulation and oxygen transfer. Weed harvesting should be limited to areas greater than four feet deep. All cut plant matter should be removed from the lake and disposed of in a location that does not have direct drainage back into the lake. DNR permits are required.

6.5 Aeration System Upgrade

An aeration system was initially installed in Black Otter Lake to prevent winter and summer fish kills in order to maintain a viable sport fishery. The system has generally been successful in accomplishing this task. However partial summer fish kills occurred in 2002 and much of the lake was anoxic during the warmer months. During this time of year it was found that oxygenated water did not extend very far from the diffusers.

When an aeration system is capable of mixing oxygenated water throughout a lake a number of improvements can occur, including reduced algae growth, improved water clarity and reduction of organic sediments. These improvements occur primarily by meeting bacterial oxygen demands. Adequate oxygen supports large bacteria populations that effectively compete with algae for available nutrients. It also allows bacteria to digest organic sediments and suspended organic matter. These improvements are likely to occur in Black Otter Lake with a lake-wide aeration system. An added benefit would be increased surface disturbance that makes conditions unfavorable for duckweed growth.

The existing aeration system in Black Otter Lake employs nine Mix Air Tech® TB16 diffusers. These diffusers are powered by one 1 HP and one ¾ HP rotary vane compressor, and one ¾ HP piston compressor. Using lake volume calculations and the inversion data for the TB16 diffusers, a 30 diffuser system would be capable of aerating the entire lake, and would provide better than 0.5 whole lake inversions per day. A map of recommended diffuser placement is shown in **Figure 16**. Recent advances in air motor technology would allow this entire system to be powered with one 2 HP and one 3 HP regenerative blower. While this system will be capable of providing significant water quality improvements for Black Otter Lake, its success will rely on an aquatic plant management program. If dense weed growth is allowed to form around diffusers, their effectiveness will be greatly reduced.

6.6 Lawn Fertilizer Use

Elevated nitrate + nitrite levels were found at the south inlet. This may indicate a nearby source of nutrient contamination. A likely culprit is the residential neighborhoods that exist nearby. The most likely source is lawn fertilizer runoff. Since Black Otter Lake was found to be phosphorus limited, lawn fertilizers containing zero-phosphorus could be used without impacting the lake. Therefore the Lake District should encourage or require owners of residential properties with drainage into Black Otter Lake to discontinue use of lawn fertilizers or to use zero-phosphorus fertilizers.

6.7 Construction Site BMP's

Residential land uses typically have higher nutrient exports than other land use types. Developing residential areas have the highest nutrient exports of any land use type. With considerable new home construction occurring in the Black Otter Lake watershed, it is imperative that construction site Best Management Practices (BMP's) be used. The Lake District should continue to support implementation and enforcement of new construction site erosion control BMP's.

6.8 Stormwater Management

The high level of pollutants entering the lake from the north inlet emphasizes the need for improved stormwater management in the upper-subwatershed. While some direct drainage will be unavoidable, it may be possible to divert some stormwater to detention or infiltration sites. drainages in the upper- and mid-subwatersheds found to have eroded banks should also be stabilized. Any new residential or commercial developments in the watershed should incorporate features, such as stormwater wetlands and detention ponds, which prevent direct runoff. These programs would likely result in significant lake water quality improvements. The Lake District should encourage and cooperate with local units of government as well, as real estate developers, in developing better stormwater management practice and erosion control measures in these subwatersheds.

