Management Plan

Mill Lake Management Plan

Prepared for:
Mill Lake Association

and

Bloomingdale Township
P.O. Box 11
Bloomingdale, MI 49026

Prepared by:
Progressive AE
1811 4 Mile Road, NE
Grand Rapids, MI 49525-2442
616/361-2664

February 2009

Project No: 60340101

ProgressiveAE

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Executive Summary

Mill Lake is located in Bloomingdale Township in Van Buren County, Michigan. In March of 2007, Progressive AE was retained by Bloomingdale Township to conduct a lake improvement feasibility study and to prepare a management plan for Mill Lake.

Based on water quality data collected to date, Mill Lake is categorized as a mesotrophic lake. That is, the lake is moderate between a lake that is deep and clear with little plant growth and one that is shallow, nutient-enriched and supports abundant plant growth. Phosphorus levels, chlorophyll-*a* levels, and Secchi transparency in Mill Lake are moderate. However, the depletion of dissolved oxygen and the build-up of phosphorus in the deep waters in late summer are early signs that “eutrophication” (or nutrient enrichment) is occurring in Mill Lake.

An ounce of prevention is worth a pound of cure.

As part of the study, a theoretical nutrient budget was constructed for Mill Lake. A nutrient budget is a calculation of phosphorus inputs to the lake based on land use, soil types, and other conditions in the surrounding watershed. The nutrient budget focused on phosphorus because phosphorus is usually the nutrient that controls eutrophication and because phosphorus inputs are more subject to control through management practices. Phosphorus budget calculations indicate that current levels of input to Mill Lake are sufficient to push the in-lake phosphorus concentration above the eutrophic threshold. Above the threshold, plant growth would be expected to increase, water transparency and dissolved oxygen levels would decrease, and the quality of the lake would decline. The most significant sources of phosphorus to Mill Lake include septic systems (which account for 41% of phosphorus input), residential runoff (30%), and agricultural runoff (11%). In order to protect the quality of Mill Lake over the long term, phosphorus inputs should be reduced. As is often the case, an ounce of prevention is worth a pound of cure.

The recommended management plan for Mill Lake includes aquatic plant surveys and nuisance aquatic plant control; water quality monitoring; and watershed management. The watershed management program includes preparation of a guidebook for homeowners; septic system management; phosphorus fertilizer regulations; wetland protection; agricultural best management practices; and planning and zoning.

Although there is currently no crisis in the quality of Mill Lake, this period of time is critical to prevent water quality degradation and costly remediation. The Mill Lake Association should be commended for taking a proactive approach to protect that precious resource known as Mill Lake.

Introduction

Mill Lake is located in Sections 13, 14, 23, and 24 of Bloomingdale Township in Van Buren County (T1S, R14W; Figure 1). In March of 2007, Progressive AE was retained by Bloomingdale Township to conduct a lake improvement feasibility study. The objective of the study was to develop and define a management plan for Mill Lake. The purpose of this report is to present study findings, conclusions, and recommendations.

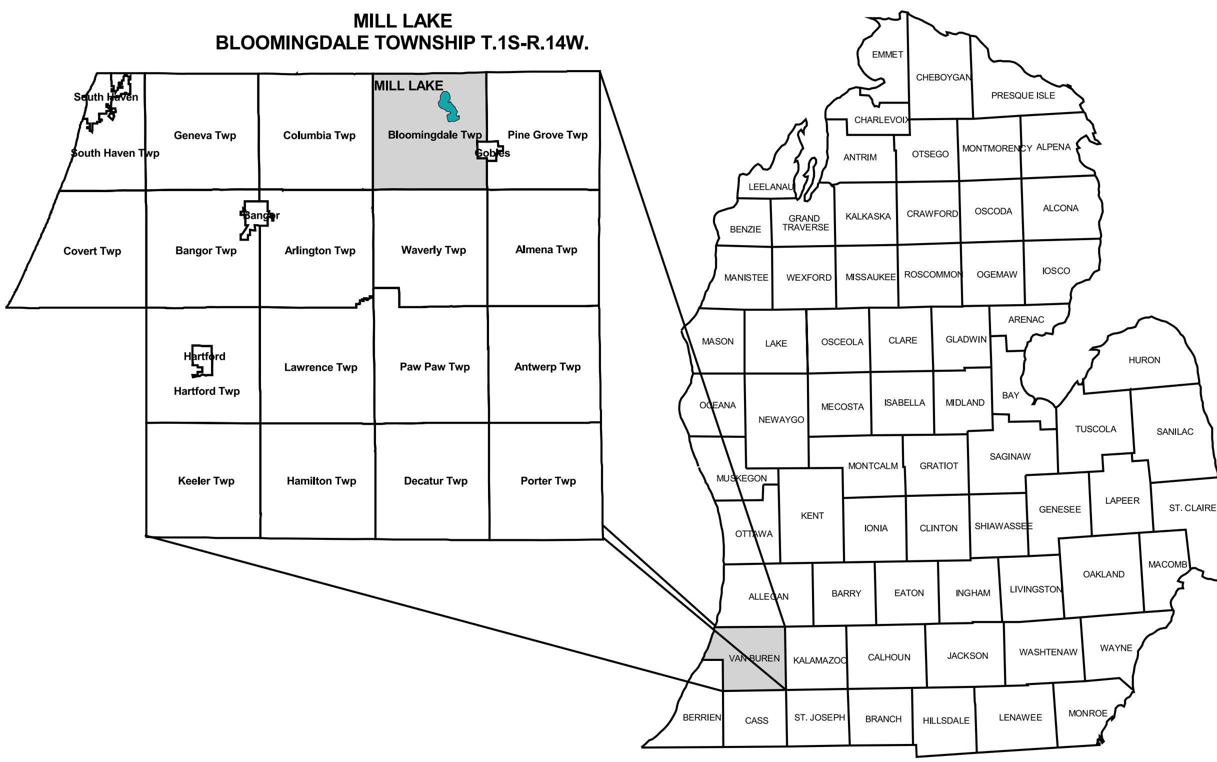


Figure 1. Project location map.

Physical, Chemical, and Biological Characteristics

Lake water quality is determined by a unique combination of processes that occur both within and outside of the lake. In order to make sound management decisions, it is necessary to have an understanding of the current physical, chemical, and biological condition of the lake, and the potential impact of drainage from the surrounding watershed.

Lakes are commonly classified as **oligotrophic, mesotrophic, or eutrophic**. Oligotrophic lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient dissolved oxygen in the cool, deep bottom waters during late summer to support cold water fish such as trout and whitefish. By contrast, eutrophic lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish such as bass and pike. Lakes that fall between these two extremes are called mesotrophic lakes.

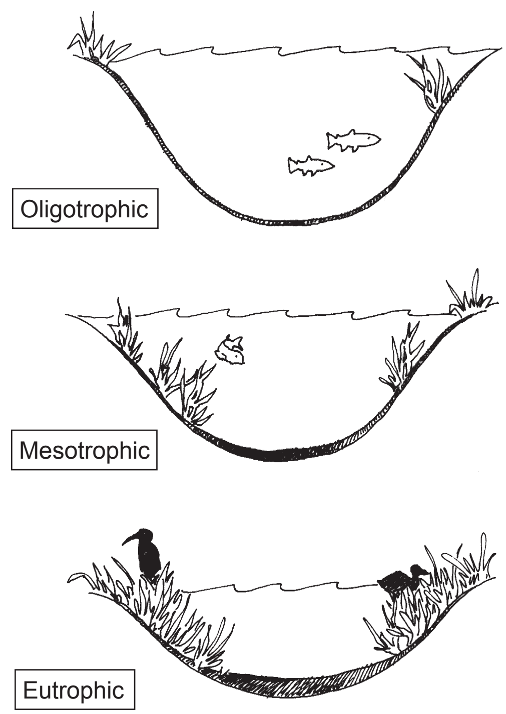


Figure 2. Lake classification.

Under natural conditions, most lakes will ultimately evolve to a eutrophic state as they gradually fill with sediment and organic matter transported to the lake from the surrounding watershed. As the lake becomes shallower, the process accelerates. When aquatic plants become abundant, the lake slowly begins to fill in as sediment and decaying plant matter accumulate on the lake bottom. Eventually, terrestrial plants become established and the lake is transformed to a marshland. The aging process in lakes is called "**eutrophication**" and may take anywhere from a few hundred to several thousand years, generally depending on the size of the lake and its watershed. The natural lake aging process can be greatly accelerated if excessive amounts of sediment and nutrients (which stimulate aquatic plant growth) enter the lake from the surrounding watershed. Because these added inputs are usually associated with human activity, this accelerated lake aging process is often referred to as "**cultural eutrophication**." The problem of cultural eutrophication can be managed by identifying sources of sediment and nutrient loading (i.e., inputs) to the lake and developing strategies to halt or slow the inputs. Thus, in developing a management plan, it is necessary to determine the limnological (i.e., the physical, chemical, and biological) condition of the lake and the physical characteristics of the watershed as well. Methods used to study Mill Lake are included in Appendix A.

MILL LAKE AND ITS WATERSHED

A summary of the physical characteristics of Mill Lake and its watershed is provided in Table 1. Mill Lake has a surface area of 104 acres, a maximum depth of 63 feet, and a mean or average depth of 19.1 feet. A map depicting approximate depth contours in Mill Lake is shown in Figure 3. Mill Lake contains about 1,983 acre-feet of water, a volume which would cover an area over 3 square miles to a depth of 1 foot. The lake has a shoreline 2.2 miles long and a shoreline development factor of 1.5. The shoreline development factor indicates the degree of irregularity in the shape of the shoreline. That is, compared to a perfectly round lake with the same surface area as Mill Lake (i.e., 104 acres), the shoreline of Mill Lake is 1.5 times longer because of its irregular shape. Currently, approximately 80 seasonal and year-round homes border the lake.

