LPL-407

MUSKELLUNGE LAKE
LINCOLN COUNTY
LAKE PLANNING GRANT REPORT

INVENTORY & RECOMMENDATIONS

COMPLETED BY

MUSKELLUNGE LAKE
PROTECTION & REHABILITATION DISTRICT

AND

RAND ATKINSON
AQUATIC RESOURCES, INC.
BIRNAMWOOD, WISCONSIN

IN COOPERATION WITH

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
LAKE PLANNING GRANT PROGRAM

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INTRODUCTION

Muskellunge Lake is a 167 acre soft water drained lake located in north central Lincoln County. The deepest depth of approximately 25 feet is found in the north bay and several other deep holes of 20 feet are found throughout the lake. Most of the shoreline is steeply sloped as sand and gravel shallows quickly drop off to deep water. The water is clear in spring and early summer and submergent aquatic plants grow to a depth about 11 feet around the perimeter of the lake. Floating and emergent aquatic plants are abundant in the shallow bays of Muskellunge Lake. Late summer brings algae blooms to the lake reducing water clarity.

A small unnamed creek enters Muskellunge Lake from a wetland complex to the northeast. This wetland complex originally connected Bridge and Muskellunge lakes before being isolated by road construction. Muskellunge Creek leaves the lake from the southwest and travels approximately 4 miles before entering the Wisconsin River at Tomahawk. Rice Reservoir's Bridge, Deer, and Nokomis lakes are located immediately to the north.

The largest area of the watershed extends east and southeast of Muskellunge Lake. Steep-sloped hills formed on end moraines of the last glacial are found on the eastern edge of the watershed. A large forested wetland complex is also found east of the lake and a second open wetland is found northeast of the lake. STH 51 now divides the watershed with the glacial hills and forested wetland complex located east of the four lane highway. Much of the immediate shoreline and surrounding land is forested except several agricultural fields can be found south of the lake.

Most of the shoreline has been developed with 65 dwellings identified in a 1979 study. Much more of the shoreline and watershed has been developed and existing dwelling use has probably increased since that time. State highways 51 & 8 and their connecting intersection have been enlarged and improved in close proximity to the lake - a new 4-lane Tomahawk bypass will be constructed in the near future further severing the eastern watershed area from the lake.

An extensive lake study was completed in 1978 & 79 by the Muskellunge P & R District and Northern Lake Service, Inc. in cooperation with the DNR Office of Inland Lake Renewal. The study addressed water chemistry & budgets, watershed boundaries & usage, and ground water flow and septic interactions. A sediment profile and aquatic plant survey was also a part of this inventory. Three categories of management alternatives were recommended in a 1981 report: 1.) nutrient & erosion control in the watershed, 2.) in lake weed reduction, and 3.) aeration.

Aquatic nuisance control treatments on select shoreline areas were conducted from 1974 through 1989. Limited aquatic plant harvesting by a small harvester was utilized from that time until 1994 to remove abundant aquatic plants in several areas of the lake.

Fisheries surveys were completed in 1979,1981,1986, and 1994. Northern pike and bluegill are the dominant game fish and panfish, respectively. Recent stocking efforts have keyed on increasing the muskellunge and walleye populations.

The Muskellunge Lake P & R District is concerned with changes that have occurred in the aquatic resources in recent years and are looking for current management strategies and methods to understand and cope with these changes. They recognize the problems that are associated wih the abundance of aquatic plants and the potential effects on an overabundance of bluegill. Much of the deep water areas are void of oxygen during the growing season and in late winter. Partial winter kill occurred in the past. These biological and physical limitations greatly effect the establishment and maintenance of a fisheries as well as contribute to other water quality problems. Major changes in the watershed have occurred with the development and improvements in state highways 51 & 8 the last ten years and further develop along these transportation corridors will further impact watershed water quality. The Muskellunge Lake P & R District would like to address these issues by gathering current resource data, comparing it to the 78 & 79 inventories, and updating the management alternatives to deal with them.

Acknowledgements

Lake planning is a complicated process of taking existing knowledge on a lake, adding missing knowledge, and using this knowledge to make good decisions for the health of the lake. The formidable task cannot be done effectively or economically without partners in the lake management process.

Muskellunge Lake is fortunate in having an intensive study of the lake completed in 1978-79 that could be used in comparison to the current inventory. We must be appreciative of those who formed the lake district at that time and the government and private resource individuals that completed this earlier inventory.

To meet the objectives of the planning grant current knowledge was gathered by the consultant and lake volunteers. Lake District residents stepped forward to help in anyway they could. A very special thanks to to KEN & LYNN KENWORTHY who led the coordination of lake volunteers to take additional water clarity observations and gather fish scales. A thanks to AL ERDMAN and KEITH JENSEN who spent the summer of 1997 collecting extra secchi disc readings in three different bays. A thanks also to the many fisherman that collected scale samples and data from fish that they caught in 1997.

A special thanks to HARRY & NANCY GLADWIN who assisted the consultant in so many ways. Harry was the safety and technical repair man on many of the oxygen/ temperature profiling dates on open water and on thin ice. His humor and questions kept you smiling and on-your-toes. Nancy was always there with the hospitality and a warm cup of coffee. Also thank you Harry for the observation plane ride and the saved time and expense to detect obstructions in Muskellunge Creek.

A thank you must also go out to Muskellunge Lake District members who contributed funds through their assessments for this project. Also thanks to Wisconsin DNR personnel - especially BOB YOUNG - that reviewed this project and excepted it for grant funding.

LAND RESOURCES OF THE MUSKELLUNGE LAKE WATERSHED

Geology

The movement and melting of three different ice sheets from the last glacial advance created diverse topographic features and soil types in a relatively small area around Muskellunge Lake. These three different ice sheets created differences in lakes, ponds, and marshes in the watershed. Muskellunge Lake is the only lake in the immediate area with steep shoreline areas around most of the lake - a characteristic separating it's specific glacial origin from other nearby lakes.

A review of the glacial history as presented in the recently completed soil survey of Lincoln County indicates that the three unique glacial ice sheets (sub lobes) from the Wisconsin Valley Lobe and one ice sheet from the Langlade Lobe of the Late Wisconsin Glacier covered the area of Muskellunge Lake and it's watershed about 15,000 to 18,000 years ago. See **FIGURE 1**. The result was that different glacial sub lobe deposits covered other earlier glacial sub lobe deposits in the area of Muskellunge Lake.

First, a brown glacial till ice sheet traveling from the northwest to the southeast carried gravelly sandy loam with clay,cobbles and gravel to an area west of Muskellunge Lake. Glacial till is unsorted, non stratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacier ice. Streams flowing from this melting ice sheet carried mostly brown sandy deposits to where Muskellunge Lake is today.

A second red till ice sheet containing mainly loamy sand & sand with a small amount of clay flowed south around the brown till ice sheet on the west side of Muskellunge Lake.

About 14,500 years ago a third ice sheet from the Langlade lobe came from the Northeast and deposited sand loam soils in an area south of Muskellunge Lake and in the eastern end of Muskellunge Lake's watershed. Both the red till soils from the Wisconsin Valley Lobe and the Langlade till soils are described to be found west of Smith Lake located just south of Muskellunge Lake.

As these ice sheets retreated melt water also deposited outwash in the morainic areas as the glacial front fluctuated. Glacial outwash is gravel, sand, and silt that is commonly stratified and deposited by glacial melt water. Muskellunge Lake area is one of these morrainic areas. The result is a landscape of small outwash flats intermixed with swells and hills of outwash, washed-veneered till, and till. It is these types of deposits that formed the hills and slopes that we see today around Muskellunge Lake. Some of the poorly washed sediments within these moraines are probably mud flow materials or materials that washed off the steep slopes resulting from differential melting of buried ice during the post glacier period.

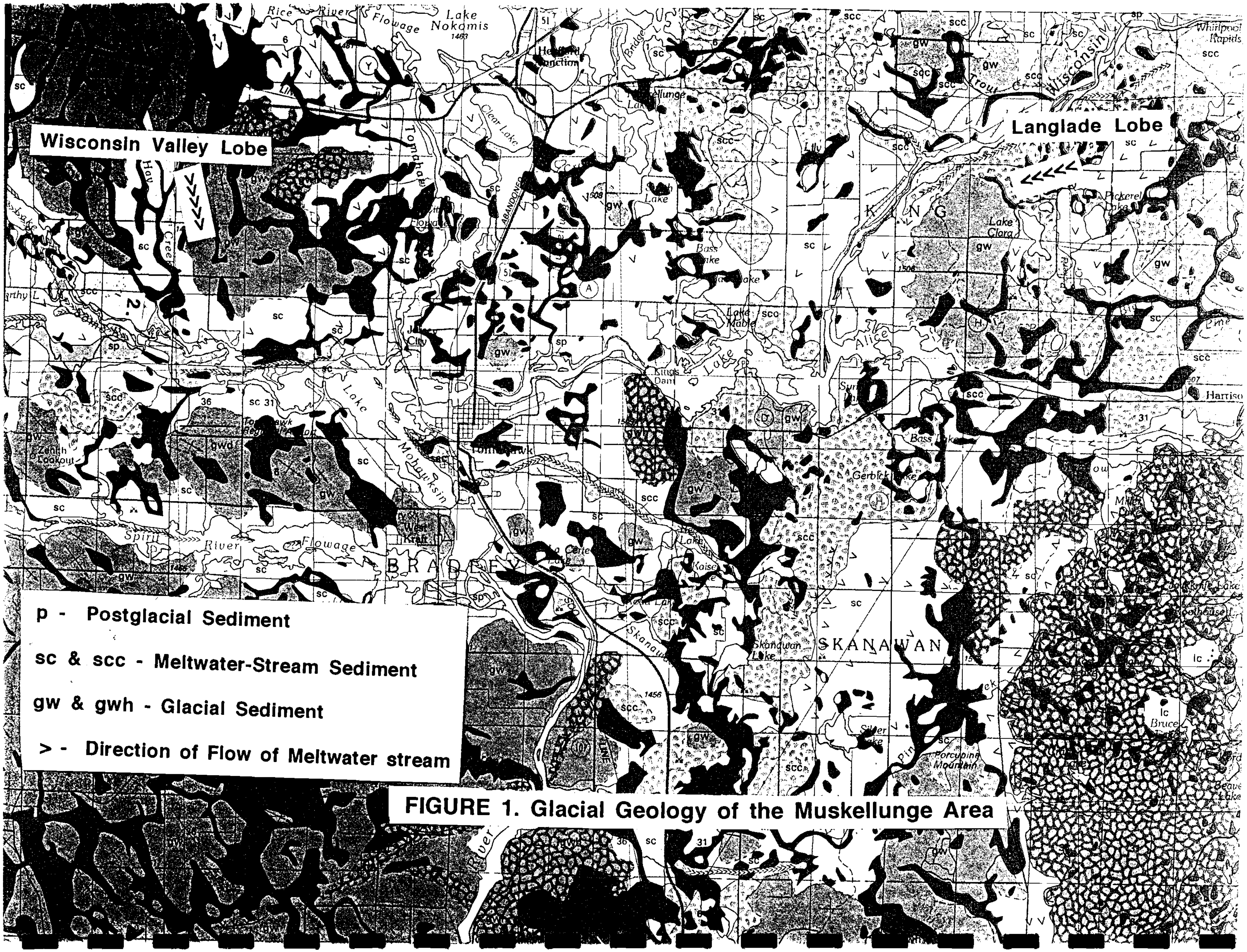


FIGURE 1. Glacial Geology of the Muskellunge Area

Melt water from the retreating ice sheets also buried or veneered the subglacial drumlins with outwash. Drumlins are low, smooth, elongated oval hills, mounds, or ridges of compact drift. The longer axis is parallel to the path of the glacier and commonly has a blunt nose pointing in the direction from which the ice approached. These drumlins can be found east and northeast of Muskellunge Lake and indicate the direction of the retreat of the Langlade Lobe of the last Wisconsin Glacier from the Muskellunge Lake Watershed.

Soils

The surface soils that surround Muskellunge Lake hillsides are in the Vilas-Sayner soil complex and were developed in sandy outwash from the last retreating ice sheet. This sandy outwash from the last retreating ice sheet covered deeper Keweenaw till that has have been described earlier. See the soil symbols VsB, VsC, and VsD for this complex in **FIGURE 2** and **TABLE 1a & 1b**. The B, C, & D symbols represent slope of 1 to 6%, 6 to 15%, and 15 to 35%, respectively.

These soils are mostly coarse sand and all excessively drained. Therefore, they readily absorb but do not adequately filter the effluent from septic tanks or other pollution sources. This poor filtering capacity may result in pollution of ground water - which flows to the surface water of Muskellunge Lake. This same excessively drained soil characteristic affects it's water holding capacity which in turn limits it's natural fertility for growing any type of plant.

A ground cover on this soil is essential in controlling soil blowing and water erosion. Any exposed soil during storm events and spring thaw , especially on the steep slopes of the shoreline of Muskellunge Lake, can be washed into the lake. Establishment of grass is very difficult during dry periods even with the addition of fertilizers and nutrients due to the low available water content of this soil.

These soil are, however, suited for trees and woodlands. The mature timber stands are mostly red maple, northern red oak, paper birch, eastern white pine, and red pine; but jack pine, balsam fir, and quaking aspen are in most stands. The ground flora includes blueberry, bracken fern, wintergreen, bigleaf aster, beaked hazelnut, grasses, barren strawberry, American starflower, wild sassaparilla, blackberry, wild strawberry, and pipsissewa. Canada mayflower, yellow beadlily, and rosy twisted stalk are the ground cover on the more productive soils.

The canopy created by the mature forest is important in providing an umbrella to slow heavy rains from reaching the forest floor and beginning water erosion. Cutting of this canopy on the steep slopes of the Muskellunge Lake shoreline to create a view can be disastrous due to this potential for water erosion. This same canopy shades and cools these droughty soils below which in turn provides better habitat for the survival of tree seedlings and ground cover plants . South and west exposures on steep slopes are especially vulnerable to drying of the soil.

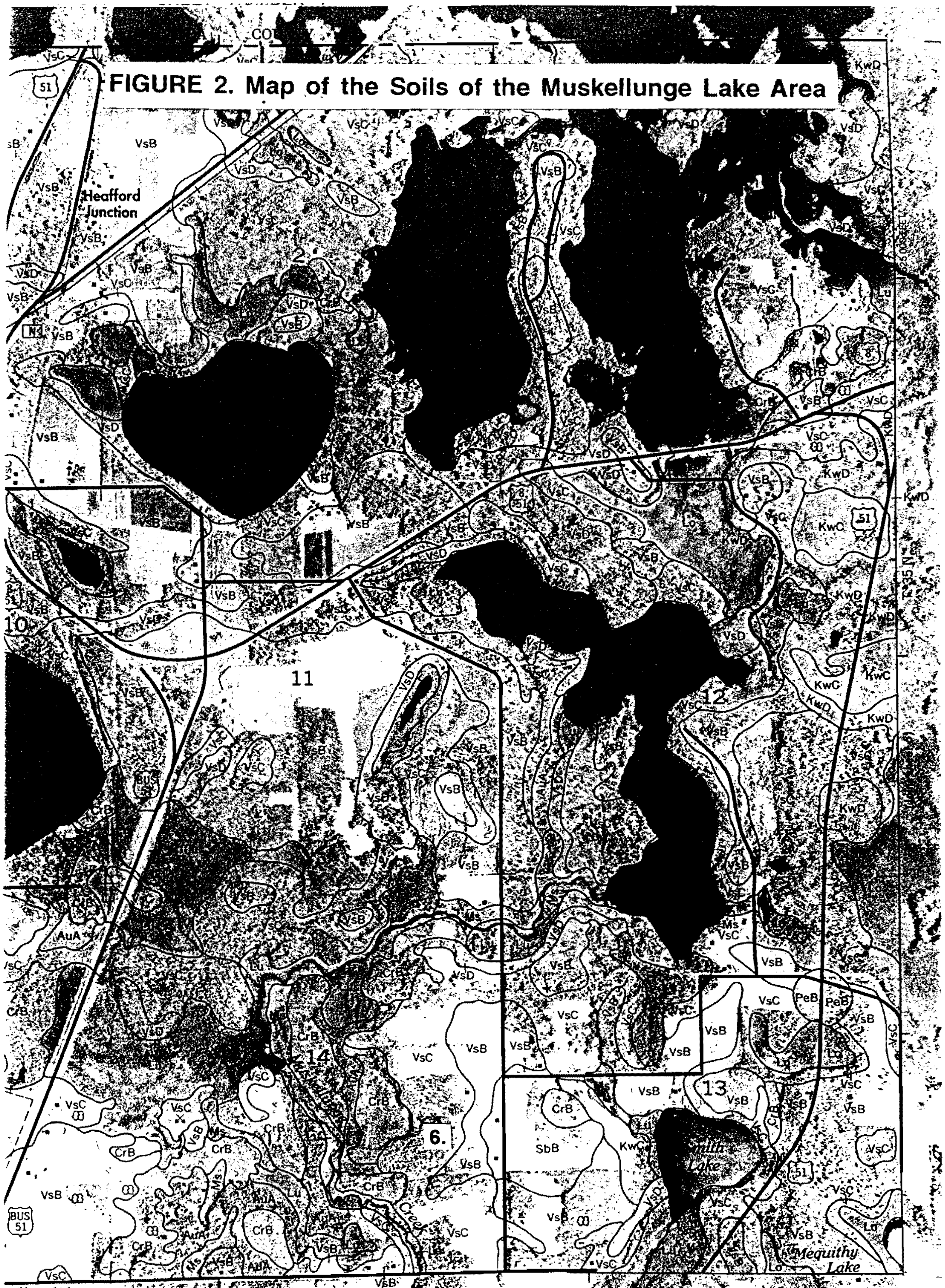
Table 1a & b . Muskellunge Lake Watershed Soils