6.9 Conservation Programs

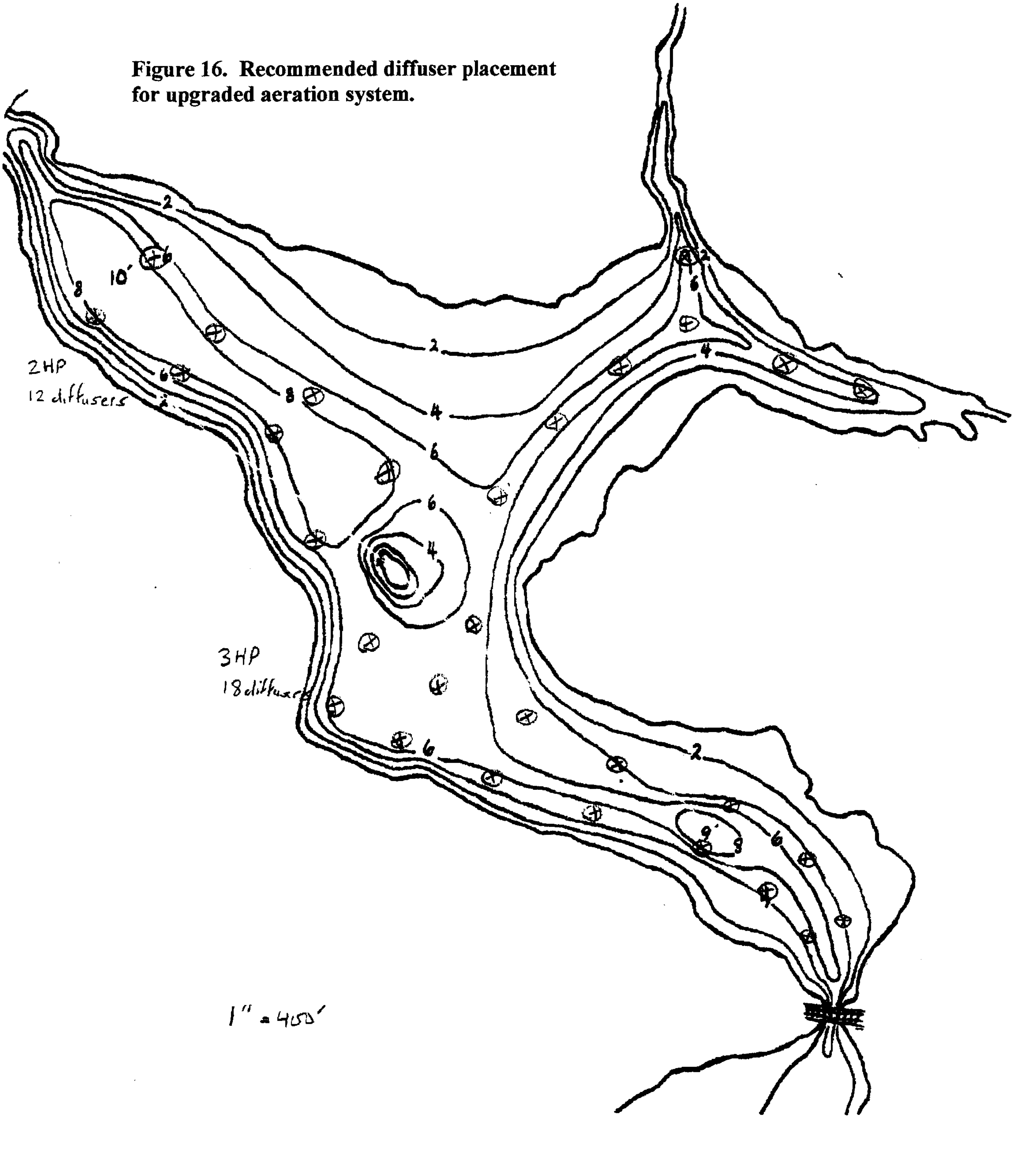
One of the greatest benefits to water quality in agricultural areas has been the Conservation Reserve Program (CRP). This program provides financial incentives to farmers who set aside erodeable croplands, and allow them to revert to natural vegetation. Many similar programs exist that are suited to different land uses and acreages. The Lake District should encourage efforts to make landowners in the watershed aware of these programs.

6.10 Future Lake Monitoring

The success of any lake management effort will depend upon an active monitoring program. A monitoring program will provide information needed to assess effectiveness and to fine-tune management efforts. With regard to Black Otter Lake, periodic monitoring of the plant community will be essential. Regular water quality monitoring should also be done. The Lake District should enlist the help of volunteers, school groups or lake management consultants to conduct annual lake monitoring. Financial assistance is available through the DNR's Self Help Lake Monitoring Program.

Another comprehensive lake survey should be conducted on Black Otter Lake within the next ten years. This survey should evaluate the effectiveness of lake management efforts and form the basis of an updated lake management plan.

Figure 16. Recommended diffuser placement for upgraded aeration system.



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