TABLE 1
MILL LAKE
PHYSICAL CHARACTERISTICS

Lake Surface Area	104	Acres
Maximum Depth	63	Feet
Mean Depth	19.1	Feet
Lake Volume	1,983	Acre-Feet
Shoreline Length	2.2	Miles
Shoreline Development Factor	1.5	
Lake Elevation	761	Feet
Watershed Area	852	Acres
Ratio of Lake Area to Watershed Area	1:8.5	

Watershed Land Uses	**Acres**	**Percent of Total**
Agricultural	215	12%
Forested/Undeveloped	205	38%
Residential	115	14%
Wetlands	317	37%
Total	**852**	**100%**

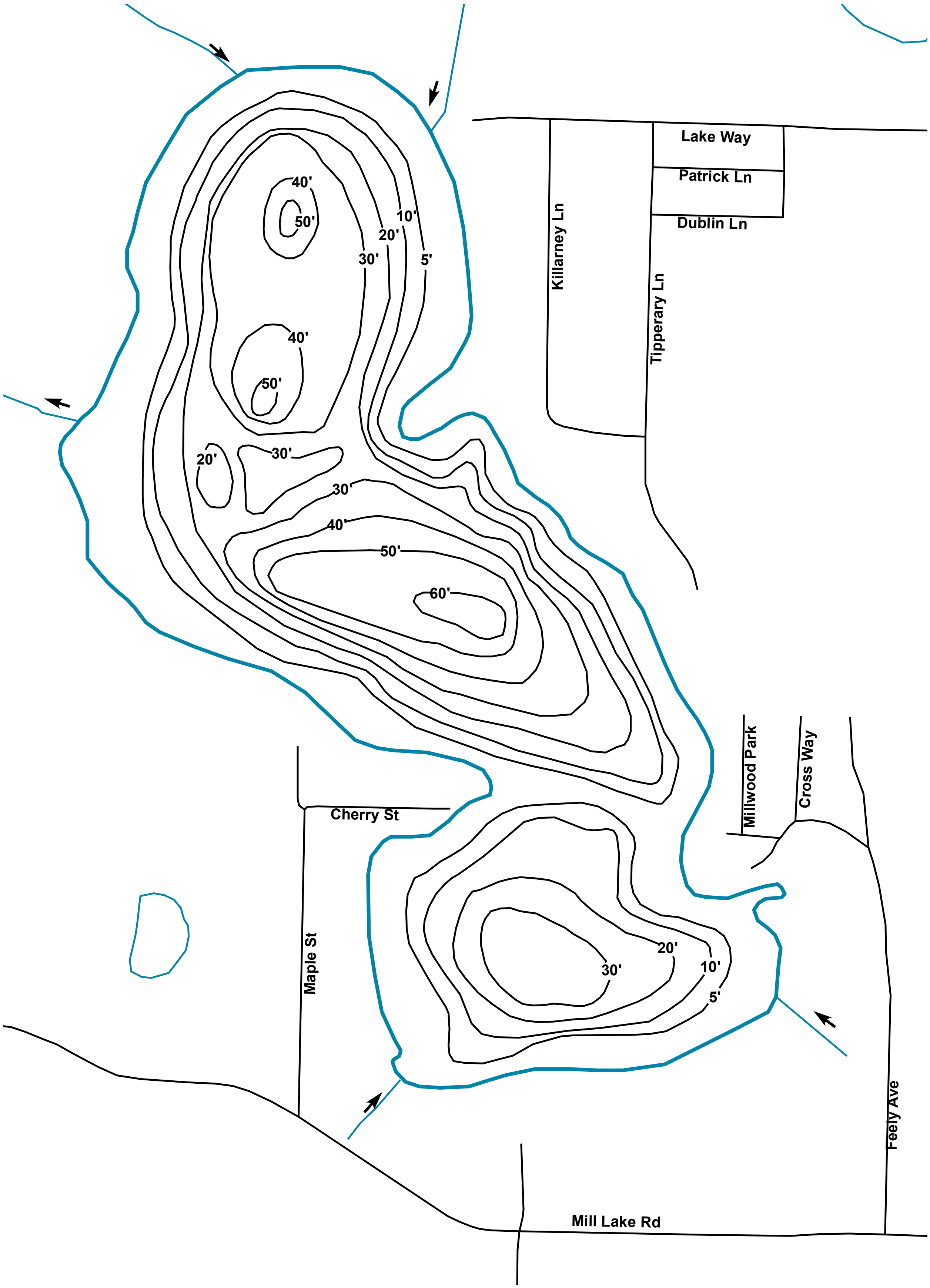


Figure 3. Mill Lake depth contour map.

The land area surrounding a lake that drains to the lake is called its watershed or drainage basin. The Mill Lake watershed encompasses 852 acres (Figure 4). The majority of the watershed is roughly equally divided between agriculture, forested/open land, and wetland with a smaller portion of the watershed in residential land. However, most of the residential land in the watershed abuts Mill Lake (Figure 5). Water drains to Mill Lake via several small tributary streams that primarily drain wetlands. Water flows out from the west shore of Mill Lake to the Mill Lake Drain, a designated county drain. The Mill Lake Drain flows west to Max Lake, to the Max and Haven Drain, to Great Bear Lake, to the Great Bear Lake Drain, to the Black River Extension Drain, to the South Branch of the Black River, and then to the Black River which empties into Lake Michigan in South Haven.

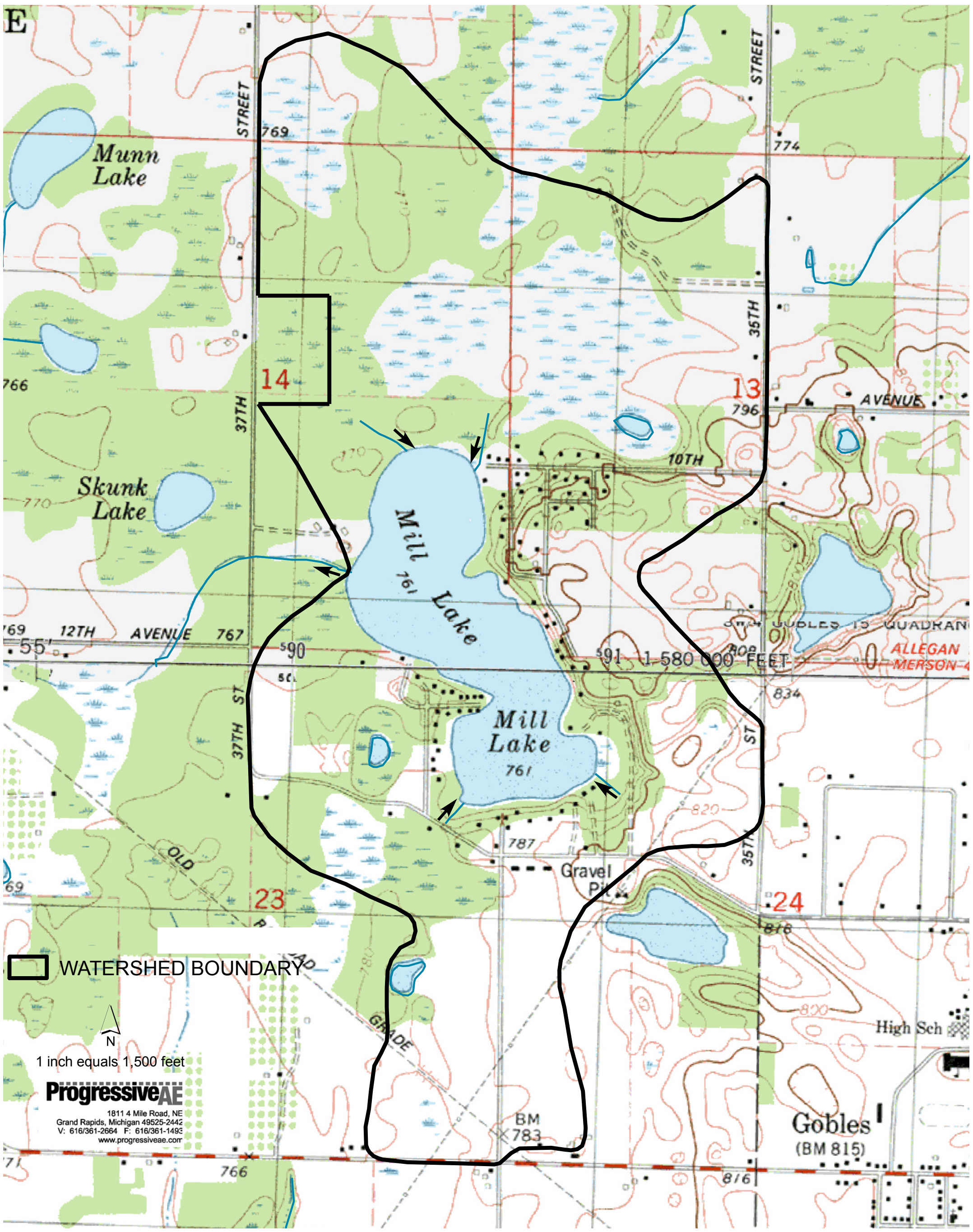


Figure 4. Mill Lake watershed map. Source: US Geological Survey.

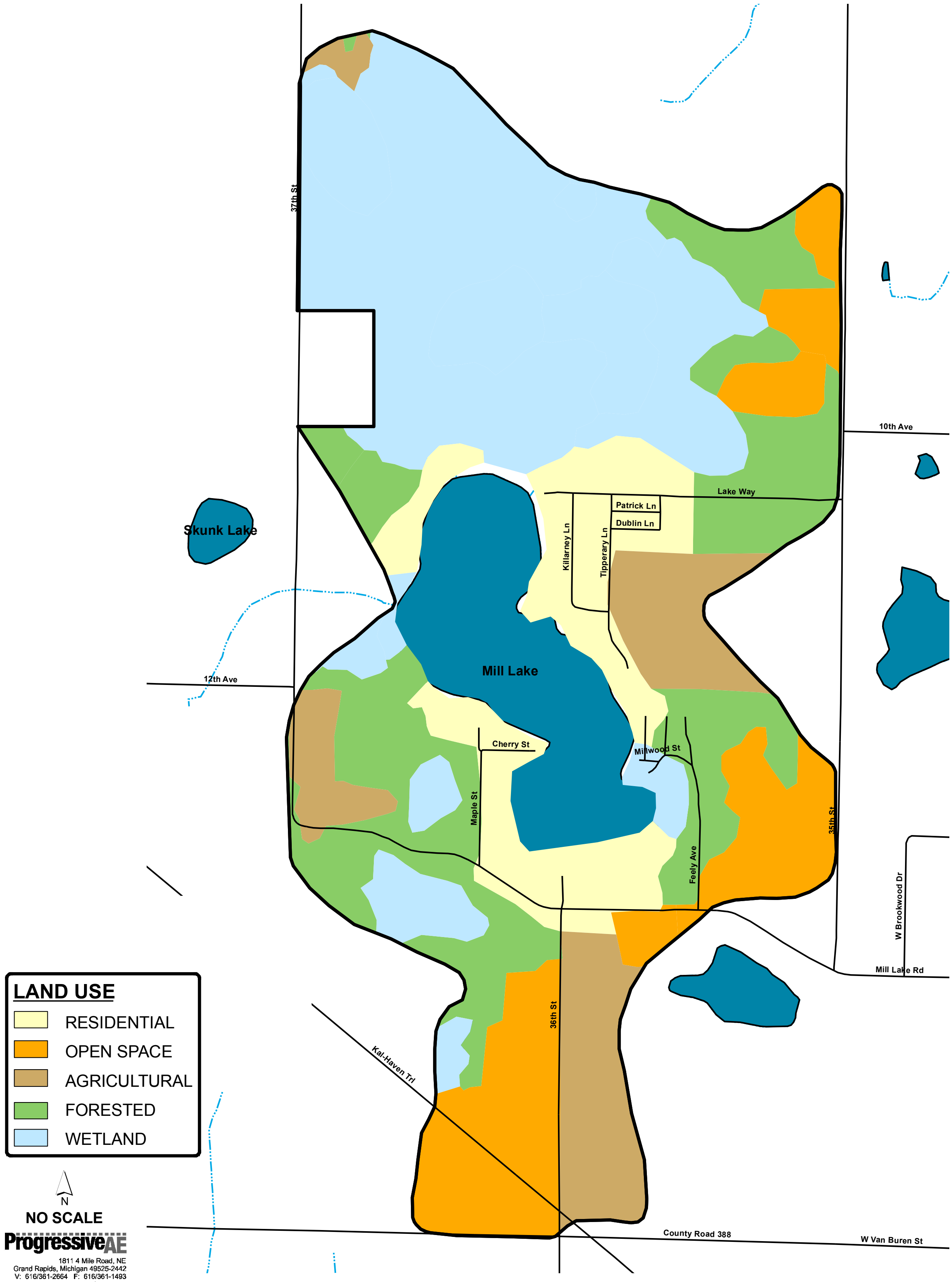


Figure 5. Mill Lake watershed land use map.