SOIL NAME	Vilas-Sayner	Vilas-Sayner	Vilas-Sayner	Lupton,Cathro	Minoqua &	AuGres
	Complex	Complex	Complex	&MarkeyMucks	Capitola Mucks	Loamy Sand
SYMBOL	VsB-400B	VsC-400C	VsD-400D	Lu-900	Ms-910	AuA-402A
COMPONENT	Sayner	Sayner	Vilas	Markey	Capitola	AuGres
NAME						
Surface	0-5"	0-5"	0-15"	0-36"	0-5"	0-5"
	Loamy sand	Loamy sand	Loamy Sand	Muck	Muck	Loamy sand
					5-7"	
Subsoil	5-32"	5-32"	15-30"	36-60"	Silt	5-21"
	Loamy Sand to	Loamy Sand to	Sand	Fine Sand or	7-22"	Sand to
	Sand to	Sand to		Gravelly/	Loamy Sdy Lm	Loamy Sand
	Gravelly Sand	Gravelly Sand		Loamy Sand	22-33"	
					Fine Sdy Lm to	
Substratum	32-60"	32-60"	30-60"		Gravly Sdy Lm	21-60"
	Stratified	Stratified	Sand		33-60"	Sand
	Sand & Gravel	Sand & Gravel			Fine Sdy Lm to	
					Gravly Lmy Sd	
Slope	1-6%	6-15%	15-35%	0-2%	0-2%	0-3%
Septic Tank	Severe	Severe	Severe	Severe	Severe	Severe
Absorp.Field	-Poor Filter	-Poor Filter	-Poor Filter	-Percs Slowly		-Wetness
			-Slope	-Ponding		-Poor Filter
Daily Cover		Poor	Poor	Severe	Poor	Poor
for Land Fill		-seepage	-seepage			-Wetness
		-too sandy	-too sandy			-Too Sandy
		-small stones	-slope			-Seepage
Shallow		Poor	Severe	Severe	Severe	Severe
Excavations		-Cutbanks Cave	-Cutbanks Cave			
Dwllngs/Bldngs			Severe	Severe	Severe	Severe
			-Slope			
Streets/Roads			Severe	Severe	Severe	Severe
			-Slope			
Lawns/		Severe	Severe	Severe	Severe	Severe
Landscaping		-Droughty	-Slope			
Sm Commercial			Severe	Severe	Severe	Severe
Bulidings			-Slope			
Location on	Middle Bay	North Bay NE,	N. Bay N & NE	N.BayW.Wtlnd	SBay E.Wtlnd	M.Bay East
Lake	SW Point	MidleBayNE,SE	N. BayS.Points	M.BaySW.Wtlnd		
		SBayW,SW&E,E	M. Bay N Point	SBay S.Wtlnd		
			M. Bay East	Outlet area		
Characteris-	-Excessively	-Excessively	-Excessively	-Very Poorly	-Very Poorly	-SWhat Poorly
tics	Drained	Drained	Drained	Drained	Drained	Drained
	-Not Highly	-Pot. Highly	-Pot. Highly	-Organic	-Muck+Loamy	-Inclusions of
	Erodible	Erodible	Erodible	-Hydric	-Hydric	Hydric Soils

Table 1a & b . Muskellunge Lake Watershed Soils

SOIL NAME	Loxley &	Keweenaw	Keweenaw			
	Dawson Peats	Sandy Loam	Sandy Loam			
SYMBOL	Lo- 930	KwC-520C	KwD-520D			
COMPONENT	Dawson	Keweenaw	Keweenaw			
NAME						
Surface	0-8"	0-4"	0-4"			
	Peat	Sandy Loam	Sandy Loam			
		4-20"	4-20"			
Subsoil	8-40"	Lmy F. Sand to	Lmy F. Sand to			
	Muck	Grvly Lmy Snd	Grvly Lmy Snd			
		to Sand	to Sand			
		20-43"	20-43"			
		SandtoLmyF.Sd	SandtoLmyF.Sd			
Substratum	40-60"	toGrvlyLmySnd	toGrvlyLmySnd			
	Sand to	43-60"	43-60"			
	Grvly Snd to	F.SndyLm to	F.SndyLm to			
	V.Grvly-VFnSd	Sndy Lm to	Sndy Lm to			
		Grvly Lmy Snd	Grvly Lmy Snd			
Slope	0-2%	6-15%	15-35%			
Septic Tank	Severe	Moderate	Severe			
Absorp.Fields		-Slope	-Slope			
		-Percs Slowly				
Daily Cover	Poor	Poor	Poor			
for Land Fill		-Seepage	-Seepage			
		-Small Stones	-Small Stones			
			-Slope			
Shallow	Severe	Severe	Severe			
Excavations		-Cut banks	-Cutbanks Cave			
			-Slope			
Dwllngs/Bldr	Severe	Moderate	Severe			
		-Slope	-Slope			
Streets/Roa	Severe	Moderate	Severe			
		-Slope	-Slope			
Lawns/	Severe	Moderate	Severe			
Landscaping		-Lrg Stones	-Slope			
		-DroughtySlope				
Sm Commerc	Severe	Severe	Severe			
Bulidings		-Slope	-Slope			
Location in	Marsh Connect.	Trmnl Morraine	Trmnl Morraine			
Watershed	to Bridge Lake	Till E. of STH51	Till E. of STH51			
	-Lrg Wetland W					
	of STH 51					
Characteris-	-v.poorly drned	-well drained	-Well Drained			
tics	-extremelyacid	loamy soil w/	Loamy Soil w/			
	organic soil	Sandy Glacial	Sandy Glacial			
	-Hydric	Till Beneath	Till Beneath			
		-pot.H.Erodable	-HghlyErodable			

FIGURE 2. Map of the Soils of the Muskellunge Lake Area



These soils are poorly suited to local roads especially on the slopes. Land shaping is needed to reduce the slope, or the road can be built on the contour. But the substratum soil often exposed by road building is very droughty and difficult to vegetate which leads to soil caving and erosion.

There are four wet soil areas on the immediate shoreline of Muskellunge Lake. See **FIGURE 2** .These wetland areas are composed of muck soils either named the Lupton, Cathro, & Markey Mucks using the soil symbol Lu or Minoqua & Capitola Mucks using the soil symbol Ms. Muck is dark, finely divided, well decomposed organic soil material. The Lu wet soil that is usually over 3 feet deep is excellent for growing a variety of aquatic plants used by fish, waterfowl, and the organisms they feed on. The presence of this well decomposed soil indicates that an abundance of minerals and oxygen are available for decomposition of organic matter. The Ms mucks are more mottled with mineral soil and silt loams and are usually found in areas where water flows and spring seepage is greater.

A long, low flat drainage way of wet loamy sand connects the west central bay of Muskellunge Lake to Muskellunge Creek. Dereg Road crosses this drainage way near the resort entrance. The soil symbol for this area is AuA, for Augres loamy sand. This poorly drained soil can supports trees but rooting depth is limited and wind thrown trees are common.

Peat and sandy loam soils are found in the watershed to the north and east . A spring from a peat soil area to the north enters Muskellunge Lake in the east bay through upland soils. This spring flow year round.

Watershed Characteristics and Land Use

Muskellunge Lake watershed is a sub watershed of the Wisconsin River. Muskellunge Lake is located at the head waters of this sub watershed with Muskellunge Creek leaving the lake and traveling over 5 miles before entering the Wisconsin River between King's Dam and the business STH 51 bridge in Tomahawk. Along this route Muskellunge Creek crosses 4 town roads and County Highway A. This route is bordered by many open and forested wetland areas as well as uplands with very porous soil that drain to and increase the flow of Muskellunge Creek.

The highest elevation in the watershed is at 1800 feet above sea level and located in the high hills southeast of the lake. Muskellunge Creek drains into the Wisconsin River at a normal elevation of 1435.4 feet above sea level. Muskellunge Lake is at an elevation of 1463 feet above sea level. The small stream that enters Muskellunge Lake east bay drains from a north wetland that at one time before the construction of Cottage Road was attached to Bridge Lake and the Lake Nokomis (Rice Reservoir system). The Rice Reservoir system is operated at an elevation of 1,450 feet above sea level during the winter drawn down of 12 feet. By June 1, this reservoir is raised to a 1463.25 which approximately the same level as Muskellunge Lake.

Watershed boundaries are identified in **FIGURE 3**. Land use in the watershed is as follows:

Land Use Type	Acres	% of Watershed
Forestry	651.50	59%
Wetland	266.25	24%
Low Development	125.00	11%
Pasture or Cover Crop	54.50	5%
Farm steads & Roads	13.00	1%
	1,109.25 acres	

State Highway 51 crosses the watershed for 1.1 miles through wetland and forest. Total loss of wetland and forest from the construction of this road and right-of-ways is approximately 30 acres. Culverts beneath the STH 51 road bed were placed so the invert (bottom) elevation was at the surface elevation of the wetland. Therefore only storm and spring runoff waters would pass under the road but the lateral movement of water in the wetland would be interrupted by the fill. This effects the hydrology or movement of water and nutrients that would effect the ecology of a much larger area of wetland.

In the defined watershed of Muskellunge Lake described in **FIGURE 3**, many small above ground water inflows in shallow wetlands have been interrupted by the new four lane. A much deeper marsh (32' deep according to DOT engineering plans) that probably intercepts ground water just southeast of Muskellunge Lake but not within the Muskellunge Lake watershed boundaries was filled in during the construction of the four lanes. A year round spring flows into Muskellunge Lake on the south end of the South bay or seepage into the lakes bottom could be effected by this filled wetland.

The largest continuous wetland and upland forests in the Muskellunge Lake watershed has been cutoff from the lake area by this four lane development. This physical barrier probably has little measurable effect on surface water runoff to Muskellunge Lake because existing tree canopy, vegetation cover, and porous upland soils in this area of the watershed limits the amount of surface movement of water towards the lake. The largest tract of this upland forest is owned by industrial forest concerns. This four lane highway does isolate and sever the corridors for wildlife between these large tracts and the lake community.

But, ground water movement in this cutoff area and in the watershed not cutoff by both STH 8 and 51 can be effected by ground water pollution from the surface. The soils are not suited for filtering the chlorides or volatile fluids from highway development from entering the ground water and moving towards Muskellunge Lake. The vegetative ground cover and and decomposing organic surface layer on top of the soil are the first barriers in preventing these pollutants from entering the ground water.

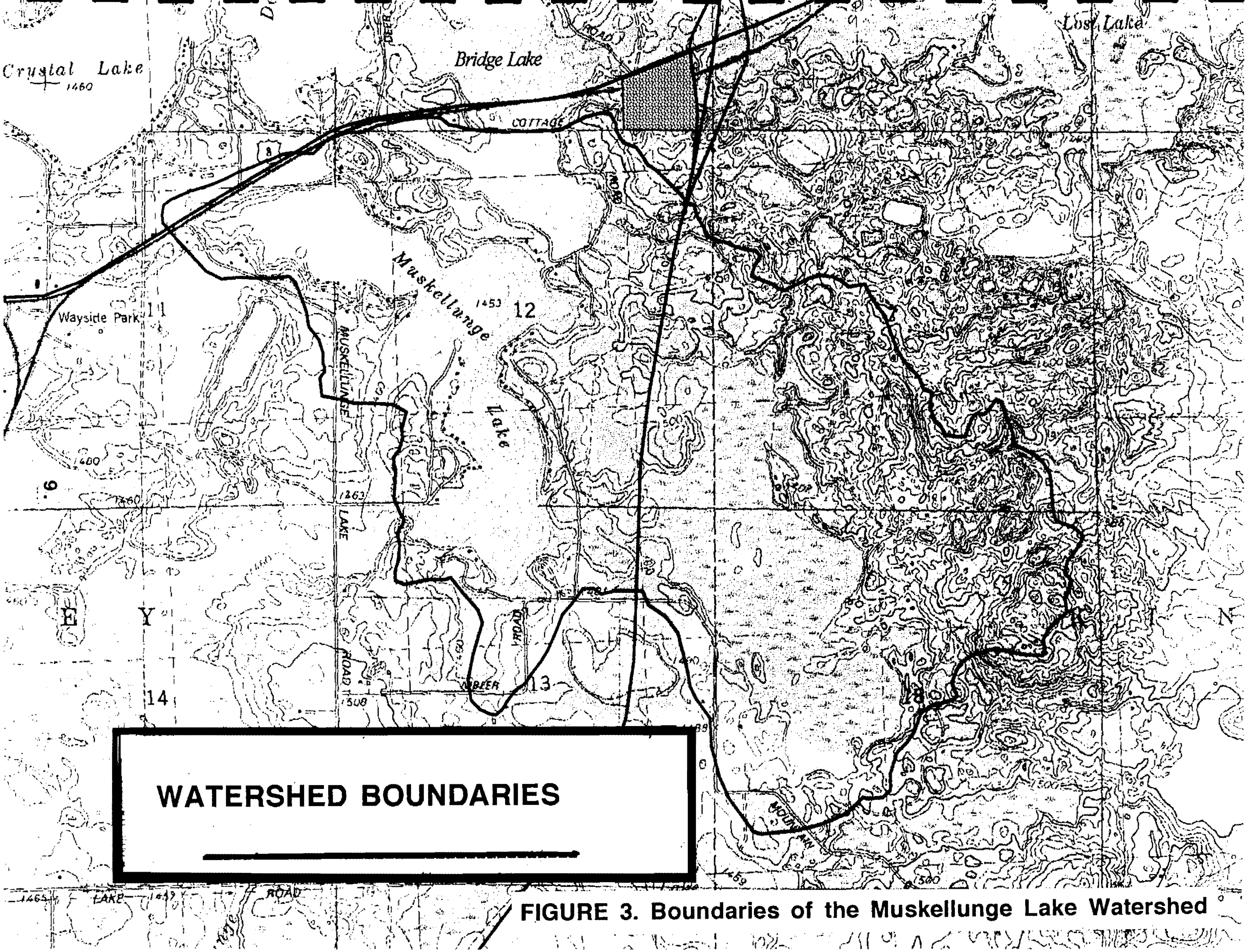


FIGURE 3. Boundaries of the Muskellunge Lake Watershed

All the agricultural land in the watershed in 1996 were in pasture or had a cover crop of alfalfa or grass. These lands are found on fairly level open field with Vilas-Sayner complex soils. Again, the soil characteristics of these agricultural lands in the watershed are affected by their poor water holding capacity which in turn limits it's natural fertility for growing any type of plant.

Land use in the immediate watershed surrounding Muskellunge Lake is primarily light residential but two private campgrounds are also found on the lake. Most of the land adjoining the lake slopes towards the lake at an angle from 7- 35%. These steep angles combined with the characteristics of the light soils above have increased erosion of shoreline soils into the lake where the native tree canopy and ground cover have been removed for viewing the lake or for construction.

PROPERTY OWNER'S SURVEY & RESULTS

A property owner's survey was mailed to the Muskellunge Lake District members with the spring of 1998 newsletter to assess current lake use and gather opinions on the lake's problems and possible solutions to them. The survey can be found in in Appendix I. Twenty-nine questionnaires were returned.

Results

Question 1 ask" How long have you owned property on Muskellunge Lake?" The answers ranged from 1 to 61 years. The survey represents and wide range of time of ownership. The breakdown was a follows:

Length of Time with Property	# Respondents	%
0-5 years	8	28%
6-10 years	5	17%
11-15 years	0	0%
16-20 years	6	21%
21-25 years	5	17%
25-61 years	3	10%
Left Blank	2	7%

	29	

Question 2 owners were ask to check one of several options that describe their property and dwelling type. The majority of the respondents were year-round residents and in general represented the "newest" members of the lake community. Their responses were as follows:

Dwelling or Property Use Description Respondents (Years owned property)	# Respondents	%
Year-round Home (3,3, 5,8.5,9,9,10,16, 18,19,20,21,25,30.5,24,26,Blank)	17	59%
Three-season Home (4,5,18,22,25,)	5	26%
Summer Cottage (Blank)	1	3%
Winterized Cottage (7,1)	2	6%
Vacant Land (1,2,20,23)	4	14%
Business	(2)*	
	------	
* Double Entry w/ Year Round Home	29	

Question 3 & 4 related to lake property use. These questions gave several options on how often they used their property and how many people used the facility during that period. The options were: Weekends/ year, and Weekdays/ year, & Other. The second question ask how many people,on an average, use the property during the time indicated in the previous question.

The results were interpreted and broken down into categories to describe weekend vs. weekday use. "Other" data was interpreted and added to the other two category data. The "year- round residents" were separated from the other categories from Question 2 to clarify lake use. The results are as follows:

All Other Respondents Except Year- round Home(12 Total)

Weekends / year (ave. people use)		**Weekdays / year (ave. people use)**
39(4)	Three Season Home	25(4)
35(4)	Winterized Cottage	-
26(2)	Three Season Home	183(2)
15(12)	Three Season Home	35(5)
35(4)	Winterized Cottage	25(2)
2(2)	Summer Cottage	2(2)
16(3)	Three Season Home	40(3)
20(3)	Three Season Home	-
-	Vacant Land (acreage)	-
-	Vacant Land (acreage)	-
-	Vacant Land (acreage)	-
-	Vacant Land (acreage)	-
-------------		-------------
Totals **188(34)**		**310(18)**

Number of Year-round Homes
(17 Total)

50 (2?)		221 (2)
52 (2?)		221 (2)
50 (3)		120 (1.5)
50 (2)		260 (2)
20 (22.5)	Campground Occupancy	100 (22.5)
52 (2)		221 (2)
52 (6)		221 (2)
52 (2)		221 (2)
?	Campground Occupancy	?
52 (2)		221 (2)
52 (8)		221 (4)
30 (2)		40 (2)
52 (2)		221 (2)
52 (2)		221 (2)

	40 (2)	20 (2)
	50 (2)	211 (2)
	52 (2)	221 (2)
	36 (2)	120 (2)
	52 (2)	221 (2)
	----------	------------
Totals	**846(69.5)**	**3,523 (58)**

Question 5 related to lake use and recreational value of their Muskellunge Lake property. Respondents were ask to number their priorities 1 to 8 (1 being highest value, 8 being lowest value) on a list of brief recreational descriptions. The response was as follows:

Description	**#1**	**#2**	**#3**	**-**	**#4**	**#5**	**#6**	**-**	**#7**	**#8**
Swimming	4	0	8	-	4	3	3	-	0	0
Pleasure Boating	4	4	3	-	10	4	0	-	1	0
Fishing	6	8	5	-	4	2	1	-	1	1
Duck Hunting	0	0	0	-	0	3	3	-	8	1
Wildlife Viewing	5	6	6	-	1	0	2	-	0	0
Scenic Beauty & Tranquility	15	6	2	-	1	0	6	-	0	0
Water Skiing	0	0	2	-	4	5	8	-	5	0
Jet Skiing	0	0	2	-	1	1	2	-	8	2
<u>Other</u>										
Business	1									

Question 6 ask what type of waste disposal system does your dwelling have? Also questions were ask regarding the age of their waste disposal system and the maintenance that it required. This question was compared with the background information regarding dwelling use in questions number 2 & 3.