LAKE WATER QUALITY

There are many ways to measure lake water quality, but there are a few important physical, chemical, and biological parameters that indicate the overall condition of a lake. These measurements include temperature, dissolved oxygen, total phosphorus, chlorophyll-*a*, and Secchi transparency. The latter three measures are used in classifying a lake. Other important parameters include pH, total alkalinity, and fecal coliform bacteria levels.

Temperature

Temperature is important in determining the type of organisms that may live in a lake. For example, trout prefer temperatures below 68°F. Temperature also determines how water mixes in a lake. As the ice cover breaks up on a lake in the spring, the water temperature becomes uniform from the surface to the bottom. This period is referred to as “spring turnover” because water mixes throughout the entire water column. As the surface waters warm, they are underlain by a colder, more dense strata of water. This process is called thermal stratification. Once thermal stratification occurs, there is little mixing of the warm surface waters with the cooler bottom waters. The transition layer that separates these layers is referred to as the “thermocline.” The thermocline is characterized as the zone where temperature drops rapidly with depth. As fall approaches, the warm surface waters begin to cool and become more dense. Eventually, the surface temperature drops to a point that allows the lake to undergo complete mixing. This period is referred to as “fall turnover.” As the season progresses and ice begins to form on the lake, the lake may stratify again. However, during winter stratification, the surface waters (at or near 32°F) are underlain by slightly warmer water (about 39°F). This is sometimes referred to as “inverse stratification” and occurs because water is most dense at a temperature of about 39°F. As the lake ice melts in the spring, these stratification cycles are repeated. Shallow lakes do not stratify. Lakes that are 15 to 30 feet deep may stratify and destratify with storm events several times during the year.

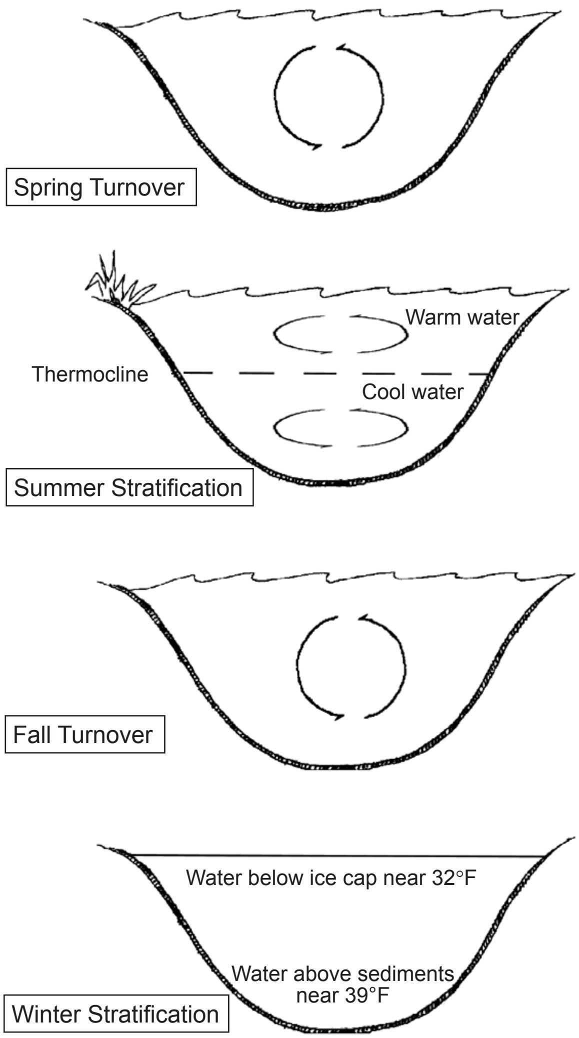


Figure 6. Lake stratification and turnover.

Dissolved Oxygen

An important factor influencing lake water quality is the quantity of **dissolved oxygen** in the water column. The major inputs of dissolved oxygen to lakes are the atmosphere and photosynthetic activity by aquatic plants. An oxygen level of about 5 mg/L (milligrams per liter, or parts per million) is required to support warm water fish. In lakes deep enough to exhibit thermal stratification, oxygen levels are often reduced or depleted below the thermocline once the lake has stratified. This is because deep water is cut off from plant photosynthesis and the atmosphere, and oxygen is consumed by bacteria that use oxygen as they decompose organic matter (plant and animal remains) at the bottom of the lake. Bottom-water oxygen depletion is a common occurrence in eutrophic and some mesotrophic lakes. Thus, eutrophic and most mesotrophic lakes cannot support cold water fish because the cool, deep water (that the fish require to live) does not contain sufficient oxygen.

Phosphorus

The quantity of **phosphorus** present in the water column is especially important since phosphorus is the nutrient that most often controls aquatic plant growth and the rate at which a lake ages and becomes more eutrophic. In the presence of oxygen, lake sediments act as a phosphorus trap, retaining phosphorus and, thus, making it unavailable for aquatic plant growth. However, if bottom-water oxygen is depleted, phosphorus will be released from the sediments and may be available to promote aquatic plant growth. In some lakes, the release of phosphorus from the bottom sediments is the primary source of phosphorus loading (or input). By reducing the amount of phosphorus in a lake, it may be possible to control the amount of aquatic plant growth. In general, lakes with a phosphorus concentration greater than 20 µg/L (micrograms per liter, or parts per billion) are able to support abundant plant growth and are classified as nutrient-enriched or eutrophic.

Chlorophyll-*a*

Chlorophyll-*a* is a pigment that imparts the green color to plants and algae. A rough estimate of the quantity of algae present in lake water can be made by measuring the amount of chlorophyll-*a* in the water column. A chlorophyll-*a* concentration greater than 6 µg/L is considered characteristic of a eutrophic condition.

Secchi Transparency

A **Secchi disk** is often used to estimate water clarity. The measurement is made by fastening a round, black and white, 8-inch disk to a calibrated line (Figure 7). The disk is lowered over the deepest point of the lake until it is no longer visible, and the depth is noted. The disk is then raised until it reappears. The average between these two depths is the Secchi transparency. Generally, it has been found that aquatic plants can grow at a depth of approximately twice the Secchi transparency measurement. In eutrophic lakes, water clarity is often reduced by algae growth in the water column, and Secchi disk readings of 7.5 feet or less are common.

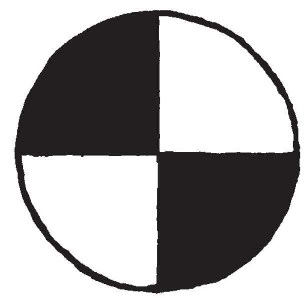


Figure 7. Secchi disk.

Lake Classification Criteria

Ordinarily, as phosphorus inputs to a lake increase, the amount of algae will also increase. Thus, the lake will exhibit increased chlorophyll-*a* levels and decreased transparency. A summary of lake classification criteria developed by the Michigan Department of Natural Resources is shown in Table 2.

TABLE 2

LAKE CLASSIFICATION CRITERIA

Lake Classification	Total Phosphorus (µg/L)[1]	Chlorophyll-*a* (µg/L)[1]	Secchi Transparency (feet)
Oligotrophic	Less than 10	Less than 2.2	Greater than 15.0
Mesotrophic	10 to 20	2.2 to 6.0	7.5 to 15.0
Eutrophic	Greater than 20	Greater than 6.0	Less than 7.5

1 micrograms per liter = parts per billion.

pH and Alkalinity

pH is a measure of the amount of acid or base in water. The pH scale ranges from 0 (acidic) to 14 (alkaline or basic) with neutrality at 7. The pH of lakes generally ranges between 6 and 9 (Wetzel 1983). The concentration of gases, such as oxygen and carbon dioxide, directly influence pH. Most organisms tolerate only very narrow ranges in pH; therefore, large amounts of alkalinity are needed as natural buffers to changes in pH.

Alkalinity is the measure of the pH-buffering capacity of water. Lakes that have high alkalinity (over 100 mg/L as calcium carbonate) are able to sustain large inputs of acid with little change in pH. Addition of acid can occur naturally (e.g., during bacterial decomposition of organic material in the sediments; during natural diffusion of carbon dioxide into the surface waters), or because of pollution (acid deposition, both wet and dry fall). The ability of the lake to maintain a stable pH is crucial to the survival of its aquatic inhabitants.

Fecal Coliform Bacteria

A primary consideration in evaluating the suitability of a lake to support swimming and other water-based recreational activities is the level of bacteria in the water. ***Escherichia coli* (*E. coli*)** is a bacteria commonly associated with fecal contamination. The current State of Michigan public health standard for total body contact recreation (e.g., swimming) for a single sampling event requires that the number of E. coli bacteria not exceed 300 per 100 milliliters of water.

SAMPLING RESULTS AND DISCUSSION

Water quality samples were collected in the spring and summer of 2007 and 2008 from the lake and the tributary streams (Figures 8, 9, and 10). Summer sampling data indicates Mill Lake was thermally stratified; there was a 34-degree difference in water temperature top to bottom, with the warm surface waters in the lake underlain by cooler bottom waters (Table 3). During the summer sampling period, bottom water dissolved oxygen was nearly depleted as a result of bacterial decomposition at the lake bottom. Mill Lake does not sustain sufficient dissolved oxygen in the cool bottom waters during the summer months to support cold water fish species such as trout. However, dissolved oxygen levels are adequate throughout most of the lake to sustain a warm water fishery. With the exception of April 2007 and August 2008, total phosphorus levels in Mill Lake were generally quite low (Table 3). These data indicate the lake has a low potential to support aquatic plant growth. pH measured in Mill Lake ranged from 6.8 to 8.8, a range that is healthy for aquatic organisms. Mill Lake contains enough alkalinity to sufficiently buffer the lake's pH from inputs such as acid rain. However, compared to many southern Michigan lakes, Mill Lake's alkalinity is low. The relatively low alkalinity indicates that groundwater feeding the lake passes through soils that are not rich in calcium carbonate.

Secchi transparency in Mill Lake was moderate and ranged from 8.0 to 11.5 feet over the course of study (Table 4). It is important to note that water transparency is reduced to some degree by the clear brown color of the water that is very likely imparted by tannins that are released from wetlands that border the lake. Chlorophyll-*a* levels were generally low to moderate indicating there was sparse to moderate algae growth in the water column during the time of sampling.

Of the thirty fecal coliform bacteria samples collected, two exceeded the state health standard (Table 5). However, the elevated bacteria levels at these two locations did not appear persistent or necessarily indicative of a septic system malfunction. Overall, these data indicate that, at the time of sampling, Mill Lake was safe for swimming and other recreational activities.