Type	No. of Respondents
Septic System	23
None -Vacant Land	3
Extra Potable Out House	1
No Answer	3

Age	
1-10 years	11
11-15 years	2
16-20 years	3
21-25 years	2
26+ years	1
No Answer	6

Maintenance	
Clean Periodically	3
Pumping	3
Pumping 3 Times /Summer	1
Pumping Yearly	4
Pumping Every 2 Years	5
Pumping Every 3 Years	3
No Answer	4
None	2
Not Sure	1

Question 7 related to understanding of ground water table elevations around the Muskellunge Lake through the lake community providing available information regarding well reports.

WELL TYPE	# RESPONDENTS (With Depths)	WELL DEPTHS
Sand Point	15 (9)	22-36' (28' average)
Drilled	9 (6)	45-175'
Static Head from ground surface	2 (2)	67' w/ 15' static head 42' w/ 9' static head

Question 8 ask the lake community" What do you feel is the major problem facing Muskellunge Lake at this time?" The results and comments are as follows:

Problem	# of Responses
Jet Skis (PWC) Unsafe operation, too close to shoreline, too loud	11
No response	11
Too many big boats for small lake	4
Too many weeds in bays	4
Too much muck or organic matter (oxygen demand & lake use)	4
Loons and ducks threatened by jet skis	2
Fishery not maintained	2
Pressure on lake from campground users	2
Jet boat noise and unsafe operation	1
Shoreline erosion	1
Disruption of fish spawning habitat	1
Wildlife habitat areas not protected	1
Slow no wake limit through channel not followed	1
Excess shoreline development and fertilization	1
Lack of landowner cooperation with district	1
Lack of communication between district members	1
Lack of control of shoreline degradation by district	1

It is apparent from this survey that lake use conflicts are a major concern on the lake and voluntary compliance with lake use ordinances and state laws established for safety and to avoid conflict is not working.

Question 9 ask " The fertility of Muskellunge Lake causes many problems for the recreational use of the lake. What priorities would you give to solve, prevent, or keep these problems from worsening?". Several options were listed and the opportunity to add options were offered. The respondents were ask to number the options from 1 to 6 with 1 being highest priority and 6 being the lowest. The results were as follows:

Possible Solutions	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**
Long Term Shoreline Stabilization Restoration, & Protection	12	1	2 -	2	3	1
Machine Harvest of Aquatic Plants	9	6	4 -	3	2	2
Chemical Treatment of Aquatic Plants	2	6	2 -	2	7	5
Dredging/ Removal of Lake Bed Material	8	2	8 -	6	0	2
Lake Aeration	0	5	5 -	10	4	2

Others

-Rely on Scientific Knowledge
-Education of Lake Community on Effects of Current Lake Use
-Establish Quality Fishing
-Periodic Walleye Stocking

WATER RESOURCES OF MUSKELLUNGE LAKE

WATER QUALITY

Introduction

Assessment of the water quality of Muskellunge Lake was made by collecting water quality data using the DNR's Long Term Lake Monitoring Program sampling protocol in 1997. This data was combined with oxygen/ temperature sampling at several locations under the ice and in the drainage system in 1997 and 1998 to understand the rate and extent of oxygen depletion in the system. This information was gathered to assess the feasibility and potential benefits of installing an aeration system. This data was compared with a comprehensive study information gathered in 1978 & 1979 and with fisheries management data collected over the past 40 years.

Procedure

Water quality information of Muskellunge Lake was collected from March 1997 to February 1998. Water chemistry sampling and oxygen/ temperature profiling followed protocol sampling as close as possible. Weekly volunteer secchi disc monitoring information was added to this data during the open water period in 1997 to assess changes in the lake between protocol sampling periods. Secchi disc water clarity sampling was completed in the north, south central , and south bays.

Additional oxygen/ temperature profiling was completed beneath the ice in March 1997 and through the winter of 1997-98. Five of the deepest areas of the lake were sampled as well as the incoming springs. Muskellunge Creek Creek was also sampled at the following road crossings: 1) Muskellunge Road (2x), 2) Moodig Road & CTH A, and 3) Mohawk Drive before entering the Wisconsin River in Tomahawk. Sample locations can be found in **FIGURE 4.**

Results and Discussion

<u>March 31, 1997</u> This additional oxygen/ temperature profiling of Muskellunge Lake was completed to determine the extent of oxygen depletion beneath the ice after a severe winter. The winter of 1996-97 included a extended ice cover and heavy snowfall which can create freeze out winter oxygen conditions. Temperature- oxygen profiling with 2 foot depth intervals from top to bottom was taken at 5 locations on Muskellunge Lake.

The weather was bright and sunny with an air temperature of 45-50 oF. There was 20" of ice on the lake of which the surface 12" was slushy and the the lower 8" was clear and solid. Snow was 2" deep over this ice after 2 days of melting under sunny conditions. Large phytoplankton was visible in the sample holes at every sight.

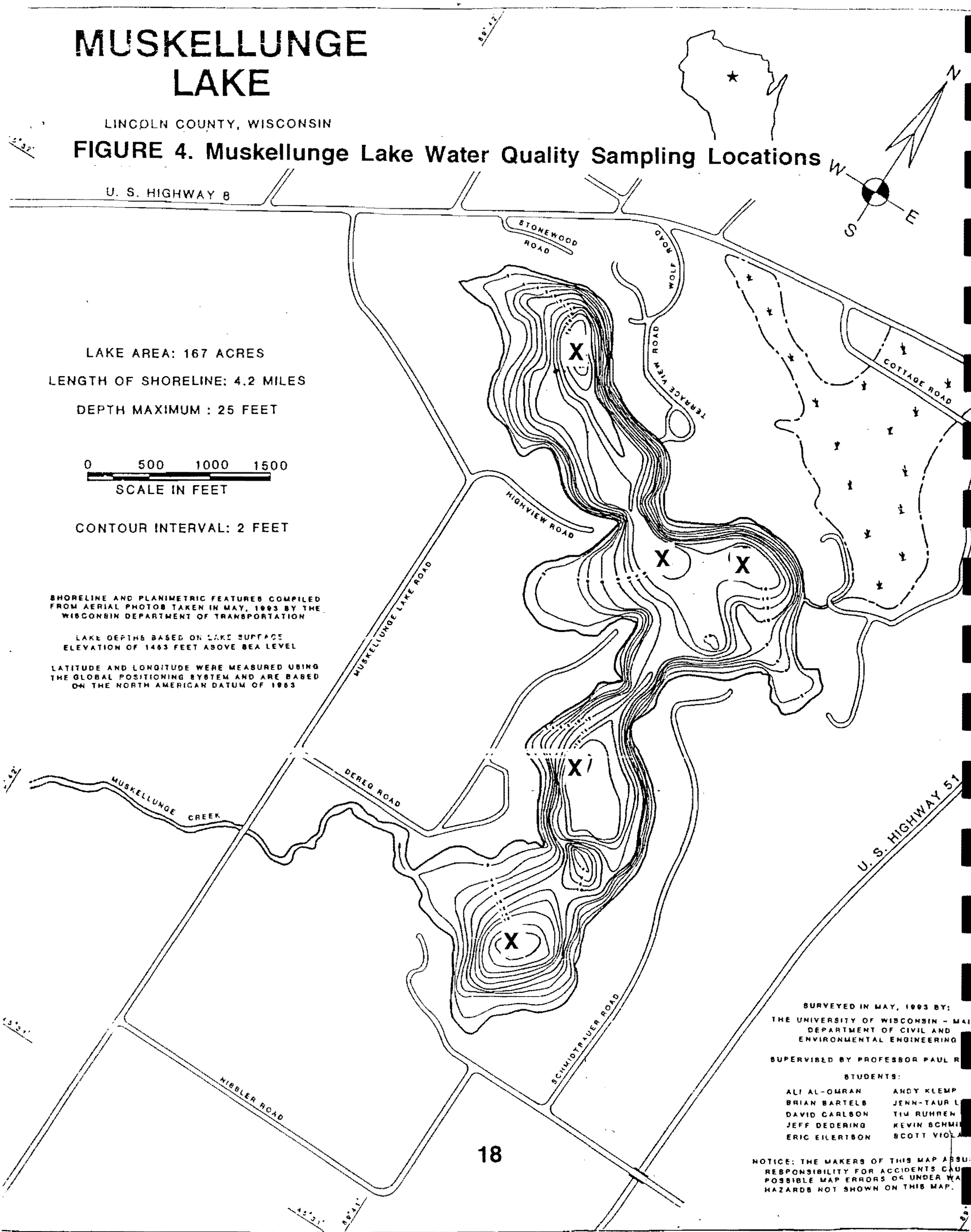


FIGURE 4. Muskellunge Lake Water Quality Sampling Locations

At all profile locations temperatures ranged form 32 oF at the surface to 38 oF (the deepest location in 26 feet of water in the north bay). Dissolved oxygen was depleted from the water column at all locations from the bottom to the top 2' of the surface except in the north bay where 0.5 mg/l was found at the 4' depth. At the 2' depth immediately below the ice oxygen ranged from 2 to 9.8 mg/l at the five sample locations. The higher the oxygen concentrations just under the ice the more phytoplankton were observed in the ice augered hole. See **TABLE 2a&2b.**

When compared March 12, 1979 data that had 24" of ice oxygen depletion in the south bay was similar to 1997. In the north bay 1.2 mg/l of oxygen still could be found in 5' of water and 0.2 mg/l could be found at 10 feet.

<u>March 24, 1998</u> After the mild winter of 1997-98 ice cover on this date was only 11" with 2" of snow. Dissolved oxygen levels down to the 6-8 foot depth were above 2 mg/l except in the south bay where oxygen levels at these depths were slightly less. Small amounts of oxygen were found throughout the water column at all locations. See **TABLES 3a&3b.**

Snowfall had only occurred two weeks prior but the rest of the winter had clear ice. Phytoplankton production created supersaturated conditions just under the ice at all locations except in the south bay. The south bay appears to have a greater oxygen demand under the ice than other areas of the lake.

When comparing under the ice water chemistry Total Phosphorus in 1979 was 0.01 mg/l and in 1998 was 0.033. The presence of phytoplankton could account for the increase in Total Phosphorus in 1998.

<u>April 28, 1997</u> Ice out had occurred 2 days prior to this spring sampling. Oxygen was being mixed in the deeper waters at all location except in the north and northeast bays. Air temperature of 65-70 oF with light winds were increasing water temperature and oxygen levels to the bottom in the channels between the bays and the south bay but not in the more protected areas of the north and northeast bays. See **TABLES 4a&4b.**

Secchi visibility was limited to 2 feet by suspended organic matter yet dissolved phosphorus levels were low at 0.002 mg/l. Total phosphorus levels near the bottom were 0.038 mg/l but mixing of these nutrients with the rest of the water column had not occurred. When compared to the May 14, 1979 bottom Total Phosphorus of 0.024 where mixing had occurred, it appears that bottom phosphorus levels in the north bay had changed little from 1979 to 1997. The later sampling in 1979 occurred when temperatures were 2-3 oF higher and a phytoplankton bloom was occurring near the surface. Water clarity was at 8.5' on this date and the phytoplankton was producing chlor a levels of 22 ug/l.

Table 2a. Muskellunge Lake Oxygen/Temperature Profiles March 31, 1997

3/31/97	N. Deep Spot		NW Central Deep Spot	
Depth	Temp oF	Oxygen mg/l	Temp oF	Oxygen mg/l
S'				
2'	32	2	32	7.65
4'	32	0.5	32	0
6'	33	0	33.5	0
8'	34.5	0	34	0
10'	35	0	34.5	0
12'	35	0	35	0
14'	35.5	0	36	0
16'	35.5	0	36.5	0
18'	36	0	37.5	0
20'	36.5	0		
22'	37	0		
24'	37.5	0		
26'	38	0		

3/31/97	NE Central Deep Spot		S. Central Deep Spot	
Depth	Temp oF	Oxygen mg/l	Temp oF	Oxygen mg/l
S'				
2'	32	9.8	32	2
4'	32	0	32	0
6'	32.5	0	34.5	0
8'	33	0	35	0
10'	33.5	0	35.5	0
12'	34	0	35.5	0
14'	35	0	35.5	0
16'	35.5	0	36	0
18'	36	0	37	0
20'	36.5	0	38	0

NE Central Deep Spot	S. Central Deep Spot
Weather: Sunny, Calm, 45-50oF	Weather: Sunny, Calm, 45-50oF
Comments: Phytoplankton in hole	Comments: Phytoplankton in hole
Ice: 20", 0-12" Slushy, 13-20" Solid	Ice: 20", 0-12" Slushy, 13-20" Solid
Snow: 2" after days of melting	Snow: 1" after days of melting

Table 2b. Muskellunge Lake Oxygen/Temperature Profiles March 31, 1997

3/31/97	S. Bay Deep Spot	
Depth	Temp oF	Oxygen mg/l
S'		
2'	4	32
4'	0	32
6'	0	32.5
8'	0	33
10'	0	34
12'	0	34.5
14'	0	35
16'	0	35.5
18'	0	36
20'	0	36.5
21.5'B	0	37

Aquatic Insect Larva Dixidae Family* in Hole
Weather: Sunny, Calm, 45-50oF
Comments: Phytoplankton in hole
Ice: 20", 0-18" Slushy, 2" Solid
Snow: 2" after days of melting

Dixidae: Larva of this aquatic family are fairly common in cattail marshes and among vegetation along streams,ponds, and lakes.They usually remain on the surface film and feed on microorganisms & detritus. Adults are short-lived midges that do not feed. Little is known about there life cycle.

Table 3a. Muskellunge Lake Oxygen/Temperature Profiles March 24, 1998

3/24/98	N. Deep Spot			NW Central Deep Spot		
Depth	Temp oF	Oxygen mg/l		Temp oF	Oxygen mg/l	
S'	32.9	15.94		33.3	16.63	
2'	35.7	16.35		35.5	15.76	
4'	39.3	7.28		39.9	3.56	
6'	39.9	2.98		39.9	3.37	
8'	40.1	2.48		40.3	1.7	
10'	40.3	0.93		40.5	0.8	
12'	40.3	0.95		40.5	0.63	
14'	40.3	0.96		40.6	0.32	
16'	40.3	0.95		41	0.15	
18'	41.4	0.35				
20'	41.4	0.15				
21'	41.4	0.13				
Weather:	Sunny, 45 oF			Weather:	Sunny, 45 oF	
Comments:	Snow Cover for 2 weeks, Ice clear before			Comments:	Little Algae visible	
Ice:	11" Clear Ice			Ice:	12" Clear Ice	
Snow:	3"			Snow:	3"	

MUSKELLUNGE CREEK DATA:	TEMP	OXYGEN	Comments:
Muskellunge Rd #1:	45.1	7.31	Water Cloudy w/ Suspended Silt,Slow Flow
Muskellunge Rd #2:	46.4	11.01	Clear More Flow
Moodig & CTH H:	43.6	11.22	Clear w/ some rolling silt
T. Live Trap Rd:	44.4	11.36	Clear Fast Plunge Pool at Culvert

Table 3b. Muskellunge Lake Oxygen/Temperature Profiles March 24, 1998

3/24/98	NE Central Deep Spot			S. Central Deep Spot		
Depth	Temp oF	Oxygen mg/l		Temp oF	Oxygen mg/l	
S'	33.1	15.27		33.1	16.14	
2'	36.1	14.48		37.9	12.12	
4'	39.7	5.3		39.2	4.13	
6'	39.9	3.77		39.2	4.13	
8'	40.1	2.25		39.9	2.11	
10'	40.3	1.15		40.1	0.85	
12'	40.3	1.41		40.1	0.5	
14'	40.5	0.66		40.3	0.34	
16'	41.5	0.2		40.8	0.21	
18'	41.9	0.17		41.7	0.17	
				42.6	0.15	
Weather:	Sunny, 45 oF		Weather:	Sunny, 45 oF		
Comments:			Comments:			
Ice:	11" Clear Ice		Ice:	11" Clear Ice		
Snow:	3"		Snow:	3"		
Stream:	Temp 39.9 oF	Oxygen: 10.79 mg/l				

3/24/98	S. Bay Deep Spot	
Depth	Temp oF	Oxygen mg/l
S'	33.3	12.24
2'	38.1	2.51
4'	39.2	1.98
6'	39.2	1.82
8'	39.4	1.72
10'	39.9	0.31
12'	40.1	0.21
14'	40.6	0.18
16'	41	0.13
18'	41.5	0.11
19'	41.9	0.12
Ice:	10.5" Clear Ice	
Snow:	3"	
Stream	Temp 42.4 oF	Oxygen: 6.34 mg/l

Table 4a. Muskellunge Lake Temperature/Oxygen Profiles April 28, 1997

4/28/97	N. Deep Spot			NW Central Deep Spot		
Depth	Temp oF	Oxygen mg/l		Temp oF	Oxygen mg/l	
S'	51.8			54	14.4	
2'	54	14		53	14.5	
4'	52	14.5		52.5	14.8	
6'	51.5	15.2		49	12.6	
8'	47	11.5		48	11.6	
10'	45	10.5		45.5	10.2	
12'	41.5	9.2		45	5.2	
14'	41	4.5		40.5	0.8	
16'	40	0		40	0	
18'	39.5	0				
20'	39.5	0				
22'	39	0				
Weather: Sunny, 65-70oF.Wind W,SW,S Gusts 2-10mph						
Comments: Ice out 2 days prior						
Secchi: 3.0'				Secchi: 3'		
Time: 2:26						
Water Chemistry Taken						

Table 4b. Muskellunge Lake Temperature/Oxygen Profiles April 28, 1997

4/28/97	NE Central Deep Spot			S. Central Deep Spot		
Depth	Temp oF	Oxygen mg/l		Temp oF	Oxygen mg/l	
S'	52	15.2		54	14.1	
2'	52	15.2		52.5	14.1	
4'	51.5	15.6		52	14.2	
6'	50	15.2		48.5	14.2	
8'	49.5	14.2		47	12.8	
10'	46	11.6		44.5	10.8	
12'	45	4		44	9	
14'	41	0		42	5.2	
16'	40.5	0		42	4.4	
18'	40	0		40.5	0	
20'						
22'						
24'						
26'						
Secchi: 3.0 feet				Secchi: 2'8"		
Inlet Creek:	50.5 oF	11.8 mg/l				
Snails(live) & Clam shells in outflow area of stream						
-Approximate flow: 1cfs						

4/28/97	S. Bay Deep Spot		
Depth	Temp oF	Oxygen mg/l	OxygenSat(%)
S'	50	13.7	
2'	49.5	13.6	
4'	49	13.6	
6'	46.5	12.6	
8'	46	12.5	
10'	44	10.2	
12'	42	8.6	
14'	42	8.25	
16'	41	6.8	
18'	40.5	5.8	
20'	40	0	
21.5'B			
Secchi: 2'10"			
Muskellunge Creek			
Outlet:	58 oF	14 mg/l	
-Shallow silted area before outlet			

June 17, 1997 By this date oxygen depletion was occurring below 16' in the deepest holes in the north, northwest central, and south central deep spots. But in the south and northeast bays where organic matter and plants are more plentiful oxygen levels were at 0 below the 14' depth. These areas also had reduced secchi disc visibilities. See **TABLES 5a&5b**.

Total phosphorus in the north bay was 0.042 mg/l with visible plankton contributing to a chlor a reading of 7.27 ug/l. On June 11, 1979 total phosphorus was 0.025 mg/l with chlor a at 8.92 ug/l. Secchi disc water clarity readings were similar on both 1979 and 1987 dates. Both temperatures and dissolved oxygen were higher in 1998. Apparently, June conditions had changed very little from 1979 to 1987.

July 31, 1997 By this midsummer date maximum warming of the surface waters had occurred. A southwest wind of 5-10 mph was blowing with an air temperature of 73 oF.

The thermocline, a depth at which there is a sudden change in temperature and oxygen, was found at all five sampling locations. Oxygen levels below this thermocline depth is usually near zero forcing fish and aquatic organisms to this depth or above. At the north bay and northwest deep spots this thermocline was at 10-12' where in the other three deep water sampling points the thermocline was at 8'. See **TABLES 6a&6b.**

The maximum surface temperature of all five locations was 75.5 oF at the surface in the south bay. The minimum temperature above the thermocline was in the north bay was 61 oF. This envelope of of 61 oF water with 5.4 mg/l oxygen was located at 14' in the north bay location with sudden changes in oxygen and temperature both above and below.

Phytoplankton (algae) was evident at all sampling locations. Chlor a levels, an indicator of phytoplankton intensity, was at 6.73 ug/l at the north bay deep hole sampling location. Secchi disc visibility at this location was 5.75'. On July 29, 1979 sampling at this north bay location found chlor a levels at 2.16 mg/l and a secchi depth of 8 feet.

Total Phosphorus at the north bay sampling location on July 31, 1997 was 0.028 mg/l, with a secchi disc water clarity of 5.75 feet. On July 16, 1979 total phosphorus was 0.02 mg/l with a chlor a reading of 2.4 ug/l and a secchi depth of 6.4 feet. An increase in phosphorus, phytoplankton (chlor a & observation), and a decrease in water clarity(secchi depth) were evident when comparing the 1979 July data to the 1987 July data.

Table 5a. Muskellunge Lake Oxygen/Temperature Profiles June 17,1997

6/17/97	N. Deep Spot			NW Central Deep Spot		
Depth	Temp oF	Oxygen mg/l		Temp oF	Oxygen mg/l	
S'	68.5	10.2		71	9.5	
2'	68	10.2		68.5	9.75	
4'	67.5	10.3		68.5	9.9	
6'	67	10.5		67	10.1	
8'	66.5	10		66.5	9.7	
10'	64	9.8		65	10.5	
12'	61.5	11.4		60	9	
14'	56.5	2.5		56	1.25	
16'	54	0		54	0.5	
18'	52	0		52B	0	
20'	50	0				
22'	48	0				
24'	45.5	0				
26'B	1 foot muck			1 foot O2 Muck		
Time:12:20	Secchi:7.25'			Time:12:45	Secchi:6.75'	
Weather: P.Sunny, SWWind 5-10,73oF Air				Weather: P.Sunny, SWWind 5-10,73oF		
3" rain Sunday 6/14				3" rain Sunday 6/14		
Comments: Phytoplankton Visible				Comments: Phytoplankton Visible		

Table 5b. Muskellunge Lake Oxygen/Temperature Profiles June 17,1997

6/17/97	NE Central Deep Spot			S. Central Deep Spot		
Depth	Temp oF	Oxygen mg/l		Temp oF	Oxygen mg/l	Depth
S'	68	10.2		68	9.8	S'
2'	67	10.25		67	9.8	2'
4'	67	10.5		67	10.1	4'
6'	67	10.6		66.5	10.2	6'
8'	67	10.75		66	10.4	8'
10'	64.5	10.4		65	9.8	10'
12'	61.5	9.25		62	8.75	12'
14'	55.5	0		56.5	4	14'
16'	54	0		54	0	16'
18'	51.5	0		52	0	18'
20'	B49.5	0		B49	0	20'
22'						22'
24'						24'
26'						26'
Time:12:45	Secchi:5.0'			Time:1:33	Secchi:5.5'	
Weather: P.Sunny, SWWind 5-10,73oF Air				Weather: P.Sunny, SWWind 5-10,73oF		
3" rain Sunday 6/14				3" rain Sunday 6/14		
Comments: Phytoplankton Visible				Comments: Phytoplankton Visible		

6/17/97	S. Bay Deep Spot		
Depth	Temp oF	Oxygen mg/l	
S'	66	10	
2'	66	10.1	
4'	66	10.4	
6'	65.25	10.3	
8'	65	10.2	
10'	63.5	9.25	
12'	59	10.6	Comment: Vegetation Patterns of floating emergent vegetation
14'	55	0	out from beach littoral zone before deep water good for
16'	53.5	0	centrarchid spawnig & young cover
18'	52	0	
20'	50	0	
22'	49	0	
22'6"B	49	0	
Time:1:45	Secchi:6.0'		
Weather: P.Sunny, SWWind 5-10,73oF Air			
3" rain Sunday 6/14			
Comments: Phytoplankton Visible			

Muskellunge Creek:			South Bay Stream:	
Outlet:	69	10.3	58oF	5.4 mg/l
-Shallow silted area before outlet			-tea colored	

Table 6a. Muskellunge Lake Oxygen/Temperature Profiles July 31,1997

7/31/97	N. Deep Spot		7/31/97	NW Central Deep Spot		
Depth	Temp oF	Oxygen mg/l		Temp oF	Oxygen mg/l	
S'	75.5	9.1		72.5	9.2	
2'	74	9.25		72	9.25	
4'	73.5	9.45		71.5	9.5	
6'	72	8.75		71.5	9.25	
8'	71.5	8.75		71.5	8.5	
10'	68	6.9		68	5.5	
12'	67	1.5		65	2.5	
14'	61	5.4		60	2.2	
16'	57.5	0.2		58B	0.2	
18'	55.5	0.2				
20'	52	0.2				
22'	50	0				
24'B	49	0				
				Comment: Verticle Plankton Tow		
				Secchi: 5.75'		
				Time: 12:26		

Table 6b. Muskellunge Lake Oxygen/Temperature Profiles July 31,1997

7/31/97	NE Central Deep Spot		7/31/97	S. Central Deep Spot		
Depth	Temp oF	Oxygen mg/l	Depth	Temp oF	Oxygen mg/l	
S'	71.5	9.4	S'	74	8.9	
2'	72	9.5	2'	73.7	9.1	
4'	72	9.6	4'	73.5	9.2	
6'	72.2	9.6	6'	72	8.7	
8'	72	9.2	8'	70	6.75	
10'	68.5	3.6	10'	66.5	1.7	
12'	65	1.4	12'	64.5	1.75	
14'	61	2.1	14'	59	4	
16'	59	0	16'	58	0.02	
18'	56	0	18'	56	0	
20'	B53	0	20'	B55	0	
22'			22'			
24'			24'B			
26'						
Weather: M.Sunny,WtoSW Wind @10,80 oF Air				Time: 1:12	Secchi:5.5'	
Comment: Plankton Visible(Blue White Body Cast Hue)						
Secchi: 5.0' Wind Blowing into bay				20' Silt		
Time: 12:05	19' soft bottom					
Inlet Creek:	65.5oF	6.4 mg/l O2				
7/31/97	S. Bay Deep Spot					
Depth	Temp oF	Oxygen mg/l				
S'	75.5	8.8				
2'	74.5	8.9				
4'	73.5	9	General Comment: Large schools of 3" LMB abundant on S. End			
6'	72	8.2	-Schools of Minnows also abundant			
8'	72	8	- Shoreline Development on Slope a Problem			
10'	69	2	- Lack of Tree Fallen in Water			
12'	65.5	2.5	- Structural Cover at 12' needed (look at Aug 02/ Temp profil			
14'	60.5	2				
16'	56	0				
18'	55	0				
20'	53	0				
22'B	51.5	0				
Weather: M.Sunny,WtoSW Wind @10,80 oF Air						
Comment: Plankton Visible(Blue White Body Cast Hue)						
Secchi: 5.2'	Time: 1:33					
Muskellunge Creek:			South Bay Stream:			
Outlet:	76 oF	6.8 mg/l	49 oF	4.0 mg/l		
-Shallow silted area before outlet			-Clear			
Time:2:12						

September 8, 1997 By September 8 the surface waters of Muskellunge lake began to cool as the growing season came to an end. Oxygen was completely depleted below the thermocline at 14'. A surface temperature of 63.5 degrees was mixed by a 10 mph wind to the top of the thermocline at 12 feet. Oxygen levels were slightly supersaturated indicating phytoplankton (algae) activity. See **Table 7.**

Water chemistry sampling found chlor a level at 12.9 ug/l, total phosphorus at 0.028 mg/l with water secchi clarity at 8.2 feet. September 9, 1979 had chlor a concentration of 9.75 ug/l and a secchi depth of 9.75 feet. A week later on September 17, 1979 chlor a levels skyrocketed to 50.25 ug/l with a bluegreen algae bloom. This bloom decreased water clarity to 5 feet but raised total phosphorus levels to 0.041, the highest for 1978-79 intensive sampling.

October 21, 1997 Fall mixing was occurring on this date cooling Muskellunge Lake from top to bottom to 51 oF. Dissolved oxygen ranged from 9.0 mg/l at 20 feet to 9.2 feet at the surface. These oxygen levels were only at approximately 82% saturation indicating an oxygen demand throughout the water column. See **TABLE 8.**

Some phytoplankton were present as chlor a concentration was at 13.6 ug/l. Total phosphorus at the surface was at 0.046 mg/l , the highest for 1997 sampling. Nitrogen sampling found high levels of organic with a Kjeldahl level of 0.3 mg/ l and high levels of dissolved nitrogen of 0.48 mg/l of nitrate- nitrite nitrogen. These water chemistry parameters confirm that the oxygen demand in the water column was from suspended and dissolved organic matter in the water column.

October 15, 1979 data found surface total phosphorus levels at 0.018 mg/l - one third the concentration found in 1997. Bottom total phosphorus concentration at that time was only 0.016 mg/l. Algae was present in the water at that time as indicated by a chlor a concentration of 9.15 ug/l. Secchi disc clarity was also higher than in 1987 at 7.1 feet.

Conclusions

Several parameters of water quality in this 1996-98 study point towards Muskellunge Lake facing eutrophication or the process of enrichment of nutrients over time when compared to the 1979 study. These nutrients increase the production of rooted plants and algae (phytoplankton) and in return are carried up the food chain by invertebrate and vertebrate animals.

Phosphorus and nitrogen are the key nutrients influencing plant growth. Total phosphorus includes the amount of phosphorus dissolved in solution and in particle form. Kjedahl nitrogen would do the same for ammonium in solution and particulate organic matter. Organic matter in solution and algae can be suspended in the water column and effect water clarity as observed through secchi disc readings.

Table 7. Muskellunge Lake Oxygen/ Temperature Sept. 8, 1997

9/9/97	N. Deep Spot		Time:10:45	Secchi:8.2'	Phosphorus & Chlor a Sampled	
	Temp oF	Oxygen mg/l	Weather: Cloudy, SW Wind 5-10, 63oF Air,			
S'	63.5	10.8	Cloudy Day Prior			
2'	63.5	11.2	Comments: Few Zooplankton Visible			
4'	63.5	11.1				
6'	63.5	11.1	MUSKELLUNGE CREEK DATA: TEMP			OXYGEN
8'	63.5	11	Muskellunge Rd #1:		64 oF	8.65
10'	63.5	11	Muskellunge Rd #2:		60 oF	8.6
12'	63.2	9.25	Moodig & CTH H:		60 oF	9.3
14'	61	0				
16'	58	0				
18'	56.5	0				
20'	53	0				
22'	50	0				
24'	47.5	0				
25'B						

Table 8. Muskellunge Oxygen/Temperature Profiles October 20. 1997

10/20/97	N. Deep Spot			NW Central Deep Spot		
Depth	Temp oF	Oxygen mg/l		Temp oF	Oxygen mg/l	
S'	52	9.3		48		
2'	51	9.2		49.5	9.3	
4'	51	9.2		50	9.2	
6'	51	9.2		50	9.2	
8'	51	9.2		50	9.2	
10'	51	9.2		50.5	9.2	
12'	50.8	9.2		50.5	9.2	
14'	50.8	9		50.5	9.2	
16'	50.5	9.1		50.5	8.7	
18'	50.8	9		50.5	8.5	
20'	50.8	9		B 50.3	0	
22'	B					
Time:12:30	Secchi:5.1'		Phosphorus & Chlor a Sampled			
Weather: 50%Cloudy, N Wind 10mph, 52oF Air,						
Comments: Water Color Tan to Brown						
MUSKELLUNGE CREEK DATA: TEMP			OXYGEN	% SAT.		
Muskellunge Rd #1:		48 oF	9.7			
Muskellunge Rd #2:		45 oF	7.3			
Moodig & CTH H:		46oF	9.6			

Variations in weather and temperature can vary from year to year and can influence nutrient cycling. Also, sampling timing can influence water quality when comparing one year to the next. But sampling of several parameters over an entire season can be used to document increases in enrichment of nutrients. Nutrients used up at the lowest point in the food chain or pyramid are used by algae or phytoplankton. Chlorophyll a (Chlor a) is a green pigment present in all plant life and is necessary for photosynthesis. Therefore, the amount present in lake water depends on the amount of algae and is used as a common indicator of water quality.

When comparing total phosphorus in 1978-79 to 1997-98 surface total phosphorus was consistently higher in 1997- 98. See **FIGURE 5.** When the amount of chlor a was sampled with phosphorus during and after the the growing season, a better picture of water quality was taken. Chlor a concentrations in 1987 were consistently higher than in 1979. See **FIGURE 6.**

When 1997 chlor a concentrations were graphed with water clarity observations over the entire season and compared to the 1979 data, again, water clarity due to algae has decreased since that time. See **FIGURE 7**. Averaging secchi disc reading taken in both years finds that water clarity over the entire open water period has also declined since 1979. The 23 secchi disc observations in 1997 averaged 6.3 feet while eleven secchi disc readings in 1979 averaged 6.8 feet.