Tributary phosphorus levels were generally high but streamflow was low indicating that little or no phosphorus reached the lake during the periods sampled.

Based on the data collected, Mill Lake is mesotrophic in that phosphorus levels are generally low to moderate, chlorophyll-*a* is low*,* and Secchi transparency is moderate (Table 7). At present, the overall water quality of Mill Lake is good. However, the depletion of dissolved oxygen and the buildup of phosphorus in the deep waters in late summer are early signs that eutrophication is beginning to occur in Mill Lake. As such, it is important to reduce the amount of phosphorus that enters Mill Lake to the extent possible.

Data collected during the course of this study are generally consistent with historical data collected from Mill Lake. A copy of the historical water quality report is included in Appendix B.

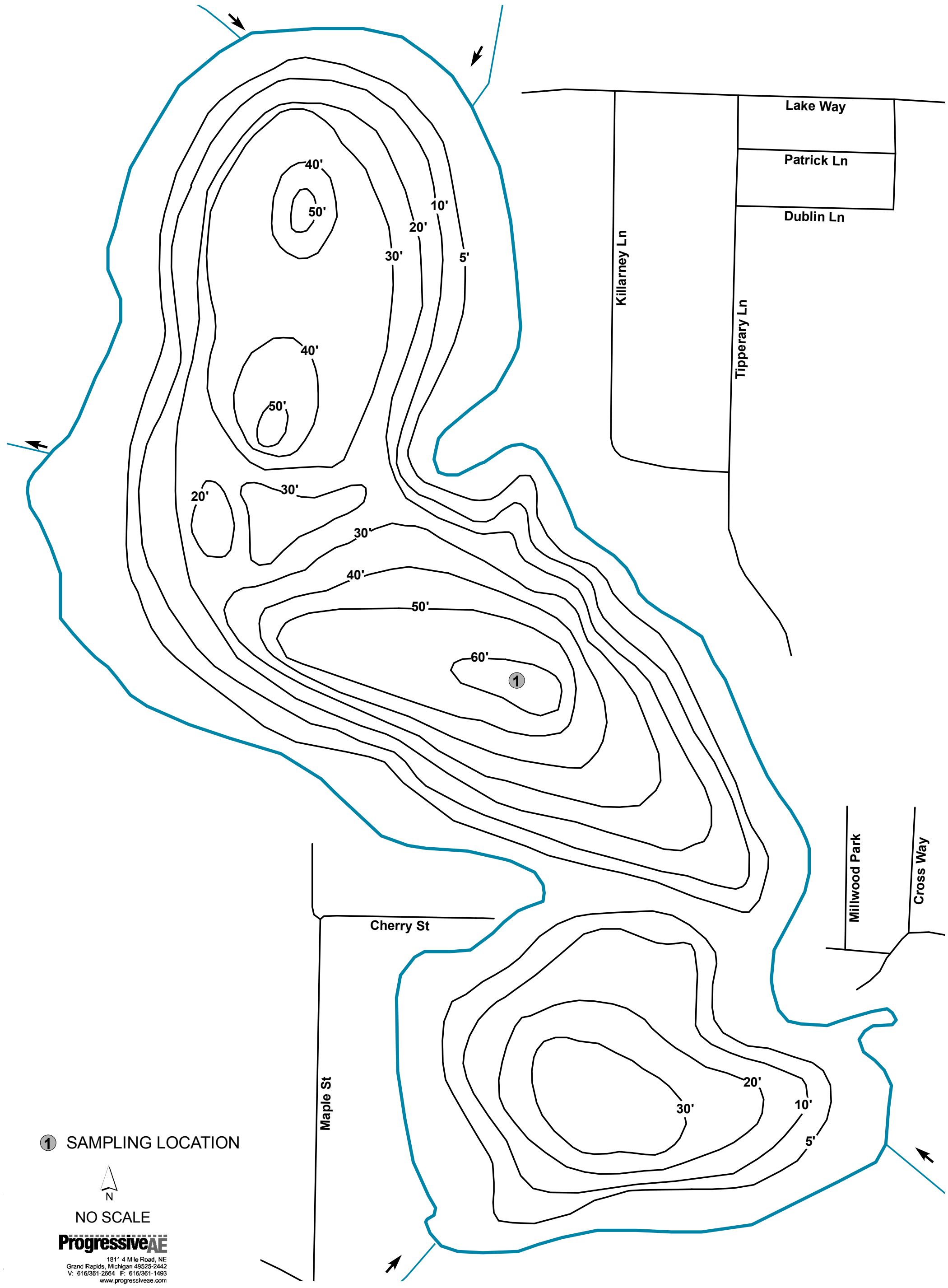


Figure 8. Mill Lake sampling location map.

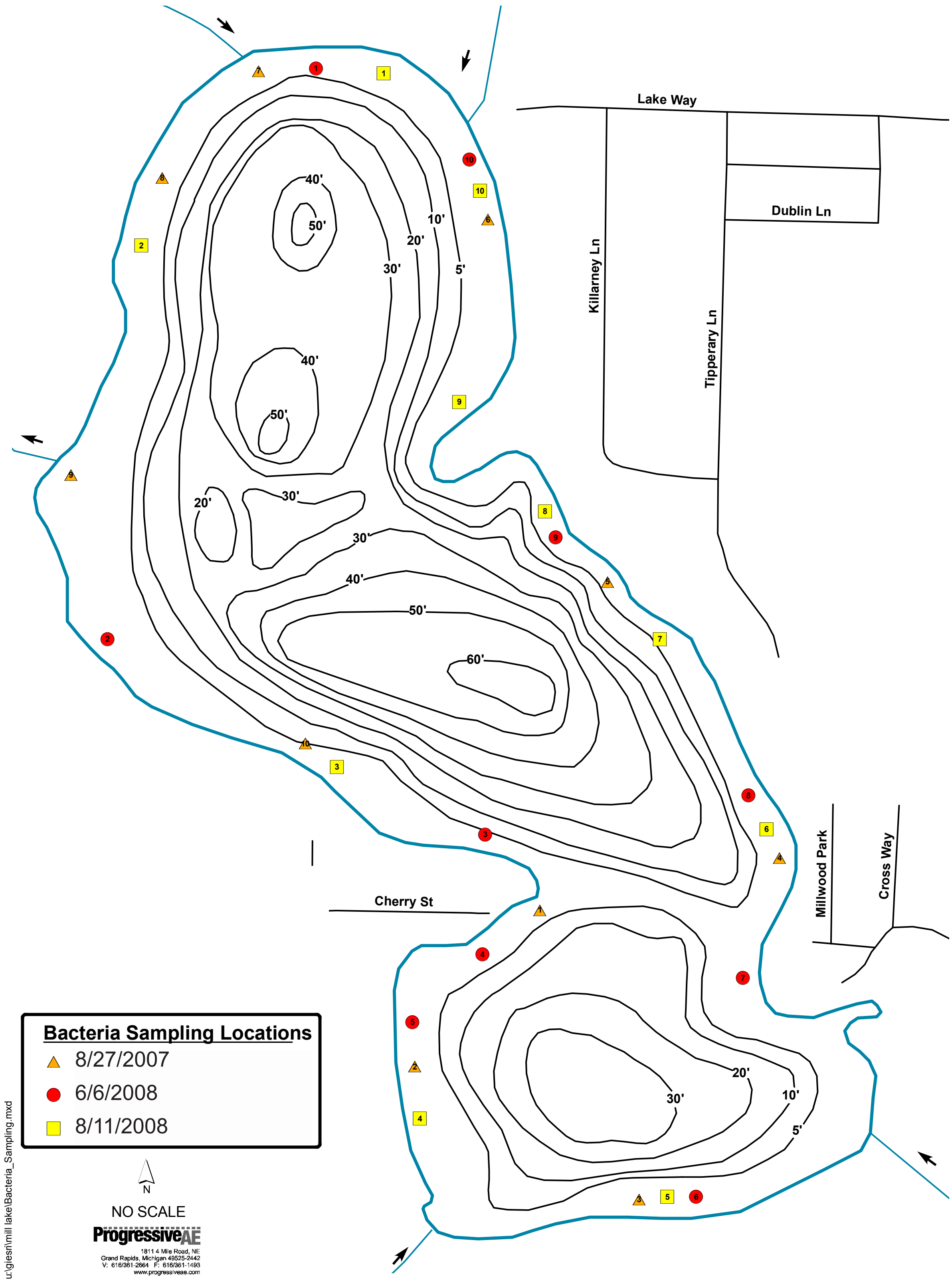


Figure 9. Mill Lake bacteria sampling location map.

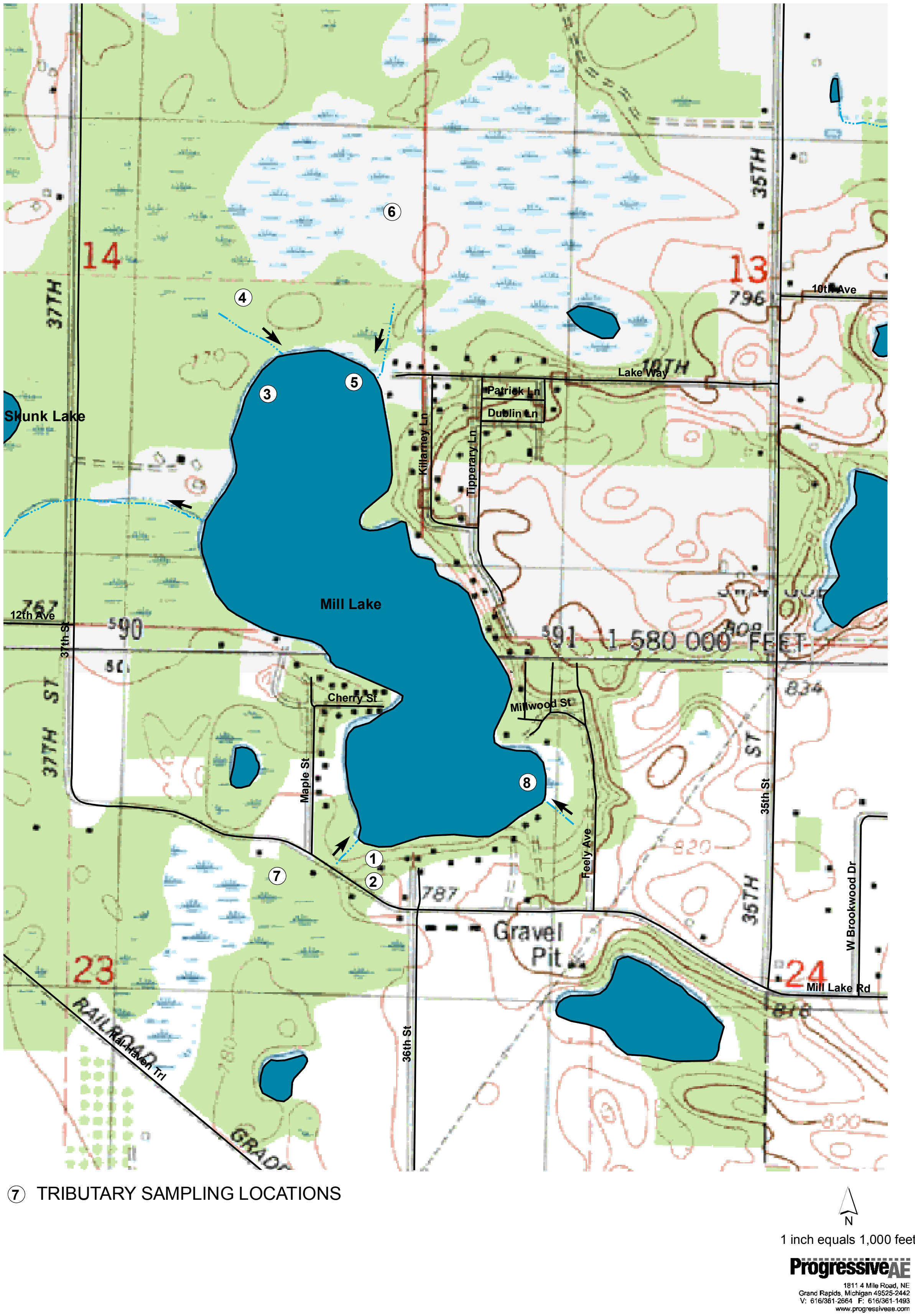


Figure 10. Mill Lake tributary sampling location map.