Figure 5. Muskellunge Lake Phosphorus 1978-79 vs 1997-98

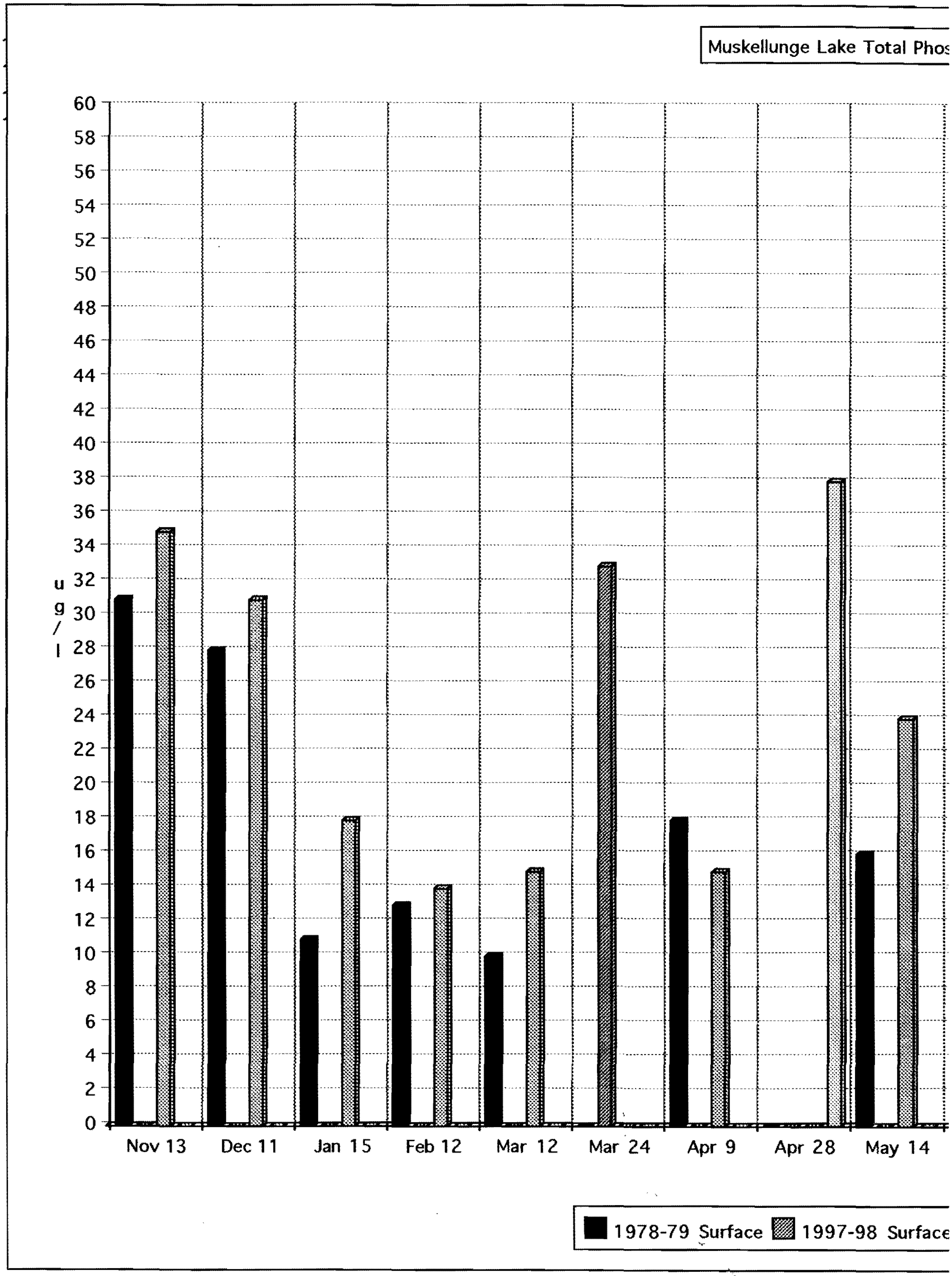


Figure 5. Muskellunge Lake Phosphorus 1978-79 vs 1997-98

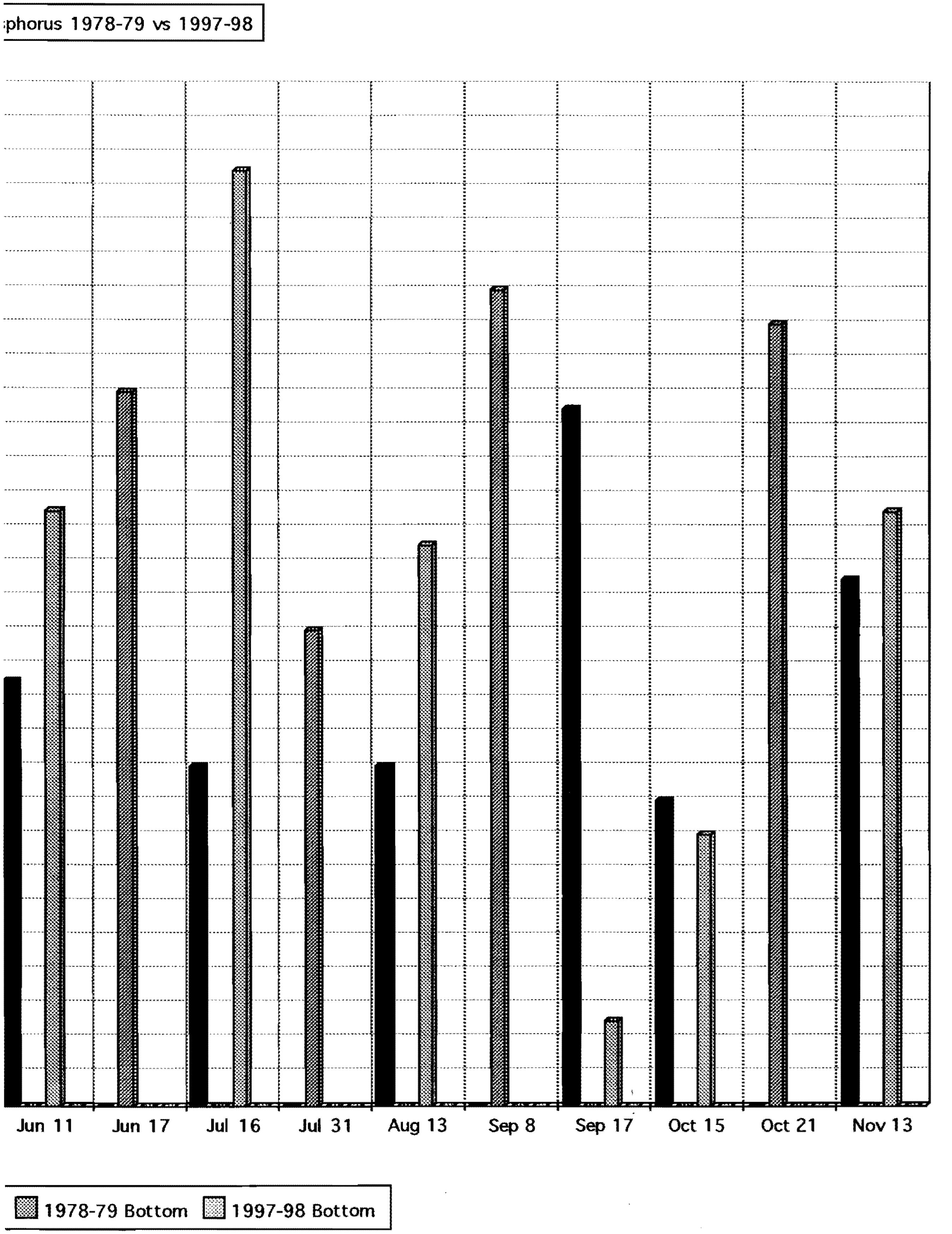


Figure 6. Muskellunge Lake Chlor a & T.Phosphorus 1979 vs 1997

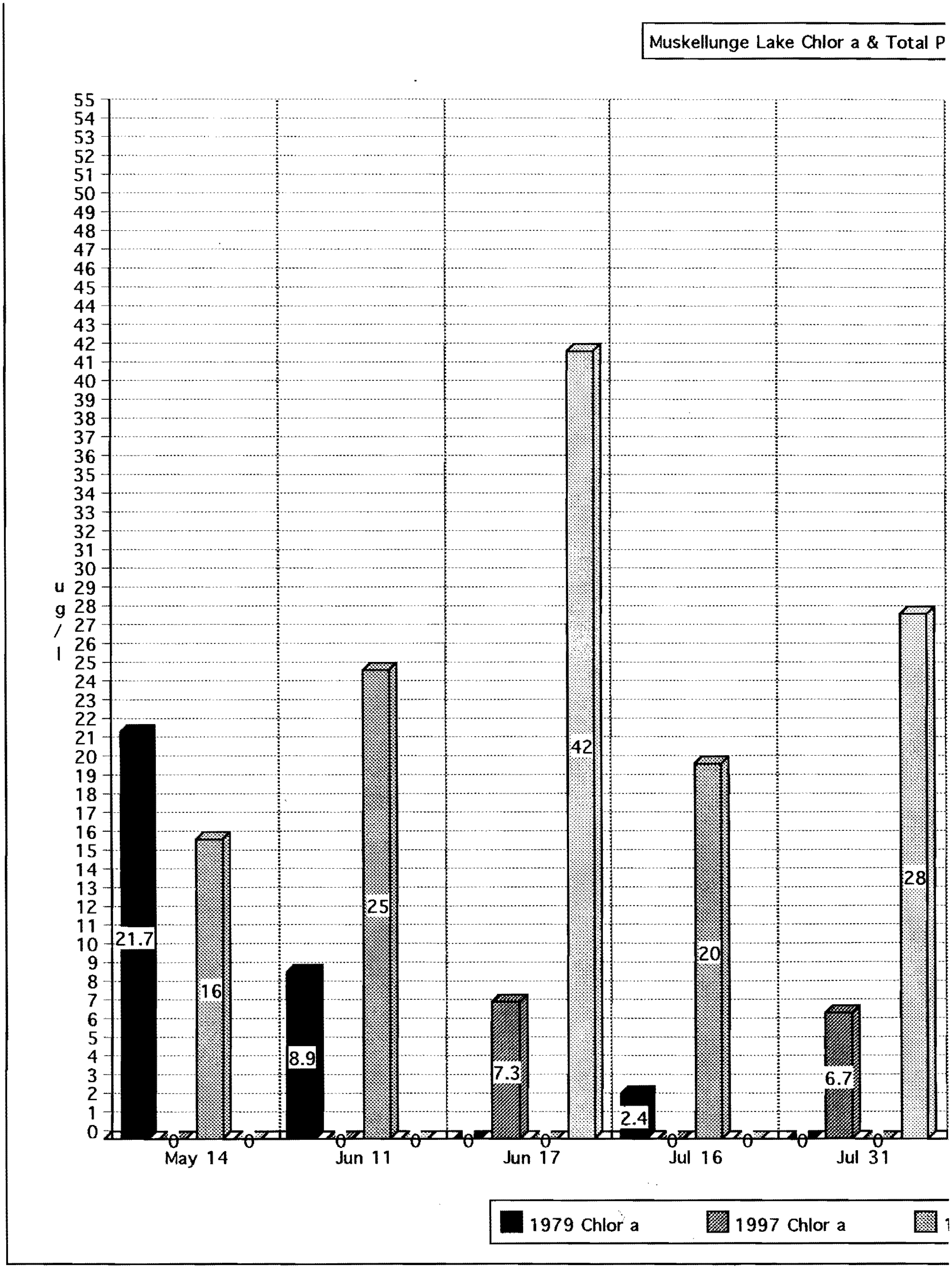


Figure 6. Muskellunge Lake Chlor a & T.Phosphorus 1979 vs 1997

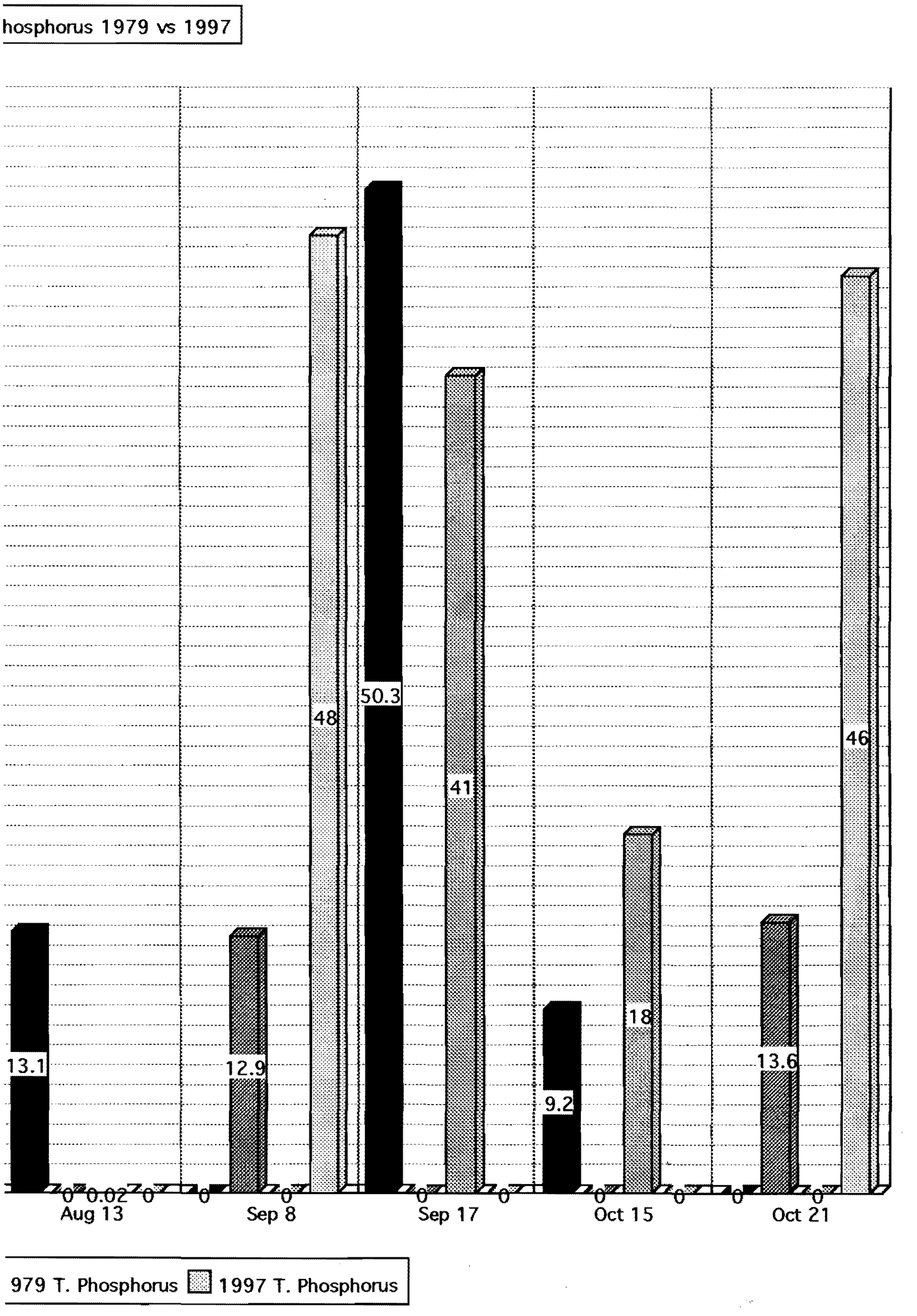


Figure 7. Muskellunge Lake Chlor a & Water Clarity 1979 vs 1997

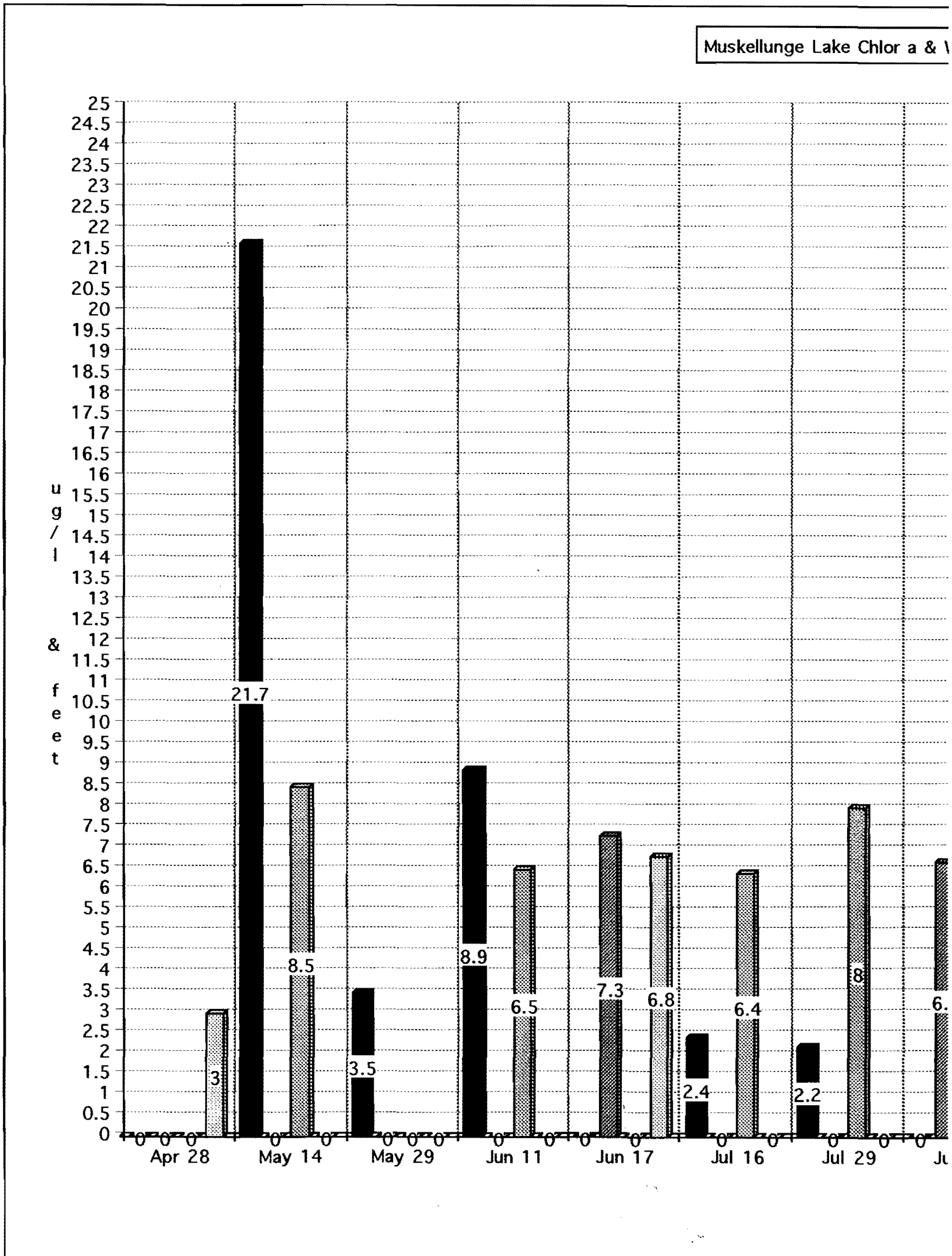
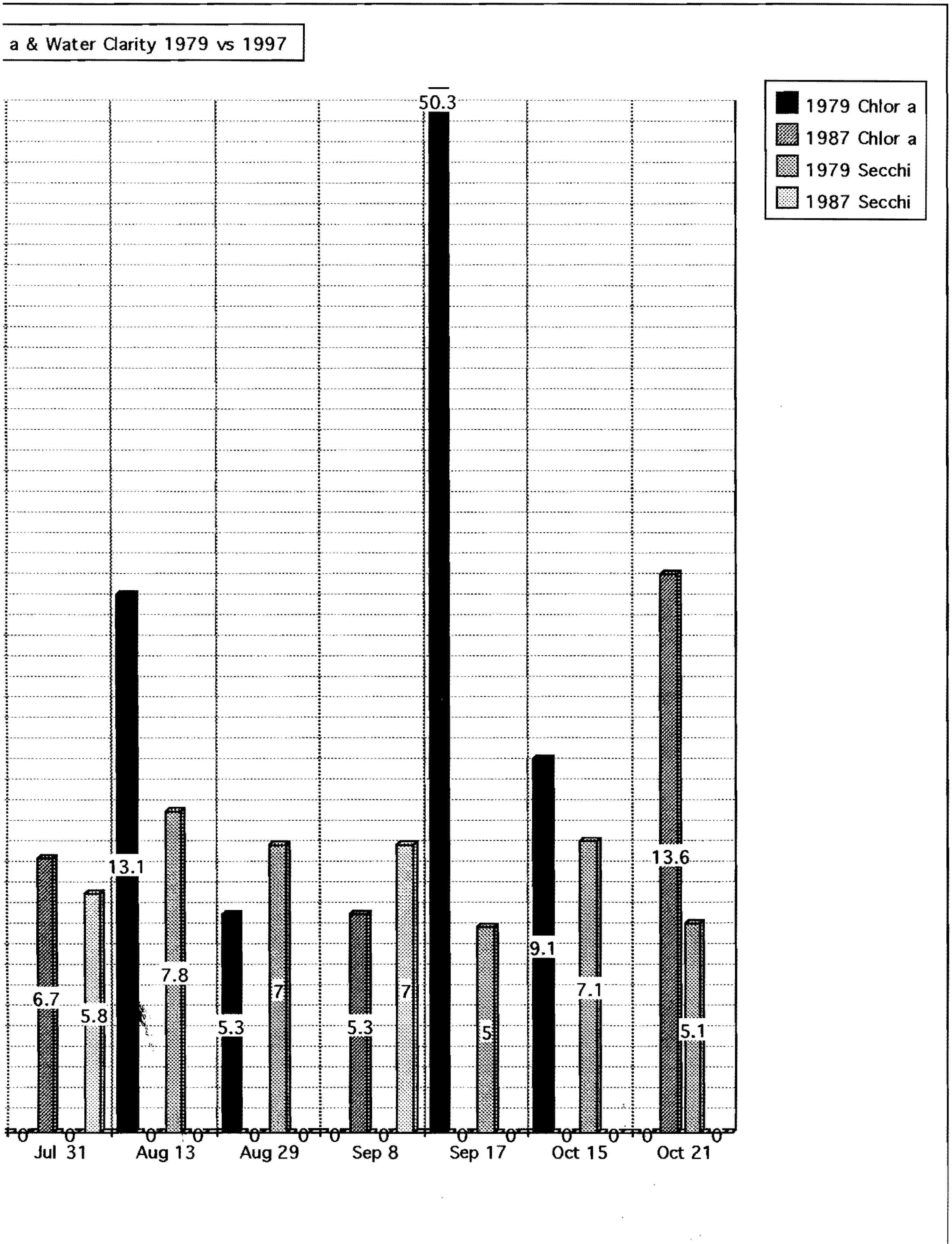


Figure 7. Muskellunge Lake Chlor a & Water Clarity 1979 vs 1997



AQUATIC PLANTS OF MUSKELLUNGE LAKE

Introduction

Muskellunge Lake has a combination of steep shorelines and long shallow bays that add diversity to the aquatic plant habitat . Muskellunge Lake bottom sediments vary from rock rubble and gravel to loose organic muck and silt. These substrates combined with light penetration to 14 feet and nutrient rich water has combined to provide a very diverse aquatic plant community.

There are four deep water areas on the lake where attached aquatic plants- called macrophytes- cannot grow but free floating phytoplankton (algae) are found throughout most of the year. Plants grow on the steep glacial outwash shorelines that border these deep water areas. It is along these steep shorelines that development has occurred but in most cases the tree canopy has remained. These deep water areas extend into five separate shallow water wetland communities that support a wide variety of plants and animals. Most of these wetland communities further extend shoreward into forested wetland communities adding even more diversity and isolation.

All three types of attached aquatic plants- emergent, submergent, and floating were identified in Muskellunge Lake. This variety of plants provide cover and food for frogs, aquatic invertebrates, and aquatic insects that are important food items for fish,waterfowl, and aquatic mammals. Structural habitat of trees and logs were sparse along the shoreline, therefore, emergent and floating vegetation is important in providing physical cover for the fishery.

Procedure

A aquatic plant survey was conducted on August 7 & 8, 1997. The survey used a standard transect sampling method that recognizes plant species, their densities, rooting depth, and substrate types. Twenty- three sample transects were made perpendicular to the shoreline extending from the shoreline to the maximum depth of light penetration. See **FIGURE 8** . The transects were chosen to represent a variety of habitats from wetlands to steep shoreline extensions and from developed to undeveloped shorelines.

Each transect was given a number as indicated in **FIGURE 8**. Each transect began on the shoreline and a compass bearing of transect direction was made and recorded. A rake was used to sample four quadrants at 4 sampling points- that represented increasing depths- along a transect. In each quadrant of a sampling point the plants were identified, given an alphabetic letter, and their densities described by a numbering system from 1 to 5. One (1) being sparse and found in only one quadrant in five (5) being dense and appearing in all four quadrants.

TABLE 9. 1997 Aquatic Plants of Muskellunge Lake, Lincoln County.

SCIENTIFIC NAME	COMMON NAME	Ave Density 97	1993	Ave Density 79
A. Potamogeton illinoensis	Illinois Pondweed	3.7		
B. Elodea canadensis	Common Waterweed	#6 6		1
C. Potamogeton foliosus	Leafy Pondweed	1.5		
D. Najas flexilis	Slender Naiad	5.5	C	3.5
E. Vallisneria americana	H2O Celery,Eel Grass	#2 12		2.8
F. Potamogeton robbinsii	Fern Pondweed	4.5	C	#2 3.3
G. Ceratophyllum dermersum	Coontail,Hornwort	#1 29.8	A (in spots)	#1 3.2
H. Potamogeton richardsonii	Claspingleaf Pondweed	0.8	P	
I. Nuphar variegatum	Bullhead Pond Lily	#5 7.7	A (in Spots)	#3 3.4
J. Chara sp.	Muskgrass	0.8		4
K. Lobelia dortmanna	Water Lobelia	3.7		
		3.8		
M. Pontederia cordata	Pickerelweed	3.8	A (in spots)	3
N. Potamogeton amplifolius	Largeleaf Pondweed	5.8	C	#5 3.1
O. Potamogeton epihydrus	Ribbonleaf Pondweed	2.7	P	
P. Nymphaea odorata	Frangrant Waterlily	1.8	A (in spots)	
Q. Brasenia schreberi	Watershield	0.8	P	3.6
R. Scirpus acutus	Hardstem Bullrush	10.3	C	4
S. Potamogeton pusillus	Small Pondweed	#4 1.5		
T. Nymphaea tuberosa	White Waterlily	11	C	#6 2.7
U. Potamogeton hillii	Hill's Pondweed	#3 58	?	
V. Potamogeton zosteriformes	Flatstem Pondweed	#7 0.3	C	#4 2.2
X. Sporangium eurycarpum	Common Burreed	0.3	?	
Y. Alisma plantago-aquatica	Water Plantain	2.7		
Z. Eleocharis acicularis	Needle Spikerush	0.7	?	3.5
AA. Anacharis canadensis	Calcareous Waterweed	0.5		
BB. Heteranthera dubia	Mud Plantain	1	P	2
CC. Typha latifolia	Broadleaf Cattail	0.17		1
DD. Sagittaria cuneata	Arumleaved Arrowhead	1.3	? P	
EE. Sagittaria rigida	Stiff Arrowhead	1.5	? P	
FF. Potamogeton gramineus	Variableleaf Pondweed	2.8		
GG. Myriophyllum verticillatum	Whorled Watermilfoil	1	P	1.8
HH. Ranaculus flabellaris	Yellow Watercrowfoot	0.3		1
II. Equisetum fluviatile	Horsetail, Flowering Rush	0.7	P	
JJ. Dulichium arundinaceum	Three-way Sedge,Pond Sedge	0.5	P	
KK. Sparangium fluctuans	Small-leaf Burreed	0.3	?	
LL. Isoletes sp.	Quillwort	0.3		
MM. Nasturtium sp.	Water Cress			3.7
NN. Same Y.	Mud Plantain			
OO. Nitella flexilis	Muskgrass, Stonewort	0.17		
Filamentous Algae				3.3
Scirpus validus	Softstem Bulrush		? C	
Eleocharis palustris	Creeping Spikerush			
Potamogeton natans	Floating-Leaf Pondweed			2
Potamogeton praelongus	Whitestem pondweed			2
Potamogeton foliosus	Leafy Pondweed			
Utriculus sp.	Bladderwort			
Spirodella polyrhiza	Big Duckweed			

TABLE 10. MUSKELLUNGE LAKE PLANT DENSITY/ABUNDANCE CALCULATIONS

Lake Wide Occurance & Abundance by Depth Listed from Most to Least Abundant
as a Percentage of Sampling Where Identified: 24 Sampling Points

0 to 2.5'	#Occurances	Density
Bullhead Pond Lily	17	36
Water Lobelia	12	22
Pickerelweed	12	20
Coontail, Hornwort	9	24
Water Celery, Eel Grass	9	21
Common Waterweed, Elodea	6	15
Needle Spike Rush	5	15

2.6' to 5.0'	#Occurances	Density
Coontail, Hornwort	20	50
Water Celery, Eel Grass	12	38
Hill's Pondweed	10	29
Flatstem Pondweed	8	13
Slender Naiad	8	11
Ribbonleaf Pondweed	8	10
Illinois Pondweed	6	12
Fern Pondweed	6	14
Bullhead Pond Lily	6	9
Whorled Watermilfoil	6	6
Largeleaf Pondweed	5	12
Common Waterweed, Elodea	5	8

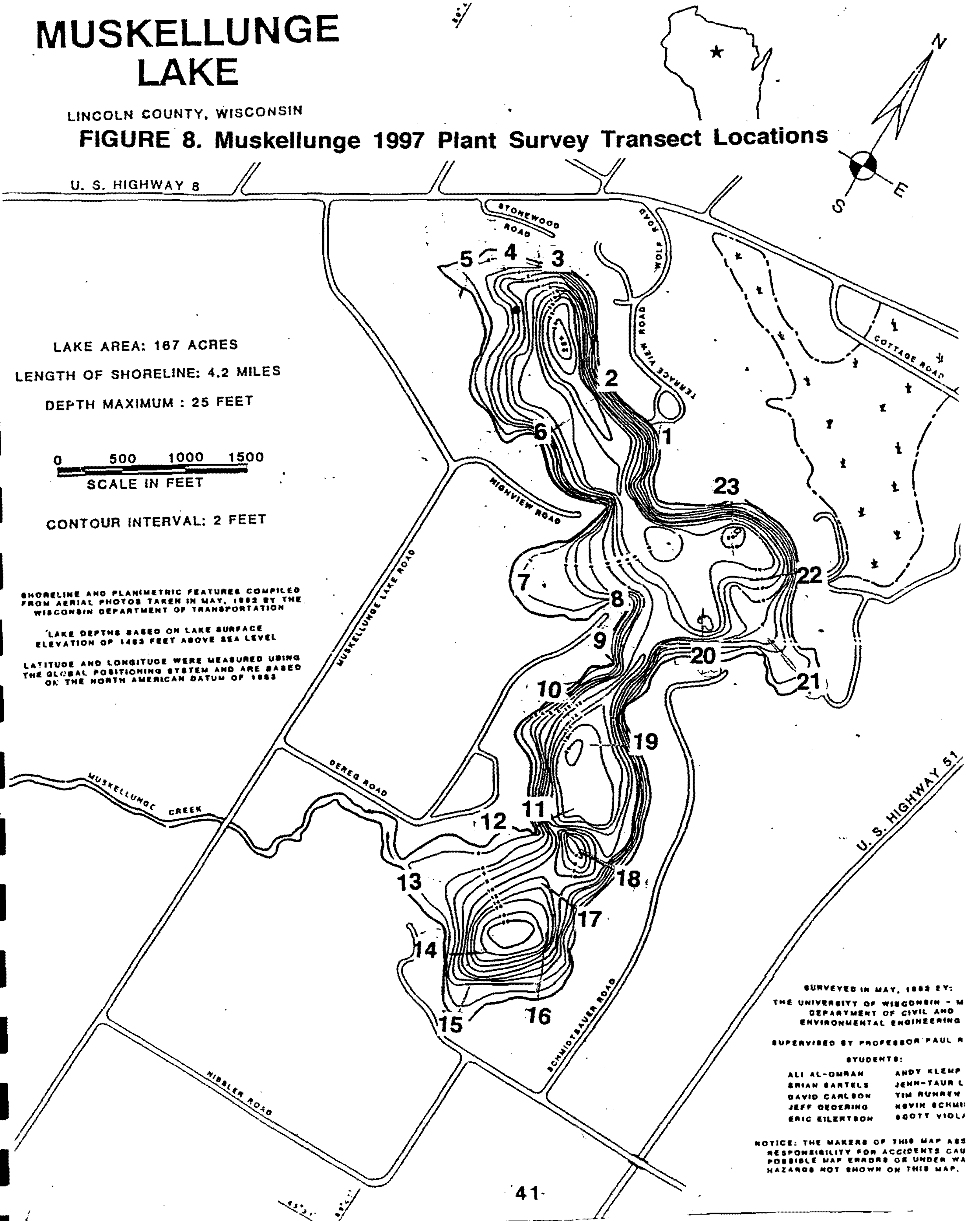
5.1' to 9.0'	#Occurances	Density
Coontail, Hornwort	20	60
Hill's Pondweed	10	28
Small Pondweed	10	14
Flatstem Pondweed	8	15
Ribbonleaf Pondweed	8	8
Water Celery, Eel Grass	7	13
Common Waterweed, Elodea	6	6
Largeleaf Pondweed	4	10
Slender Naiad	4	8

9.1' - 15.0'	#Occurances	Density
Coontail, Hornwort	18	45
Small Pondweed	17	46
Flatstem Pondweed	6	7
Common Waterweed, Elodea	5	7
Hill's Pondweed	4	6
Slender Naiad	4	5
Ribbonleaf Pondweed	4	5

MUSKELLUNGE LAKE

LINCOLN COUNTY, WISCONSIN

FIGURE 8. Muskellunge 1997 Plant Survey Transect Locations



The results of this survey were tabulated by abundance and depth. The results were further analyzed to recognize the competition between plants in the plant community. The survey results were also combined with other observations (such as interaction of the plants with substrate,light, and other physical-chemical conditions) made throughout the grant period. The results were further compared to past plant surveys that occurred in 1979 and 1993.

Results & Discussion

Thirty- nine aquatic plants were identified in Muskellunge Lake during the plant survey conducted on August 7 & 8, 1997. The aquatic plants identified include 21 submergents, 4 floating, and 14 emergent species. Aquatic plants were identified in four depth ranges extending from the shoreline to 12 to 14 feet of water. A list of the aquatic plants identified, with an assigned letter and scientific name can be found in **TABLE 9**. Nine substrate types were identified in the 0 to 2.5 foot littoral area of the shoreline. Twelve substrate types at the 2.6 to 5.0 foot depths. Eight different sediment descriptions were used in both the 5.1 to 9 foot and the 9.1 to 15 foot depth ranges.

0 to 2.5 Feet

This littoral zone of the lake is the most sensitive area of the lake ecosystem and the area most effected by human use of the lake. Shoreline development in shallow water can destroy fish and other aquatic animal habitat. Natural wave action is important in hydraulically maintaining the variety substrates for plants found at this shallow depth Excessive wave action by boat activity can destroy or alter these areas and change the plant community.

The most common and abundant aquatic plant in the 0 to 2.5 foot shoreline area was the yellow or bullhead pond lily. See **TABLE 10**. This plant was found most abundant in dense patches over the shallow water areas soft sediment, but was also found scattered along small shelves adjacent to the the steep shorelines on all the substrate types. These floating plants provide cover for almost all fish species and on the shelf areas spawning beds of bass and bluegill were observed. Their dense interwoven root system stabilize and accumulate sediment on the shelf areas. Both roots and leaves also breakdown wind and boat wave action therefore protecting shoreline areas on the landward side. A similar plant, the white waterlily appears to have decreased in numbers since the 1979 survey.

The second most abundant plant at this depth was water lobelia, an inconspicuous plant consisting of a small rosette. It was mostly found in very shallow water on sandy bottom areas but was also found in areas where muck had accumulated from decomposing organic matter. This plant appears to be associated with shoreline spring seepage areas.

The third most abundant plant was the emergent plant, pickerelweed. This plant with it's arrow- shaped leaves and purple flower spike was most abundant in shallow wetland areas with muck substrate. It was also found in small patches throughout the lake over a wide variety of substrates. This plant is often broken loose from large patches and it's root mat carried by wind and wave action to a new location. Also, the abundant seeds developed on the purple flower spike are easily distributed throughout the lake. This plant is used by waterfowl and muskrats for food. It also breaks up wave action and can protect shoreline areas from wave action.

The next three dominant plants in the 0 to 2.5 foot depth zone are emergent invaders from deeper water environment. Coontail and Elodea are plants that do well under low light and fertile water conditions. Water celery is one of the best plants for fish and wildlife food but is dependent upon clear water and the fairly firm substrate of glacial outwash sands and gravels. The emergent needle spike rush is also dependent on a firm substrate. This plant's stems often survive the winter erect and are able to catch yellow perch semi- buoyant egg ribbons after ice out, therefore suspending them off the bottom and acting as a wave-aerated incubation pedestal until they hatch into fry.

2.6 to 5.0 Feet

This depth range contains the most variety and highest densities of submerged aquatic plants. Light penetration is not limited and substrate becomes mixture of glacial outwash sand and gravels and a variety of organic material. This is also the depth range where physical wave action has less effects but warm surface water can stimulate plant growth more than deeper water. It is also the beginning of deeper water areas where there has been drastic changes in the plant density and composition since the 1979 plant survey. The main cause for this change is the ability of certain plants to absorb dissolved nutrients from the water column under low light conditions.

The plant that now dominates the deep water areas is coontail. See **TABLE 10.** These plants have long thin bushy stems that have no roots but the lower end of the branched stem may be anchored in the bottom mud. Their dark green leaves are in whorls and are crowded near the tip giving the plant a "coontail" or "Christmas tree" appearance. These have the ability to absorb dissolved organic matter and collect suspended organic matter on their fine whorled leaves. They also do well in subdued light of silty or deep water. In Muskellunge Lake this plant has replaced many of the wide-leaved plants that have extensive root systems. Therefore, nutrients once stored beneath the substrate surface are not stored in the water column. This plant's shoots are eaten by waterfowl and is important cover for young fish. Yet when this cover becomes too dense young fish are too protected from predators and can become stunted as too many survive.