TABLE 3
MILL LAKE
DEEP BASIN WATER QUALITY DATA

Date	Station	Sample Depth (feet)	Temp. (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (μg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L as $CaCO_3$)[4]
18-Apr-07	1	1	47	10.8		8.2	53
18-Apr-07	1	10	45	10.9		8.3	52
18-Apr-07	1	20	44	10.5		8.3	53
18-Apr-07	1	30	44	10.5		8.3	52
18-Apr-07	1	40	44	10.4		8.3	51
18-Apr-07	1	50	43	10.5		8.3	50
18-Apr-07	1	60	43			8.3	51
22-May-07	1	1	70	9.1	<5	8.1	
22-May-07	1	10	63	9.2	<5	7.6	
22-May-07	1	20	46	8.3	6	7.1	
22-May-07	1	30	44	7.7	6	6.8	
22-May-07	1	40	44	7.7	<5	7.0	
22-May-07	1	50	43	6.6	<5	6.9	
22-May-07	1	60	43	5.4	34	6.8	
27-Aug-07	1	1	78	8.3	<5	8.8	53
27-Aug-07	1	10	75	8.5	<5	8.7	52
27-Aug-07	1	20	55	4.7	<5	8.1	53
27-Aug-07	1	30	45	2.7	7	8.0	52
27-Aug-07	1	40	44	2.7	<5	7.9	53
27-Aug-07	1	50	44	0.6	<5	7.9	53
27-Aug-07	1	60		0.2	136	7.6	59
17-Apr-08	1	1	49	10.9	<5	7.6	48
17-Apr-08	1	10	48	10.8	<5	7.4	52
17-Apr-08	1	20	46	10.5	<5	7.3	50
17-Apr-08	1	30	43	9.9	<5	7.3	48
17-Apr-08	1	40	43	9.6	7	7.2	50
17-Apr-08	1	50	42	8.8	13	7.2	51
17-Apr-08	1	60	41	8.1	11	7.1	53
11-Aug-08	1	1	77	7.9			51
11-Aug-08	1	10	77	7.2			51
11-Aug-08	1	20	58	2.2			50
11-Aug-08	1	30	46	2.7			50
11-Aug-08	1	40	43	2.5			52
11-Aug-08	1	50	42	1.4			50
11-Aug-08	1	58	43	0.1			49

1 mg/L = milligrams per liter = parts per million.
2 μg/L = micrograms per liter = parts per billion.
3 S.U. = standard units.
4 mg/L as $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE 4
MILL LAKE
SURFACE WATER QUALITY DATA

Date	Station	Secchi Transparency (feet)	Chlorophyll-*a* (µg/L)[1]
18-Apr-07	1	10.5	2.2
22-May-07	1	8.0	0.8
27-Aug-07	1	11.0	0.2
17-Apr-08	1	11.0	0.7
11-Aug-08	1	11.5	3.0

TABLE 5
MILL LAKE
SHORELINE BACTERIA SAMPLING DATA

Date	Station	*E. Coli* Bacteria/100 mL[2]
27-Aug-07	1	15
27-Aug-07	2	4
27-Aug-07	3	1
27-Aug-07	4	2
27-Aug-07	5	9
27-Aug-07	6	109
27-Aug-07	7	12
27-Aug-07	8	6
27-Aug-07	9	51
27-Aug-07	10	10
6-Jun-08	1	99
6-Jun-08	2	34
6-Jun-08	3	14
6-Jun-08	4	11
6-Jun-08	5	190
6-Jun-08	6	23
6-Jun-08	7	16
6-Jun-08	8	4
6-Jun-08	9	112
6-Jun-08	10	2
11-Aug-08	1	1
11-Aug-08	2	19
11-Aug-08	3	16
11-Aug-08	4	1
11-Aug-08	5	1
11-Aug-08	6	16
11-Aug-08	7	35
11-Aug-08	8	328
11-Aug-08	9	4
11-Aug-08	10	770

1 µg/L = micrograms per liter = parts per billion.
2 mL = milliliters.

TABLE 6
MILL LAKE
TRIBUTARY WATER QUALITY DATA

Date	Site No.	Discharge (cfs)[1]	Total Phosphorus (µg/L)[2]
7-Jun-07	1		170
7-Jun-07	2		146
7-Jun-07	3		73
7-Jun-07	4		85
7-Jun-07	5		45
7-Jun-07	6		222
7-Jun-07	7		349
7-Jun-07	8		97
13-May-08	1	0	32
13-May-08	2	0	34
13-May-08	3	0	18
13-May-08	4	0	80
13-May-08	5	0	72
13-May-08	6	0	17
13-May-08	7	0	101
13-May-08	8	0	346
5-Jun-08	1	0	48
5-Jun-08	5	0	48
11-Aug-08	8	0	394

TABLE 7
MILL LAKE
LAKE WATER QUALITY SUMMARY STATISTICS

Statistic	Total Phosphorus (µg/L)[2]	Chlorophyll-*a* (µg/L)[2]	Secchi Transparency (feet)
Average	14	1	10.4
Standard deviation	29	1	1.4
Median	5	1	11.0
Minimum	5	0	8.0
Maximum	136	3	11.5
Number of samples	21	5	5

1 cfs = cubic feet per second.
2 µg/L = micrograms per liter = parts per billion.

AQUATIC PLANTS

The distribution and abundance of aquatic plants are dependent on several variables, including light penetration, bottom type, temperature, water levels, and the availability of plant nutrients. The term “aquatic plants” includes both the algae and the larger aquatic plants or macrophytes. The macrophytes can be categorized into four groups: The emergent, the floating-leaved, the submersed, and the free-floating.

Aquatic plant surveys of Mill Lake were conducted on May 22 and August 27, 2007, and June 5, 2008 (Table 7). Diagrams of many of the plants listed are included in Figure 11.

TABLE 7
MILL LAKE AQUATIC PLANTS

Common Name	Scientific Name	Group	Occurrence
Illinois pondweed	*Potamogeton illinoensis*	Submersed	Common
Large-leaf pondweed	*Potamogeton amplifolius*	Submersed	Common
Water stargrass	*Heteranthera dubia*	Submersed	Common
Water shield	*Brasenia schreberi*	Floating-leaved	Common
Yellow waterlily	*Nuphar sp.*	Floating-leaved	Common
Chara	*Chara sp.*	Submersed	Sparse
Coontail	*Ceratophyllum demersum*	Submersed	Sparse
Curly-leaf pondweed	*Potamogeton crispus*	Submersed	Sparse
Eurasian milfoil	*Myriophyllum spicatum*	Submersed	Sparse
Arrowhead	*Sagittaria latifolia*	Emergent	Sparse
Bulrush	*Scirpus sp.*	Emergent	Sparse

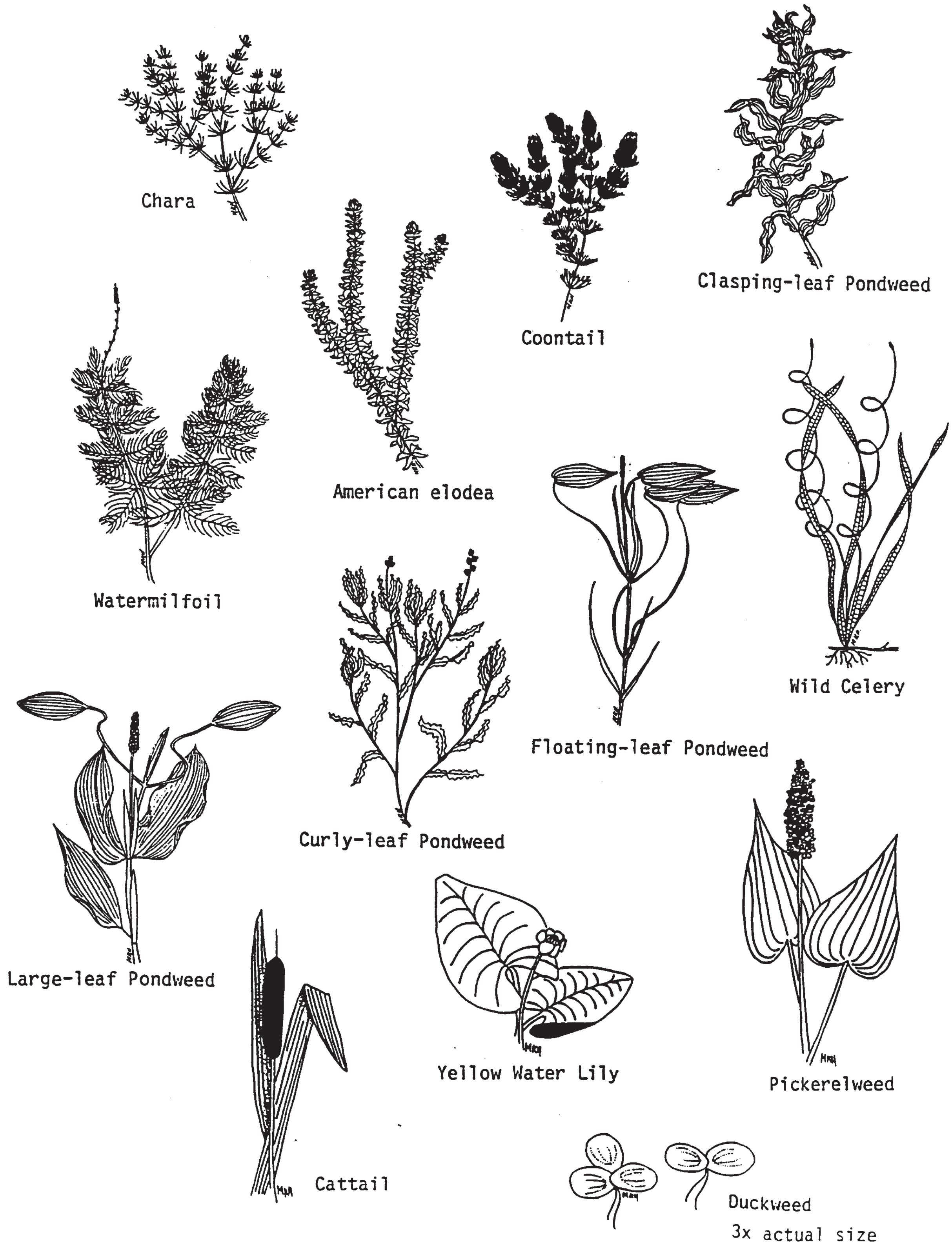


Figure 11. Common aquatic plants.