The second most dominant plant in the 2.6 to 5.0 foot range is water celery or eel grass. At this depth this plant has capitalized on the organic matter embedded in the wave packed sand that is being broken down in the presence of oxygen. This plant has an extensive root system in the substrate but no stem in the water column. The long ribbon -like leaves extend from this root system into the water column. A small whitish-yellow flower supported by a coiled stalk is visible in late summer extending to the water surface. All parts of this plant are eaten by wildlife and it provides excellent cover habitat for all sizes of fish and aquatic insects.

The rest of the submerged plants that are found at this depth are fine or narrow and ribbon-leaved plants that also trap suspended organic matter and due well under reduced light conditions. Most of these plants are in one genera of plants known as the potamogetons. The slender naiad, another fine- leaved plant also is doing well under these conditions. The large leaf pondweed that has more benefits to fish and wildlife and was more abundant in 1979 has lost to the competition of the narrower and fine-leaved plants. See **TABLE 1 0**.

5. 1 to 15.0 Feet

At these depth zones light penetration is more subdued and organic matter is both abundant in the substrate and suspended or dissolved in the water column. Water chemistry sampling during the summer growing season for phosphorus at various depths in 1979 confirms this. Again, most of the plants found at this depth are able to absorb nutrients through their leave structure and survive these low light conditions. The list of the dominant plants at this depth are listed in **TABLE 10.** Water celery still could be found at 5 to 9 feet where firm substrate was mixed with softer organic matter. In 9 to 15 feet of water only the fine - leaved aquatic plants were found in any abundance.

Conclusions

The aquatic plant community since 1979 has not changed drastically in species composition but has changed drastically in density of those plants capable of assimilating the nutrients available to them in the water column and in the substrate. Water clarity has also decreased - as described in the water quality section of this paper - due mainly to the increased organic load in the water column. The plants have responded with increased growth - as indicated by density rating increases. But this increased growth has not been able to absorb all of the nutrients available and water clarity has not improved but worsened over this short period.

What effects have increased boat traffic and suspension of bottom sediment had on these changes in the aquatic plant community? During the survey power boats turning around in the south bay of the lake had churned up the bottom sediments and were visibly suspended and settling on the aquatic vegetation. The wide leaf, more beneficial plant, had already began to decay on the survey date. Did the silt covering the leaves have a role in this early decay?

Replacement of wide - leaved plants by more narrow - leaved plants can change the aquatic organisms that feed the fishery and waterfowl communities. The former storage of nutrients beneath the substrate in roots of wide - leaved plants are now stored in the water column in leaves of the most dominant and dense plant - coontail. The leaves of these dominant plants consume more oxygen at night while living and release more nutrients to the water column after death during decomposition.

In return these released nutrients in the water column have an increased oxygen demand. Some nutrients in the water column can be used by the free-floating algae or phytoplankton, which are consumed by zooplankton and channeled up the food chain to fish. But too many nutrients in the water column, especially late in the growing season, produce bluegreen algae that cannot be utilized by zooplankton and other organisms, therefore contributing to sediment and oxygen demand as they die and decay.

THE FISHERIES OF MUSKELLUNGE LAKE

Introduction

Little is known about the current fisheries of Muskellunge Lake. The last fishery survey of the lake was a fall electroshocking survey in 1994. Surveys before this time included other boom shocker surveys in August of 1984, 1986, and 1979. These shocker surveys were completed in less than 1.5 hours. A more comprehensive fishery survey using fyke nets, seines and the electrofishing boom shocker was completed in 1981. The 1979 electrofishing survey was completed after a suspected winter fish kill, but evidence of a winterkill was not apparent from the survey.

Procedure

The purpose of this planning grant study was to gather and analyze all past data on the lake and develop a current inventory of the physical, chemical , and biological conditions. The assessment of the fisheries was limited to reviewing existing fisheries data and ecologically interpreting the relationship between Muskellunge Lake's current conditions and it's fisheries. A volunteer fish assessment program was introduced and a few scale samples were submitted for age/ growth interpretation.

Results & Discussion

Past fishery surveys of Muskellunge Lake provide little information on the ecology of the fisheries. Survey sampling identified the species present, counted number of each species captured, and identified the size range. The 1981 and 1994 survey results were used to calculate the modal (mean) size of most species. Capture/ unit was also calculated for the fyke net data of 1981. See **TABLE 11**. No age/ growth determinations were made for any of these surveys.

From the above limited data, northern pike in the past appear to be the dominant game fish. Largemouth bass appeared to be the second most abundant game fish in the most recent years. Yet in 1981, more large walleyes were captured than largemouth bass. Yet in the most recent 1994 shocker survey, 7 muskellunge were caught along with 10 largemouth bass and 22 northern pike. Five walleye averaging 13.9 inches were also captured. The mean size of the muskellunge was 28.8" while that of the northern pike was 16.6". Bass mean size was 9.4" in a range from 3.0" to 15.9". See **TABLE 11**.

From the past surveys, bluegill has been the dominant panfish, with yellow perch and black crappies also present in large numbers. Only a few pumpkinseed, rock bass, and warmouth were captured in the past surveys. Rough fish are present with a few bullheads and white suckers identified in the survey. Golden shiner and mudminnows were identified as being the most numerous minnow species in the 1979 survey.

TABLE 11. Muskellunge Lake(Lincoln Co) Fisheries Investigation & Stocking History

GAMEFISH						
SPECIE	NorthernPike	Muskellunge		Largemouth	Bass	Walleye
9/29/79						
	23	1		18		4
	11.1-29.0"	47.5"		4.2-13.8"		12.4 - 17.2"
4/7-14/81						
Fyke Net						
Number	154	1		14		23
Size Range	10.5- 30.4"	43.2"		10.5 - 30.4"		18.5 - 28.9"
Modal Size	14.5 & 18.5"	-		13.0"		> 20.0"
Catch/Unit	4.8	< 0.1		4.8		0.7
6/18&7/29/81						
Bmkng/50'Seine						
Number	11	0		34		-
Size Range				< 3.0 - ?		
Modal Size				<3.0", 6.4"		
Catch/Unit						
8/23/84						
Boomshocking						
Number	21	2		37		0
Size Range	12.0 - 22.4"	24.5 - 25.9"		5.0 - -17.9"		
Modal Size						
8/26/86						
Boomshocking						
Number	21	5		32		7
Size Range	7.0 - 25.4"	7.9 - 32.4"*		3.0 - 17.9"		8.5 - 10.4"
Modal Size						
		*+14 (7.5-7.9")				
10/5/94						
Boomshocking	1hr 5 min	1 hr 5 min		1 hr 5 min		1 hr 5 min
3.0 - 15.9'	22	7		10		5
Size Range	9.5 - 27.9"	11.5 - 31.4"		3.0 - 15.9"		12.5-14.4"
Modal Size	16.5"	28.8"		9.4"		13.9"
Catch/Unit						

TABLE 11. Muskellunge Lake(Lincoln Co) Fisheries Investigation & Stocking History

PANFISH						
SPECIE	Yellow Perch	Bl. Crappie	Bluegill	Pumpkinseed	R.Bass/Warmou	Bl/Br Bullhead
9/29/79						
Boomshocking						
Number	6	18	28	3	0	1/0
Size Range	2.6 - 6.6"	1.4 - 10.1"	3.3 - 7.0"	6.0 - 7.0"		9.6"
Mod						
4/7-14/81						
Fyke Net						
Number	349	260	1251	6	P/P	Br137/Bl P
Size Range	5.0 - 9.7"	3.6 - 11.2"	1.0 -7.6"	4.4 - 6.8"		5.8 - 13.4"
Modal Size	5.8	6.8	2.7, 5.0, 6.0"	5.6"		10.2"
Catch/Unit	10.9	8.1	39.1	0.2		4.3
6/18&7/29/81						
Bmkng/50'Seine						
Number	-	-	-	-	-	-
Size Range						
Modal Size						
Catch/Unit						
8/23/84						
Boomshocking						
Number	2	8	24	3		
Size Range	6.0 -6.3"	7.0 - 8.5"	3.6 - 6.9"	4.0,6.6,6.7		
Modal Size			5-6" abundant			
8/26/86						
Boomshocking						
Number	-	3	6			
Size Range		7.9,8.1, 7.3"	5.8 - 7.6"			
Modal Size			6.5"			
10/5/94						
Boomshocking	5 minutes	20 minutes	5 minutes	5 minutes		
Number	15	18	74	2		
Size Range	3.0-9.1"	4.4"9.5"	1.0 - 7.0"	6.2 - 6.9"		
Modal Size	6.1"	8.2"	4.8, 5.9"	6.5"		
Catch/Unit						
P = Present						

The first recorded stocking history of Muskellunge Lake began in 1938 at which time 1,250 adult bluegill and 55 adult black crappie were stocked. See **TABLE 12.** No information on the fishery prior to this stocking was found in the DNR files. Could this initial stocking of bluegills and black crappies have created the dominant bluegill population we have today and contributed to the the large numbers of black crappies that have been found in the surveys? Eighteen black crappies were captured in 20 minutes of shocking while 15 yellow perch were captured during 5 minutes of shocking. It is probable that there is also a healthy yellow perch population in Muskellunge Lake? Did the stocking of 7,600 largemouth from 1948 to 1950 establish the largemouth bass fishery we have in the lake today?

TABLE 12. Stocking History of Muskellunge Lake from 1938 -1995.

DATE	SPECIES	# PLANTED	SIZE	
1938	Bluegill	1250	Adult	
	Black Crappie	500	Adult	
1941	Muskellunge	5000	Fry	
1942	Muskellunge	10000	Fry	
1945	Muskellunge	24000	Fry	
1946	Muskellunge	1146	Fingerlings	
1947	Muskellunge	60000	Fry	
1948	Largemouth	5000	Fingerlings	
1949	Largemouth	300	Fingerlings	
	Muskellunge	1500	Fingerlings	
1950	Largemouth	2300	Fingerlings	
1952	Muskellunge	630	Fingerlings	
1953	Muskellunge	315		
1954	Muskellunge	116		
1955	Muskellunge	151		
1956	Muskellunge	30		
1957	Muskellunge	600		
1959	Muskellunge	100		
1960	Muskellunge	620		
1961	Muskellunge	150		
1962	Muskellunge	460	Fingerlings	
-See Attached Permits -				
1982	Muskellunge	160	Fingerlings	
1983	Muskellunge	150	8-10"	
1984	Wylie	150	7-10"	
	Largemouth	1200	Fingerlings?	
1985	Muskellunge	1000	8-10"	
	Wylie	610	2-3"	
	Largemouth	400	1"	
1986	Muskellunge	330	8-10"	
1992	Walleye	1000	4-9"	
1995	Walleye	1540	8-10"	Private Stocking

The walleyes captured in the 1994 shocker survey were in the 12.5 to 14.4" size range. These fish may have been from the 1992 stocking of 1000 4 to 9" walleye. Again natural reproduction or survival of small fish may not be occurring at this time. Yet in 1981- with no known stocking prior - large walleyes were captured during fyke netting indicating that some reproduction was occurring in the system at one time.

Scales collected during the 1997 growing season provided the following data in the TABLE 13 below:

TABLE 13. Age Growth of Muskellunge Lake Fish in 1997.

Capture Date	SPECIES	LENGTH	N. WIS AVE.	AGE
6/17/97	Muskellunge	40"	36 to 38"	8 to 9
6/18/97	Northern Pike	13"	13.7"	2+
6/17/97	Northern Pike	15"	19.8"	4+
6/17/97	Northern Pike	17"	22.1"	5+
6/17/97	Northern Pike	25"	27"	9+
6/18/97	LM Bass	9"	9.1"	3
7/29/97	LM Bass	13"	13.6"	6
7/29/97	LM Bass	14"	15.0"	7
6/14/97	Black Crappie	6.75"	6.7"	4
6/21/97	Black Crappie	8"	7.8"	5
6/14/97	Black Crappie	9.35"	9.2"	6
6/21/97	Black Crappie	10"	9.6"	7
6/21/97	Bluegill	7"	4.4"	4

From this small sample size it appears that most fish except the northern pike are growing well in Muskellunge Lake.

Conclusions

Very few conclusions can be made regarding the fisheries of Muskellunge Lake with the small amount of data that has been collected and interpreted. Very low winter oxygen conditions do not appear to cause fish mortalities but refuge may be found in the outlet stream or in areas near the small inlet tributaries. There appears to be adequate spawning habitat for both muskellunge, northern pike, and walleye. What is limiting walleye survival and reproduction? Does the stressful winter conditions hamper adult spawning success or do the eggs, fry, or young not survive? Are the numbers so low that they do not survive in any numbers? Do the stocked walleyes know where to spawn or do they need to be imprinted as eggs or fry? These are questions that need to be answered regarding the fisheries. Water quality problems may be linked to the fisheries in several ways. Poor water quality may stress the fish in winter months or concentrate fish in areas where they could be preyed upon. Zooplankton and phytoplankton pulses may not coincide with the timing of the food needs of post larval fish to produce good year classes of certain fish.

TRIBUTARY STREAMS AND THE MUSKELLUNGE CREEK OUTLET

Introduction

Oxygen/temperature sampling was taken at the mouth of unnamed tributaries entering Muskellunge Lake in the northeast and south bays. Sampling were also taken at several locations on Muskellunge Creek to assess the potential oxygen refuges/barriers that could effect fish & aquatic organism survival and migration.

Procedure

The assessment of the water quality included oxygen/ temperature monitoring of the unnamed tributaries entering Muskellunge Lake in the northeast and south bays plus the outlet stream - Muskellunge Creek.

Sampling locations included :

1.) the outlet of tributaries as they enter Muskellunge Lake in the northeast and south bays
2.) Muskellunge Creek outlet from lake
3.) Muskellunge Creek crosses Muskellunge Lake Road at the N-S section line between Section 13 & 14,
4.) Muskellunge Creek crosses Muskellunge Lake Road at the E-W section line of Section 14 & 23, and where
5.) Muskellunge Creek at Moodig Road and CTH A.
6.) Muskellunge Creek road crossing near the Tomahawk Live Trap driveway.

Results and Discussions

The results of the stream monitoring can be found below in **TABLE 14.**The small tributaries entering Muskellunge Lake contained adequate winter oxygen levels but the flow and stream dimensions does not allow refuge in the stream itself except for the smaller minnows and young fish. Yet Muskellunge Creek can provide a refuge for all fish during low oxygen periods plus can provide spawning habitat for all species of fish found in the lake at various times of the year. Muskellunge Creek as it leaves Muskellunge Lake has much of the same water quality characteristics as the lake but spring seepage and flowing water hydraulics soon restores oxygen to the system. In fact before it reaches the Wisconsin River at Tomahawk conditions improve enough to support a cold water fishery. Beaver dam in the past have effected fish migration to and from Muskellunge Lake and have raised water level in the Lake when built close to the lake outlet.

TABLE 14. Winter Oxygen-Temperature Profiles for Muskellunge Lake Tributaries

MUSKELLUNGE CR. DATA:	12/5/97		1/7/98	
	TEMP oC	OXYGEN mg/l	TEMP oC	OXYGEN mg/l
Muskellunge Rd #1:	36	11.5	34	16+
Muskellunge Rd #2:	32	12.3	32	16+
Moodig & CTH H:	34	11.3	32.5	16+
T. Live Trap Rd:	32	10.6	32	16+

	2/13/98		3/24/98	
	TEMP oC	OXYGEN mg/l	TEMP oC	OXYGEN mg/l
Muskellunge Rd #1:	36	6.5	45.1	7.31
Muskellunge Rd #2:	36	6.4	46.4	11.01
Moodig & CTH H:	32	11.8	43.6	11.22
T. Live Trap Rd:	32	10.6	44.4	11.36

INLET STREAM IN NE BAY	12/5/97		1/7/98	
	None		TEMP oC	OXYGEN mg/l
			32	11.8

	2/13/98		3/24/98	
	TEMP oC	OXYGEN mg/l	TEMP oC	OXYGEN mg/l
	None		39.9	10.79

INLET STREAM SOUTH BAY	12/5/97		1/7/98	
	TEMP oC	OXYGEN mg/l	TEMP oC	OXYGEN mg/l
	None		41	6.1

	2/13/98		3/24/98	
	TEMP oC	OXYGEN mg/l	TEMP oC	OXYGEN mg/l
	34	8.8	42.4	6.3

Conclusions

The tributary streams flowing into Muskellunge Lake provide year-round flowing water and provide oxygen to Muskellunge Lake during the low oxygen periods when ice covers the lake. These streams probably provide spawning habitat for several minnow species. Much of the stream entering the northeast has been cut from minnow migration by a driveway culvert that acts as a dam on this small stream.

Muskellunge Creek is an important part of the Muskellunge Lake ecosystem. The south bay of Muskellunge Lake looses oxygen beneath the ice quicker than other deep water bays of the lake. Under the severest low winter oxygen conditions this oxygen barrier could prevent fish in the rest of Muskellunge Lake from reaching the Muskellunge Creek oxygen refuge. For this reason, an aeration system needs to be placed in thenorthend of the lake to provide an alternative oxygen refuge.

Many Lake dwelling minnows and forage fish require high quality moving water streams to spawn and incubate their eggs. Muskellunge Creek can provide this environment for MuskellungeLake minnows and forage fish. The stream channel leaving the lake must be kept free of any fish barriers year-round. The present management practice of trapping beaver from Muskellunge Creek should continue.

MUSKELLUNGE LAKE
LINCOLN COUNTY

RECOMMENDATIONS FOR LONG TERM PROTECTION & MANAGEMENT

Introduction

The future health of Muskellunge Lake is dependent on area residents understanding the problems described in this study and how well and sincerely we apply the solutions suggested in this plan. The following recommendations are based on ecological principles that man can have a positive effect on if applied. The scope of this study was to look at the past , compare it to the present inventory, and create a plan to preserve or enhance the attributes of Muskellunge Lake in the future. Maintaining oxygen and maintaining habitat are two key components of the Muskellunge Lake management that must be addressed for the future welfare of the lake ecosystem.