Watershed and Nutrient Budget Analysis

INTRODUCTION

Land use activities in a lake's watershed are important from a management perspective in that runoff and drainage from the watershed directly impact lake water quality. In order to evaluate the influence of watershed drainage on lake water quality, it is necessary to estimate the quantity of nutrients contributed from within the watershed. This estimate of nutrient loading can be made by constructing a nutrient budget. A nutrient budget is a calculation of nutrient inputs to the lake based on land use, soil types, and other conditions in the surrounding watershed.

The type of land use in a watershed subarea directly influences the quantity and quality of runoff. For example, the runoff from residential areas (with rooftops, roads, driveways, and other impermeable surfaces) will generally be of greater quantity and poorer quality in terms of sediment and nutrient content than runoff from a wooded area of equal size. In wooded areas, much of the potential pollution load is retained and assimilated by the vegetative ground cover. In this study, four land use classifications were utilized: Agricultural, residential, wooded/undeveloped, and wetland.

In preparing a nutrient budget for Mill Lake, an estimate was made of the quantity of the nutrient phosphorus entering the lake from surface runoff, atmospheric deposition (both wet and dry fall), and lakeside septic systems. The nutrient budget focused on the control of phosphorus for two reasons:

- Phosphorus is usually the major nutrient in shortest supply relative to the nutritional needs of aquatic plants. Therefore, phosphorus is the nutrient that controls eutrophication.
- Of the major nutrients, phosphorus inputs are more subject to control through management practices.

Since it is extremely difficult and cost-prohibitive to directly measure nonpoint, diffuse sources of phosphorus loading such as surface runoff and atmospheric deposition, it was necessary to select phosphorus loading values from other studies in which direct measurements have been made in the field. Great care was taken to apply phosphorus-loading values that would be representative of the watershed conditions observed around Mill Lake. The values selected were based largely on a comprehensive literature review of the quantity of phosphorus transported to surface water bodies from various land uses (Reckhow et al. 1980). Phosphorus loading information used to calculate atmospheric and lakeside septic contributions are contained in Appendix C. When estimating the phosphorus load transported to the lake via surface runoff, the percent land use, and the presence or absence of "buffering areas" (wooded or wetland areas that act to reduce phosphorus inputs) were taken into account before phosphorus loading calculations were made. It is assumed that wetland areas contribute no phosphorus to the lake.

RESULTS AND DISCUSSION

The estimated total phosphorus load to Mill Lake is presented in Table 8.

TABLE 8
MILL LAKE
ESTIMATED ANNUAL PHOSPHORUS LOAD TO MILL LAKE[1]

	Area (acre)	Phosphorus Loading Values (lbs/acre/yr)	Phosphorus Load (lbs/yr)	Percent of Total Load
Agriculture	100	0.4	40	11%
Forested and Open Space	320	0.1	32	9%
Residential	115	0.9	104	30%
Wetland	317	0	0	0%
Atmospheric[2]	104	0.3	31	9%
Septic			144	41%
Total			385	100%

Various researchers have studied the impact of phosphorus loading on lake water quality, and many have developed techniques for predicting lake trophic status under different phosphorus loading scenarios (Reckhow et al. 1980; Dillon and Rigler 1975; Vollenweider 1975). Reckhow et al. (1980) developed a model for northern temperate lakes (such as Mill Lake) that can be used to predict a lake's average phosphorus concentration as a function of phosphorus loading and lake flushing rate. The model equation is:

$$P = \frac{L}{11.6 + 1.2q_s}$$

$$L = \frac{M}{A_o}$$

$$q_s = \frac{Q}{A_o}$$

$$Q = (A_d \times r) + (A_o \times Pr)$$

P = Lake phosphorus concentration (in parts per billion)
L = Surface area phosphorus loading (in grams per square meter-year)
M = Total mass loading (in kilograms per year)
A_o = Lake surface area (in square meters)
q_s = Surface area water loading (in meters per year)
Q = Inflow water volume to lake (in cubic meters per year)
A_d = Watershed area, excluding the lake (in square meters)
r = Total annual unit runoff (in meters per year)
Pr = Mean annual net precipitation (in meters per year)

By applying this modeling methodology to Mill Lake, it is possible to estimate the in lake total phosphorus concentration based on current conditions. For Mill Lake, the model predicts an in lake phosphorus concentration of 26 parts per billion a concentration above the eutrophic threshold concentration of 20 parts per billion. The model result indicates that current levels of phosphorus loading are sufficient to push the phosphorus concentration in Mill Lake above the eutrophic threshold. If the lake's ability to sustain phosphorus loadings is exceeded, plant growth in the lake would be expected to increase, water transparency and dissolved oxygen levels would decrease, and the overall quality of the lake would decline. This underscores the need to reduce phosphorus inputs into Mill Lake.

1 It should be noted that the above loading estimates do not represent absolute annual loadings but, rather, potential loadings based on field-verified literature values for the land use types and other conditions encountered in the Mill Lake area.
2 Calculations for atmospheric and septic contributions are included in Appendix C.

The model allows different development scenarios in the Mill Lake watershed to be evaluated. For example, if area septic systems were replaced with a community sewer system, the predicted phosphorus concentration in Mill Lake would be reduced from 26 parts per billion to 15 parts per billion.

It should be noted that the predicted total phosphorus concentration is greater than the average phosphorus concentration of 14 parts per billion measured in Mill Lake during the course of study. This difference may be attributable, in part, to the large amount of wetlands in the Mill Lake watershed which help trap and assimilate phosphorus.

Lake Improvement Alternatives

INTRODUCTION

In general, water quality in Mill Lake is good and the lake has a healthy, diverse population of native aquatic plants. However, Eurasian milfoil, a non-native plant, is present in the lake and has the potential to become dominant. In addition, excessive land development in the watershed would increase the amount and rate at which phosphorus and other pollutants would enter Mill Lake. Thus, protection of Mill Lake should include control of invasive plants and watershed management.

AQUATIC PLANT CONTROL

Although an overabundance of undesirable plants can limit recreational use and enjoyment of a lake, it is important to realize that aquatic plants are a vital component of aquatic ecosystems. They produce oxygen during photosynthesis, provide food and habitat for fish and other organisms, and help stabilize shoreline and bottom sediments.

The objective of a sound aquatic plant control program is to remove plants only from problem areas where nuisance growth is occurring. Under no circumstance should an attempt be made to remove all plants from the lake.

Mechanical harvesting (i.e., plant cutting and removal) and chemical herbicide treatments are methods commonly employed to control aquatic plant growth (Figures 12 and 13). For large-scale aquatic plant control, harvesting may be advantageous over herbicide treatments since plants removed from the lake will not sink to the lake bottom and add to the buildup of organic sediments. In addition, some nutrients contained within the plant tissues are removed with the harvested plants. With the use of herbicides, treated plants die back and decompose on the lake bottom while bacteria consume dissolved oxygen reserves in the decomposition process. Since the plants are not removed from the lake, sediment buildup on the lake bottom continues, often creating a bottom substrate ideal for future aquatic plant growth.

Figure 12. Mechanical harvesting.

Figure 13. Aquatic herbicide treatments.

It should be noted, however, that attempts to control certain plant types by harvesting alone may not prove entirely effective. This is especially true with Eurasian milfoil (*Myriophyllum spicatum*) due to the fact that this plant may proliferate and spread via vegetative propagation (small pieces break off, take root, and grow) if the plant is cut (Figure 14). Eurasian milfoil is especially problematic in that it often becomes established early in the growing season and can grow at greater depths than most plants. Eurasian milfoil often forms a thick canopy at the lake surface that can degrade fish habitat and seriously hinder recreational activity (Figure 15). Once introduced into a lake system, Eurasian milfoil often out-competes and displaces more desirable plants and becomes the dominant species. When Eurasian milfoil is present, it may be possible to control the growth and spread of the plant by treating the lake with a species-selective systemic herbicide. Also, since it is not economically feasible to mechanically harvest planktonic (i.e., free-floating) algae in a lake, herbicides, such as copper sulfate and chelated copper products, are often utilized to control nuisance algae growth. However, copper treatments for algae control are generally short-lived. If nutrients are available and weather and other conditions are favorable, nuisance algae conditions may recur rapidly.

Figure 14. Eurasian milfoil.

Figure 15. Eurasian milfoil canopy.

Herbicides can be applied directly to nuisance plants in a (spot treatment) or applied on a whole-lake basis. Whole-lake treatment with a herbicide called fluridone (trade names Sonar or Avast) can be used to control Eurasian milfoil. Fluridone is a systemic herbicide that, at low doses, selectively controls Eurasian milfoil while not significantly impacting desirable native plant species. In accordance with Department of Environmental Quality (DEQ) permit requirements, fluridone is applied in what is called a "6 bump 6" treatment. With this approach, fluridone is applied at an initial concentration of 6 parts per billion. About two weeks after the initial treatment, the concentration of fluridone in the lake is measured and the lake is treated again to bring the concentration back up to 6 parts per billion. The initial fluridone application is generally scheduled for late April or early May. At the low dose rates permitted, fluridone is slow acting. It takes several weeks for the Eurasian milfoil to be noticeably impacted. Although the response to fluridone is initially slow, Eurasian milfoil is generally controlled the entire year of treatment and is greatly reduced the following year as well. As part of the approval process for the use of fluridone, the Department of Environmental Quality requires that a three-year lake management plan be prepared and submitted along with the standard herbicide treatment permit application. The lake management plan must include:

- A detailed description of the physical characteristics of the lake.
- Water quality information including pre-treatment data.
- Information on the lake's plant community, fishery, and endangered and threatened species.
- A history of management on the lake.
- A discussion of control options and reasons for using or not using different options.
- A detailed three-year vegetation management plan for the lake.
- Documentation of stakeholder involvement in the development of the plan.
- Calculations for applying the correct dosage of fluridone to the lake.
- A series of maps including a depth contour map, a wetland inventory map, a shoreline land use map, a water quality sampling location map, a fluridone residue sampling location map, fluridone distribution application map, a targeted nuisance species map, a vegetation goal map, and the proposed vegetation management maps for each year of the plan.

In addition to the information required for the management plan, the DEQ requires a detailed aquatic plant survey of the lake in the year before the treatment, monitoring of treatment dose and aquatic plants during the year of treatment, and follow-up plant surveys in the second and third year after the treatment. With each plant survey, the type and relative abundance of each species throughout the lake are mapped using a protocol developed by the DEQ (Appendix D). This data is used to document the need for a fluridone treatment and to assess treatment impacts.

Mill Lake was treated with fluridone in 1999 to control a severe infestation of Eurasian milfoil. Since then, milfoil re-growth has been controlled with herbicide spot-treatments, and milfoil has occurred in only sparse densities in Mill Lake.

In Michigan, Part 33, Aquatic Nuisance Control, of the Natural Resources and Environmental Protection Act, PA 451 of 1994, requires that a permit be acquired from the DEQ before any herbicides are applied to inland lakes. The permit will include a list herbicides that are approved for use in the lake, respective dose rates, use restrictions, and will show specific areas in the lake where treatments are allowed.

In recent years, considerable research has been conducted on the biological control of Eurasian milfoil. This approach currently focuses on the introduction of a small weevil (*Euhrychiopsis lecontei*; Figure 16) that feeds almost exclusively on Eurasian milfoil. Weevils are native to the United States and Canada, and populations have been observed in Michigan lakes. However, control of Eurasian milfoil generally requires that large numbers of weevils be stocked to augment natural populations. Weevils do not eradicate Eurasian milfoil, and the overall biomass of Eurasian milfoil in the lake may not decline substantially as a result of weevil stocking (Cofrancesco et al. 2004). Rather, the boring action of weevil larvae can cause the plant to lose buoyancy and drop to the bottom. By preventing the formation of a dense canopy at the water surface, weevils can help to control the primary nuisance characteristic of Eurasian milfoil.

Figure 16. Milfoil weevil. Photo courtesy of EnviroScience, Inc.

Weevil stocking programs appear to be more successful when conducted over multiple years, as opposed to a single year. In general, the more weevils that are stocked in a specific area, the better the chances of success. However, as is the case with most biological controls, it is not possible to predict with certainty how effective weevils may be in controlling milfoil in a particular lake. Weevil and Eurasian milfoil populations can be expected to fluctuate up and down over time.

At present, herbicide spot-treatments are controlling Eurasian milfoil very effectively in Mill Lake. Since milfoil densities are so sparse, there is an insufficient density of milfoil to stock milfoil weevils. It would be difficult to establish a weevil population with such a sparse food source, i.e., Eurasian milfoil. Therefore, it is recommended that annual surveys of Mill Lake be conducted to determine the type and distribution of aquatic plants, with particular attention paid to invasive, non-native species. Eurasian milfoil should continue to be spot-treated with herbicides to control spread of the plant.

WATER QUALITY MONITORING

It is recommended that water quality monitoring of Mill Lake be continued in order to gauge the overall health of the lake. *E. coli* bacteria samples should be collected annually in summer from the shoreline of the lake. Additional samples should be collected every fifth year during spring and late summer at 10 foot intervals over the deepest portion of the lake to measure total phosphorus, temperature, dissolved oxygen, pH, and alkalinity. Surface water chlorophyll-*a* levels and water transparency should also be measured during spring and late summer.

WATERSHED MANAGEMENT

The nutrient budget provides a useful tool to help prioritize watershed management options. For Mill Lake, it appears that the largest single source of phosphorus to the lake is shoreline septic systems, followed by runoff from residential and agricultural lands in the watershed. It is important to understand that septic leachate and watershed runoff eventually make their way into Mill Lake; there is nowhere else for those pollutants to go. Once phosphorus concentrations in the lake reach high levels, then the damage done is done and it becomes extremely expensive to remediate the resultant water quality problems. The ensuing discussion explores several alternatives to help minimize watershed phosphorus inputs to Mill Lake.

Septic Systems

An analysis of soils around Mill Lake indicates that most of the soils have limited phosphorus absorption potential. In the Soil Survey of Van Buren County, Michigan, prepared by the U.S. Department of Agriculture Soil Conservation Service, the majority of the soils bordering Mill Lake have a rating of “severe” for septic systems (Figure 17). The severe rating was the result of slope, wetness, ponding, or poor filtering capability. Currently, about 70 percent of the Mill Lake residents are seasonal occupants. Nutrient loading and other problems associated with septic systems can be expected to increase as more homes around the lake are converted from seasonal to year round use. Eventually, the finite ability of area soils to bind phosphorus will be exceeded allowing phosphorus (and potentially other pollutants) to leach to the lake. Sanitary sewer systems are the best solution for eliminating septic pollution. However, sewer systems can stimulate development in areas that may have been unsuitable for septic systems. The additional development can increase runoff of fertilizers and other pollutants to the lake. While sewers reduce phosphorus inputs from septic systems, runoff may increase if further development occurs. Thus, appropriate planning and zoning provisions should be adopted to help minimize this potential. Until such time as the Mill Lake area is serviced with a sanitary sewer system, proper construction and maintenance of area septic systems will be critical to water quality protection. One way to ensure proper septic maintenance is to establish a community septic pumping program wherein all septic systems around Mill Lake are pumped regularly. Another way is to, by ordinance, require a septic inspection and, if needed, a system upgrade before the property can be sold.

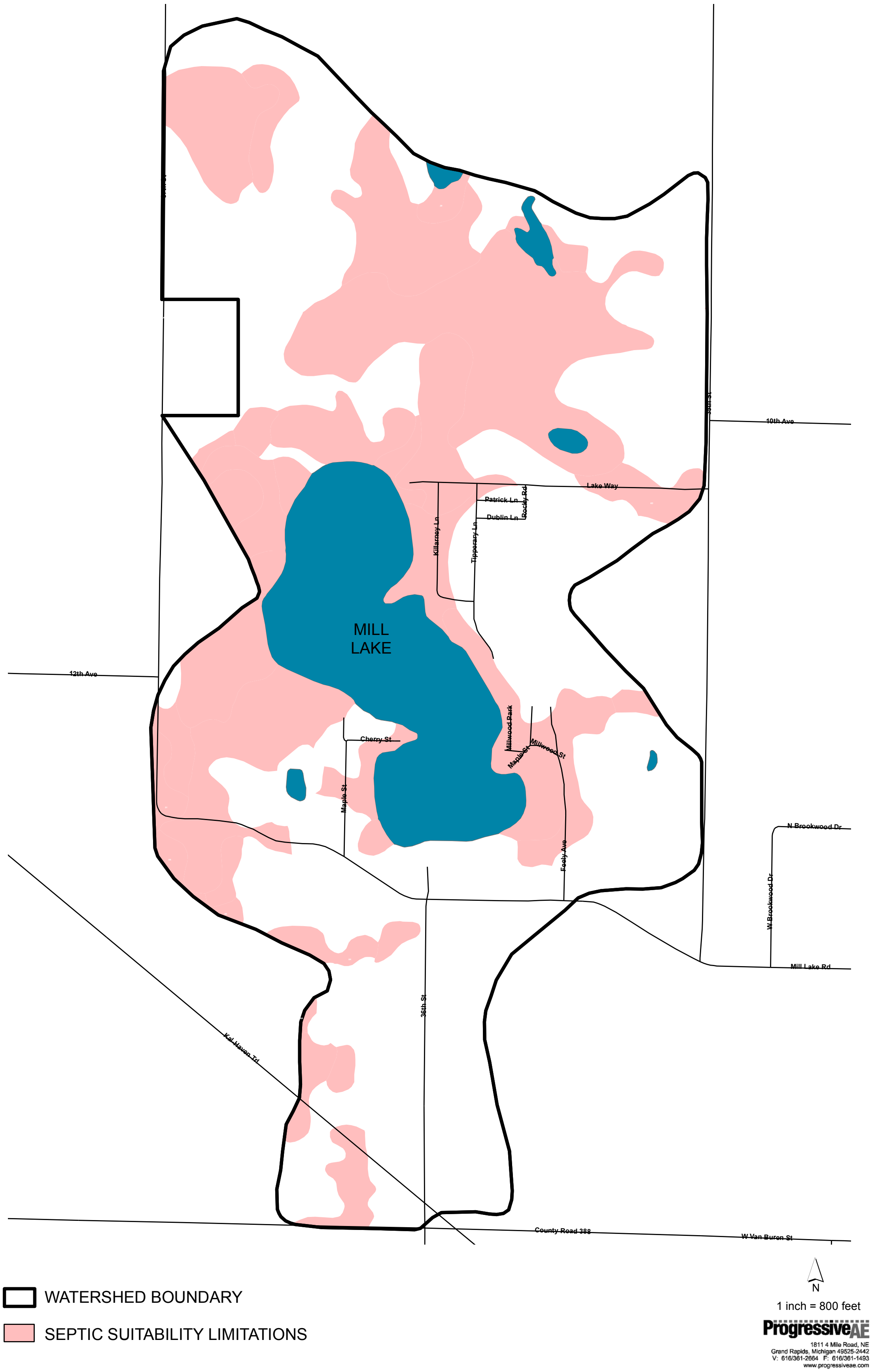


Figure 17. Mill Lake shoreline soils with septic suitability limitations.

Residential Runoff

Most of the development in the Mill Lake watershed occurs in close proximity to the lake. Currently, the majority of the shoreland areas around the lake have been developed for single family residential use. As shoreland vegetative cover was replaced by rooftops, roads, driveways, and other impermeable surfaces, runoff to the lake likely increased over pre development levels. Pollutants of primary concern in residential runoff include fertilizer, sediment, and oil and gas residues. Pollution inputs to Mill Lake from residential runoff could be substantially reduced if lake residents curtailed the use of fertilizers containing phosphorus and if vegetative buffers (i.e., greenbelts) were established around the perimeter of the lake. In addition, loss of vegetative cover associated with both existing and new development should be minimized, and steps should be taken to infiltrate storm water, where practical, rather than allowing water to drain directly to the lake.

Future Land Development

There are several regulatory techniques that can be used to minimize the impact of development on water quality. Some of these regulatory techniques require zoning, others do not. At present, neither Bloomingdale Township nor Van Buren County have zoning in place. Using zoning to protect water quality would be the preferred method, but townships can adopt general law regulations as well. An example of a general law regulation is Bloomingdale Township's Boat Launching and Docking Regulation Ordinance.

Shoreland Overlay District: Excessive development of environmentally sensitive lake shorelands can have direct, adverse water quality impacts including loss of fish and wildlife habitat at the water's edge, increased runoff of fertilizers and other pollutants, and erosion and sedimentation. Recognizing the need to protect shoreland areas, several states (including Maine, Minnesota, and Wisconsin) have adopted state-wide standards to minimize the impacts of shoreland development. Michigan, through the Natural Rivers Program, requires that shoreland development standards be met on several designated rivers including the Pere Marquette, Au Sable, Betsie, Huron, and Lower Kalamazoo. However, there are no state-wide shoreland development standards in Michigan for lakes. Thus, this issue of protection of lake shorelands is left largely to local units of government and waterfront property owners.

One way that shoreland protection can be accomplished at the local level is through the creation of an overlay district within a township's zoning ordinance. An overlay district is a zoning district that applies to a specific geographic area, such as a lake shoreland or a stream corridor. In an overlay district, proposed developments must meet all the conditions of the underlying district in addition to the provisions set forth in the overlay district. A shoreland overlay district could require building setbacks, shoreline vegetative buffers, limits on imperviousness, and prohibit specific uses and activities that could be detrimental to water quality, such as gas stations and confined feedlots. Overlay zoning can be used to help ensure uniform zoning regulations are in place across several zoning districts. However, Bloomingdale Township would need to first adopt zoning before a Mill Lake overlay district could be established.