There are plenty of nutrients available for fish and aquatic plant growth in Muskellunge Lake. The future of Muskellunge Lake is dependent on providing a suitable oxygenated environment so these nutrients can be utilized by fish, wildlife, a diversity of beneficial plants, and by man. At the same time, every effort must be made so no new nutrients enter the lake that would add to those already found there in abundance.

The lake community will be the one that benefits from their own actions if they follow the recommendations below. Recreational benefits include a sustainable restored fishery, and a diverse and manageable aquatic plant community for wildlife viewing and boating. The monetary value of your lake property is reflected in the quality of your lake.

Muskellunge Lake management options and recommendations are discussed under the following headings:

Winter Aeration System
Watershed Land Use Plan
Lake Use Plan
Habitat Restoration
Fishery Restoration
Ecosystem Restoration

WINTER AERATION SYSTEM

Background

The evaluation of the oxygen- temperature regimes of Muskellunge Lake combined data collected from 1996 to 1998 and past data collected in 1978-79 . During long winters with prolonged snow cover oxygen is nearly completely depleted from Muskellunge Lake in all deep hole areas. During less severe winter oxygen is totally depleted below the 6 to 8 foot depth and stressful low oxygen levels are found above these depths. The north bay maintained remnant oxygen levels just beneath the ice after the severe winter of 1996-97.

Natural oxygen refuges can be found in the Muskellunge Lake ecosystem. The small streams entering the northeast bay and south bay maintains oxygen throughout the winter but their shallowness would only supply a refuge for small fish during the winter oxygen depletion periods. The small plume areas where they enter Muskellunge Lake do supply a small area as refuge to larger fish and aquatic organisms. Muskellunge Creek can provide a winter oxygen refuge for all fish and mobile aquatic organisms that are able to reach it. Spring seepage which is dependent upon rainfall and hydrostatic pressure may also provide oxygen to Muskellunge Lake under the ice. These areas are important in maintaining invertebrate that require higher oxygen levels for survival.

Management Options

The organic load of bottom material has a large oxygen demand and any attempt to provide enough oxygen to meet this demand over the entire lake under the ice would be cost prohibitive. It appears that some aeration could especially help the lake during severe winters and provide a fish refuge for fish species less tolerate of low oxygen during most winters.

The FIRST OPTION is to do nothing and let nature take it's course. Changes in the plant and fisheries communities that are moving towards those species more tolerant of poor water quality will continue. The present oxygen refuges can be effected by development pressures of increased pumping of ground water and habitat destruction.

The SECOND OPTION is to maintain an oxygen refuge by the installation of a small compressor aeration system. An evaluation of the system should be made after the installation. It is recommended that the aeration system be installed and placed in the north bay. The north bay has the best water quality of deep areas sampled, therefore the oxygen demand would be the least and higher winter oxygen levels maintained. This area is also the farthest area from the Muskellunge Creek outlet, therefore this installation would provide a second oxygen refuge closer in proximity to depleted oxygen areas. The north bay and adjacent areas also have the most suitable spawning habitat for fish species that spawn shortly after ice out (e.g. walleye,northern, and perch) - therefore reducing under the ice oxygen stress for these species prior to spawning.

WATERSHED LAND USE PLAN

Background

A total of 1,109 acres of land drain through Muskellunge Lake. Most of the upland soil is very well drained to excessively drained, therefore water enters the water table of Muskellunge Lake very quickly.

Fifty-nine percent of the watershed is forested and is mostly in private ownership. Some of the forested canopy is on the steep slopes of land adjacent to wetlands and open water of Muskellunge Lake, but most of it is on industrial forest land separated from the lake by STH 51 east of the lake. Maintaining a canopy over the light soils in both locations in the watershed are very important in preventing surface erosion and loss of plant life beneath the canopy.

Wetlands make up 24% of the watershed land and provide nesting habitat and cover for much of the wildlife found in the Muskellunge Lake community. Some of this wetland habitat is found adjacent to the lake but much is also found east of STH 51. These wetland areas are all ground water recharge areas that eventually provide water to Muskellunge Lake. Wetland forest, which is habitat for plant and animals and water retention areas, are also include in forested area of the watershed.

Low development, farm steads, and roads make up about 13% of the watershed. Because of the proximity to STH 51 and the City of Tomahawk increases in these land uses will create further development pressures on the watershed and resources that effect Muskellunge Lake. Ground water contamination and habitat loss would be the greatest threats to the Muskellunge Lake ecosystem with this increased land use. Very little agriculture exists in the watershed and pasture and cover crops at the time of the study were the only agricultural uses on the 55 acres identified. The light soils prevent much intensive farming without irrigation. It is more likely this land will be converted to low development and roads in the near future.

Management Options

Land use planning is proceeding in the Town of Bradley. This new process takes aim at controlled development that considers the value of preservation of the ecological systems described in this report. The following management options should give guidance to the lake district as to what they need to do to protect the resources of the lake through protection of the watershed.

The citizens of the lake community have already become involved in the protection of the watershed from ground water pollution of the southwest corner of STH 8 and 51. The effectiveness of any plan or regulation to protect a resource is only as good as the power of an informed citizen to inform other community members and react to the threats to the resource.

The FIRST OPTION to the lake district is to do nothing. This allows individuals to act on their own in matters that involve zoning ordinances and planning. Time, energy, and effectiveness of individual accomplishing watershed protection is limited. Lake district action and influence can personify the individual effort into positive action that can protect the resource.

The SECOND OPTION is to work towards a land use plan that can protect the wetlands and forest canopy on the lake shore and in the watershed. The approach for protection of each will vary because of their location.

The existing zoning law for shoreline development with it's setbacks and shoreline vegetation preservation are currently being reviewed for their failure of enforcement and variance abuses. Wetland protection is also facing the same protection failures. The lake district can support the enforcement and changes in variance practices at the both the county and state levels. Lake district members are presently active in the land use planning for the Town of Bradley and are striving for protective measures.

The THIRD OPTION can be taken by the lake district directly. The lake district, as as a legal governing body, can pass regulations of their own to stop removal of shoreline vegetation and the tree canopy. The need to enforce canopy removal beyond the distance protected by county shoreline zoning is evident on Muskellunge Lake. Areas of steep slope and light soils should be designated for protection and lake riparian owners informed of the importance of this regulation.

The FOURTH OPTION is to take lake district action on the restoration of the immediate shoreline. The immediate shoreline area is also an area where dwellings can contribute waste to the lake. The trend identified in this study is that replacement with newer septic systems is occurring based on use and property ownership changes. Yet the effectiveness of nutrient removal on the excessively drained soils even with new septic systems is limited. The restoration of the shoreline buffer using plants with deep root systems to intercept the nutrients entering the lake is an excellent way to keep these nutrients from entering the lake. The lake district through the planning grant process can recognize the sites with the greatest potential and work with landowners in development of a shoreline buffer that is acceptable to them. A demonstration project can be completed through the lake protection grant process.

The FIFTH OPTION is to be active in protecting the forest canopy and wetlands east of STH 51. The future construction of the four lane could be altered to lower the culverts under the highway to accommodate both surface and groundwater flow from this area of the watershed to Muskellunge Lake. Hydrological studies could be completed, but not in time to alter the construction plans. The district should approach the DNR environmental liaison representative and the DOT environmental coordinator regarding this matter.

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The lake district should also become aware of the long term plans for the industrial forest land east of STH 51. Clear cutting activity could create erosion and effect the large areas of wetland bordering this forested area. This action could also be approached in the land use planning activities.

The SIXTH OPTION is to remain aware of development activities in the watershed. Certain land uses could threaten groundwater quality entering Muskellunge Lake or effect surface water drainage patterns that can effect adjacent wetlands. Specifically, the development of farmland areas immediately to the east and southeast should be of concern. Again, protection can be addressed through being very active as a lake district in the land use planning in the township.

LAKE USE PLAN

BACKGROUND

Muskellunge Lake has a very diverse population of aquatic plants. This diversity of plants is now being threatened by high organic levels. Those plants that do well with a high organic load have increased in density over the past 20 years. What roles do boat and personal watercraft play in suspending the organic matter when they are operated in shallow water? It is hard to quantify but it is occurring.

Muskellunge Lake with it's relatively small size and narrow width limits most "turnaround areas" to shallow areas on both ends of the lake. Several more shoreline areas are subject to wave action as boats pass through narrow passages from one bay to the next. Other silted bays are filled with floating vegetation through much of the year that make access to riparian lands and the boat landing difficult without stirring up bottom sediments.

The most common problem recognized in the property owner's survey was those that dealt with the noise, safety, and destructiveness of watercraft on shoreline fish and wildlife habitat . The west northwest bay of Muskellunge lake has already been identified as a refuge area but other equally sensitive areas are also threatened. Too much organic matter and "weeds" in bays were also common problems recognized in the property owner's survey. Machine harvesting of aquatic plants and dredging of lake bed materials were the priorities offered the most to solve the problems of the lake in the property owner's survey.

Management Options

Many of the conflicts on Muskellunge Lake could be resolved by compliance with existing boating regulations. Many sensitive areas could also be protected by the compliance with these laws. It is unlawful to operate any motor powered boat within 100 feet of any dock, raft, pier or buoyed restricted area on any lake at a speed in excess of slow no wake. Since much of the shoreline of Muskellunge Lake is developed, these structures are present around most of the lake . Other sensitive area could be buoyed off from watercraft.

The FIRST OPTION is to do nothing. User conflicts will increase and eventually an accident could occur. The suspension of organic material will eventually turn the plant community into species that will further interfere with navigation and decrease the plant diversity.

The SECOND OPTION involves the education of lake residents & visitors. A map indicating sensitive areas and the navigational plan could be distributed to lake residents and posted at the resorts boat landings and at the public landing. Major boating laws that address the conflicts identified above also could be posted with the map.

The THIRD OPTION would be to develop a navigation plan that would identify navigational routes that consider protection of sensitive areas and current laws that address distances from shorelines. This navigation plan would include a aquatic plant management plan that would provide a harvest system to open up access to riparian and public accesses yet protect sensitive areas. This plan would require more input from lake residents for formation and acceptance of the plan.

The navigation plan would recognize areas of navigational buoy placement that could be help in the education and enforcement efforts. The options for buoys include: Slow-no-wake areas, restricted use areas, and channel markers. With proper marking violations could be enforced at the state-county level.

The FOURTH OPTION would be to help form and contribute to a shared boat patrol. Information as to sensitive areas (restrictive areas), buoyed areas and boat routing could be provided to the boat patrol for enforcement.

HABITAT RESTORATION

Background

The accumulation of nutrients in Muskellunge Lake, if not channeled into plants and animals that can be harvested from the lake, will eventually cause water quality problems that can only support a few fish species. Habitat is nearly as important as water quality in maintaining a diverse fish population.

Development of the shoreline and depletion of summer oxygen below 6 to 10 feet are two habitat limitations that are effecting the habitat of the fisheries at the present time. Shoreline development has decreased the amount of fallen tree snags that are important for both fish and the aquatic organisms that fish feed on. In-lake activities of shoreline development have effected shallow water plants that are also contain cover, food, and spawning substrate for the fish of Muskellunge Lake.

Local development has also effected streams entering and leaving Muskellunge Lake including creating barriers to fish migration. Misplaced culverts as well as beaver dams can stop both game and forage fish from reaching spawning or oxygen refuge areas.

Options

The FIRST OPTION is to begin a fish crib restoration project. Cribs should be placed in pods of three at a depth of 6 to 10 to coincide with summer thermocline conditions in each bay. This depth also would coincide with the depth where some oxygen is present during most of the winter under the ice. This depth will not hamper navigation. Placement in pods of three will provide a refuge for various species of fish- from game to panfish to minnows. DNR Water Regulation plan and permit must be submitted and applied for.

The SECOND OPTION is to begin a snag restoration project around Muskellunge Lake. Trees that have fallen into the water from the shoreline are rare in the Lake. Snags provide shallow water cover and food for all sizes of fish species. There surface provides nutrients for snails and other invertebrates that fish feed upon. The yellow perch lays it's ribbon of eggs on sandy shorelines. The survival of this semi buoyant egg mass depends on being suspended off the bottom on snags or old emergent vegetation in shallow water. If they drift to deeper water where there is no circulation of water or low oxygen the eggs will not hatch. Every sandy shoreline riparian lot should have at least 1 snag on Muskellunge Lake. DNR current policy considers placement of a snag a structure that requires a permit. A condition of the permit is that it must be anchored as to not float away and become a hazard to navigation.

The THIRD OPTION is similar in purpose to the second option. Several rush species were identified in the plant survey (*Eleocharis* & *Scirpus sp.*). These species like sand and gravel bars and prefer a firm bottom with little muck. There location in small shallow bays makes them ideal not only for yellow perch spawning areas but spawning areas for northern pike and muskellunge. Later these over wintering rigid stems provide spring cover for fish and their fry before other vegetation can grow to provide cover. These rush beds and an abundance of former beds of these species could have been responsible for the the production of muskellunge that created the namesake.

The FOURTH OPTION is to reset a private driveway crossing on the unnamed tributary that enters Muskellunge Lake in the Northeast bay. The culvert was not set low enough so a plunge pool exists below the culvert. This prevents the migration of minnow species to the wetland stream above for spawning. Minnow species are important in the food chain in consuming of plankton, detritus, and periplankton and sending it up the food chain as forage for other fish. Many minnow species spawn in streams and their young migrate back to the lake for feeding. An improperly placed culvert or snag or beaver dam obstructions on Muskellunge Creek would have the same repercussions on the outlet stream.

FISHERY RESTORATION

Background

The restoration of a diverse fisheries will ultimately depend on providing fish oxygen refuges under the ice in winter, and preserving and restoring the habitat considerations discussed in other parts of these recommendations. Their appears to be adequate spawning habitat for both muskellunge, northern pike, and walleye. According to the 1981 survey a self reproducing walleye population was present in the lake at that time. The extended growth walleye stocked in 1992 have also survived.

There is no available knowledge on the minnow species of Muskellunge Lake. These species are important in the converting organic nutrients into fish. Therefore, they are important in dampening the effects of accumulation of organic matter on water quality. Again, the greater diversity of fish and other organisms that Muskellunge lake can support the more nutrients can be channeled up the food chain and away from poor water quality conditions.

In return, water quality problems may be linked to the decline fisheries in several ways. Poor water quality may stress the fish in winter months or concentrate fish in areas where they could be preyed upon. Providing adequate winter oxygen refuges may alleviate the stress to early spawning fish such as the muskellunge, northern pike, yellow perch, and white sucker.

Management Options

The Wisconsin DNR has recognized that a minimum of 5 year classes of walleye must be present in a population to provide any kind of fishery. Therefore, it should be a goal of the Muskellunge P & R District to establish a minimum of 5 year classes of walleye and establish a natural reproducing population. Wisconsin walleye populations that are maintained by natural reproduction average between 3 to 5 adults/ acre and about 20 individuals of all ages per acre.The following options address this goal. Cost sharing for these options can be secured through the Lake protection grant program.

The FIRST OPTION is to stock extended growth walleyes for three years which should allow the first year walleyes stocked to reach maturity (approximately 15" minimum). With this option natural reproduction should be assessed by boom shocking for fall fingerlings in the fourth year or wait for capture of smaller fish in the fifth and sixth year.

The SECOND OPTION is to plant fertilized eggs or fry at suitable spawning sites to imprint those stocked to return to the site as an adult to spawn. This is based on the assumption that those stocked as extended growth fingerlings are unable to identify and use the suitable spawning sites.

The THIRD OPTION is to appraise the N. Redbelly Dace and White Sucker population of Muskellunge Creek and the lake. This could be done monitoring water temperatures and observing spawning runs. If inadequate stocks exist stocking of each species is possible to reestablish populations.

The FOURTH OPTION should follow habitat restoration of snags and protection of rush beds. If yellow perch spawn ribbons are not observed in the shallows stocking of spawn of yellow perch may be needed.

ECOSYSTEM MANAGEMENT

Background

The relationship of Muskellunge Lake with the surrounding land is evident in the watershed information in this report. But Muskellunge lake is also dependent on a larger watershed area that the Muskellunge Lake area drains to. Muskellunge Lake's outlet connection to Muskellunge Creek, which further connects to the Wisconsin River at Tomahawk, is just as important to the restoration and functioning of Muskellunge Lake ecosystem.

Muskellunge Creek's water quality actually improves significantly between Muskellunge Lake and the Wisconsin River. Springs entering at several locations actually cool the water in summer and warm the water in winter providing excellent water quality year round. The use of Muskellunge Creek as a fish refuge for the winter, oxygen depleted Wisconsin River and Muskellunge Lake is an important aspect of this ecosystem. Most Wisconsin fish migrate - from minnows to panfish to game fish. Muskellunge Creek is the corridor to the vast network of waterways of the Wisconsin River for fish to migrate to and from as populations fluctuate.

Management Options

At the present the City of Tomahawk is pursuing the annexation from the Town of Bradley areas bordering Muskellunge Creek. Developing the area adjacent to Muskelluinge Creek without proper planning can threaten the important stream resources that now exist. Runoff from new paved roads and altered drainage patterns from the land can severely effect Muskellunge Creek. With develop comes road river crossings and any misplaced culvert can create a fish barrier. Oil and salt runoff from paved areas will also threaten Muskellunge Creek.

Muskellunge Lake Protection and Rehabilitation District must make every effort to protect Muskellunge Creek. The following options are written to quite the district.

The FIRST OPTION is to do nothing allowing further development adjacent to the stream without the consideration of the effects on the stream

The SECOND OPTION is for the Lake District to be active as a government body in reviewing and responding to any township or city action that could effect the stream. The immediate corridor area adjacent to the stream should be designated and managed as green space.

The THIRD OPTION is for the Lake District to development a management plan for the Muskellunge Creek corridor with the town,city, and adjacent landowners that protects the stream. Existing environmental sensitive areas need to be recognized and protected. Drainage from future developed areas must be diverted from directly entering Muskellunge Creek. Any existing fish barrier or future barriers should be removed or avoided.

The FOURTH OPTION would extend protection efforts to the Wisconsin River. Cleanup and protection of the Wisconsin River is the next link in protecting Muskellunge Lake.

The third option could be done cooperately with the township and the city with cost sharing secured through the Lake planning grant program. This plan could be incorporated into a land use plan in the future.