Open Space Development: An approach that is gaining acceptance in communities across the state is a zoning technique called "open space (cluster) development." With this approach, the base density for a zoning district does not increase (although in some cases density bonuses are given for additional preservation of open space). Open space development typically allows the same number of homes to be built, but they are clustered on a smaller portion of the development site, thus preserving more undeveloped land. With open space development, a site analysis can be required to identify natural features such as wetlands, steeply sloped lands, forested areas, stream corridors, lake shorelands, and rural views. These natural features can constitute part or all of the designated "open space" portions of the development site. Development is then clustered in appropriate locations on the site and the designated open space elements are protected in perpetuity, typically through a deed restriction or conservation easement.

Properly designed open space developments can provide the following water quality benefits:

- Clustering development can minimize impervious surfaces by shortening road lengths;
- If wetlands and forested areas are preserved as “open space elements,” the natural ability of these areas to filter and trap pollutants is not lost;
- Development of erosion prone areas (such as steeply sloped forest lands) can be avoided;
- The land’s natural ability to convey and cleanse storm waters can be preserved; and
- The natural infiltration of storm waters can be sustained.

Low Impact Development: A method of managing stormwater that is gaining prominence and acceptance is a concept called Low Impact Development (LID). LID is defined as an approach to land development that uses various planning and design practices to simultaneously conserve and protect natural resource systems and reduce infrastructure costs. LID still allows land to be developed, but in a cost effective manner that helps mitigate potential environmental impacts. Essentially, LID’s are designed to maintain the natural hydrological cycle by:

- Preserving open space and minimizing land disturbances;
- Protecting natural features and natural processes;
- Reexamining the use and sizing of traditional infrastructure (lots, streets, curbs, gutters, sidewalks) and customizing site design;
- Integrating natural site elements (wetlands, stream corridors, mature forests) into site designs; and
- Decentralizing and managing stormwater at its source.

With an LID, the development process includes a detailed site analysis that identifies natural drainage patterns and key natural features such as forested areas, wetlands, stream corridors, steeply sloped areas, and soil types. This information is then used to help define development opportunities and constraints and areas requiring protection. The site analysis is followed by an evaluation of alternatives to minimize development impacts. Alternatives to accomplish these objectives could include minimizing clearing and grading, reducing impervious surfaces, clustering development, limiting lot disturbance, and preserving permeable soil types. An attempt is then made to slow the conveyance of storm water from the site by dispersing (rather than concentrating) drainage, maintaining natural flow paths, and by using vegetated swales to convey water (as opposed to pipes). A key element of an LID is to treat storm water at its source, rather than conveying water to a centralized storm water basin. The overall goal of storm water management in an LID is to mimic pre development hydrologic conditions.

Wetland Protection

In addition to providing fish and wildlife habitat, wetlands in the Mill Lake watershed provide several valuable functions including pollution prevention, flood control, and groundwater recharge. Protecting these wetlands from excessive encroachment is critical to the long-term health of Mill Lake.

Michigan’s wetland protection regulations are contained within Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act. In accordance with Part 303, the following activities require a permit from the Department of Environmental Quality:

- Deposit or permit the placing of fill material in a wetland;
- Dredge, remove, or permit the removal of soil or minerals from a wetland;
- Construct, operate, or maintain any use or development in a wetland; and
- Drain surface water from a wetland.

Certain activities, such as fishing, trapping and hunting, grazing of animals, certain farming activities, and harvesting of lumber are exempt from permit requirements. Part 303 requires that the DEQ not issue a wetland permit unless the applicant shows either that the proposed activity is primarily dependent on being located in a wetland, or that a feasible and prudent alternative does not exist.

Mill Lake residents should continue to monitor development in the watershed to ensure encroachment into area wetlands does not occur. If residents observe wetland encroachment, they should contact the DEQ to investigate and, if warranted, take enforcement action.

Agricultural Runoff

Although most farmlands in the Mill Lake watershed are not in close proximity to the lake, agricultural runoff contains fertilizers and sediment. Over the years, many techniques have been developed to minimize soil erosion from farms while protecting downstream water quality. These techniques are known as agricultural best management practices (BMPs). To encourage land-owner participation, the US Department of Agriculture has many cost-share programs to assist farmers with the design and installation of BMPs. Installation and maintenance of BMPs will help to protect Mill Lake from agricultural runoff.

Recommended Management Plan

Study findings indicate that Mill Lake is mesotrophic in that the average phosphorus level is moderate at 14 parts per billion, bottom water oxygen is low, and chlorophyll-*a* and transparency is moderate. Currently, the overall water quality of Mill Lake is good. However, in order to protect the lake over the long term, it is recommended that the management plan for Mill Lake include the following elements.

Aquatic Plant Surveys and Nuisance Aquatic Plant Control: Annual surveys of Mill Lake should be conducted to determine the type and distribution of aquatic plants, with particular attention paid to invasive, non-native species. The current aquatic plant control program should continue to focus on non-native plants and only those native plants growing at nuisance densities.

Water Quality Monitoring: Water quality monitoring of Mill Lake should be continued in order to gauge the overall health of the lake. Monitoring should consist of annual *E. coli* measurements. Every fifth year in spring and late summer, Mill Lake should be sampled from top to bottom at the deepest point for temperature, dissolved oxygen, total phosphorus, chlorophyll-*a*, and Secchi transparency.

Watershed Management: Study findings indicate that watershed management is essential to preserving the quality of Mill Lake over the long term. To this end, it is recommended that a watershed management program for Mill Lake be implemented that consists of the following:

A Homeowners Guidebook: Lake protection guidelines should be prepared and mailed to all lake residents. The guidelines should include information on the physical characteristics of Mill Lake and its watershed, aquatic plants, lake water quality, invasive species, and watershed management techniques (i.e., wetland protection, septic system maintenance, lakeside landscaping and lawn care, and low impact development practices).

Septic Systems: Shoreline septic systems are a substantial source of phosphorus loading to Mill Lake. Until such time as the Mill Lake area is serviced with a sanitary sewer system, proper construction and maintenance of area septic systems will help to slow the eutropication or lake-aging process. Lake residents should advocate for a septic system maintenance ordinance that requires that septic systems be inspected and meet sanitary code requirements at the time a property is sold. In addition, residents should establish a community septic pumping program wherein all systems around the lake are pumped on a regular basis.

Planning and Zoning: Lake residents should advocate for zoning regulations designed to minimize the impact of future development in the Mill Lake watershed. Approaches that may prove useful include open space zoning, a shoreland overlay district, and low impact development regulations.

Phosphorus Fertilizer Regulations: Phosphorus in lawn fertilizers is often a primary source of phosphorus input to lakes. To help address this problem, many communities across Michigan have adopted ordinances to regulate the application of phosphorus lawn fertilizers. Mill Lake residents should advocate for a phosphorus fertilizer ordinance for Bloomingdale Township (Appendix E).

Wetland Protection: In addition to fish and wildlife habitat, wetlands in the Mill Lake watershed provide several valuable functions including pollution prevention, flood control, and groundwater recharge. Mill Lake residents should continue to monitor development in the watershed and cooperate with DEQ to ensure encroachment into area wetlands does not occur.

Agricultural Best Management Practices: Agricultural landowners should employ best management practices to protect downstream water quality.

Appendix A

Study Methods

Lake and Watershed Physical Characteristics

Depth contours were digitized from a bathymetric map prepared by Progressive AE in 1997. Watershed area was delineated using U.S. Geological Survey topographic maps (Bloomingdale, Mich. 1981; Gobles West, Mich. 1981), then digitized for analysis. Lake area, shoreline length, watershed area, and land use were computed from Michigan Department of Natural Resources (MDNR) Michigan Resource Information System (MIRIS 1978) updated with aerial photography (Van Buren County Department of Land Services, 2007). Lake volume was estimated using the conical-segment method. Mean depth was calculated from lake volume and surface area.

Lake Water Quality

Temperature was measured using a YSI Model 550A probe. Samples were collected at ten-foot intervals with a Van Dorn sampler to be analyzed for dissolved oxygen, pH, total alkalinity, and total phosphorus. Dissolved oxygen samples were fixed in the field and then transported to Progressive AE for analysis using the modified Winkler method (Standard Methods Procedure 4500 O C). pH was measured in the field using a YSI EcoSense pH meter. Total alkalinity and total phosphorus samples were placed on ice and transported to Progressive AE and to Prein and Newhof[1], respectively, for analysis. Total alkalinity was titrated at Progressive AE using Standard Methods Procedure 2320.B, and total phosphorus was analyzed at Prein and Newhof using Standard Methods Procedure 4500 P E. In addition to the depth-interval samples at each deep basin, Secchi transparency was measured and composite chlorophyll-*a* samples were collected from the surface to a depth equal to twice the Secchi transparency. Chlorophyll-*a* samples were analyzed by Prein and Newhof using Standard Methods Procedure 10200H. Water samples from near-shore areas were collected in sterilized bottles and analyzed by Kent County Health Department to determine *E. coli* bacteria levels.

[1] Prein and Newhof, 3260 Evergreen Drive, NE, Grand Rapids, MI 49525.

Appendix B

Historical Data

Mill Lake
Historical Total Phosphorus Data Summary

Date	Depth	Total Phosphorus (ppb)	Collector
6/22/1977	1	10	USGS
6/22/1977	1	10	USGS
6/22/1977	1		USGS
4/27/1993	1	8	WQI
4/27/1993	1	7	WQI
4/27/1993	1	9	WQI
8/19/1993	1	15	WQI
8/19/1993	1	16	WQI
8/19/1993	1	20	WQI
4/1/1995	1	12	CLMP
4/1/1995	1	12	CLMP
4/1/1995	1	10	CLMP
4/1/1995	1	10	CLMP
4/1/1995	1	10	CLMP
4/1/1995	1	9	CLMP
4/1/1995	1	9	CLMP
4/1/1995	1	9	CLMP
7/3/1997	1	11	Progressive
7/3/1997	36	14	Progressive
7/3/1997	60	29	Progressive
6/1/2005		12	PLM
9/15/2005		123	PLM
4/1/2006	1	14	CLMP
4/1/2006	1	12	CLMP

APPENDIX 2
2006 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus (ug/l)								Carlson
		Spring Overturn				Late Summer				TSITP
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
MILL	VAN BUREN	14 b	12 b			11				39
MOON	GOGEBIC	11				4 T				<27
MUD	JACKSON	15				14				42
MULLETT	CHEBOYGAN	5				5				27
MURRAY	KENT	34				14 g	14 g			42
MUSKELLUNGE	MONTCALM	21				17				45
NEPESSING	LAPEER	12	10			22				49
ONEIDA	LIVINGSTON	12	13			11				39
ORE	LIVINGSTON	12				15				43
ORION	OAKLAND	5				*				
OSTERHOUT	ALLEGAN	*				16				44
OTSEGO	OTSEGO	10				12				40
OXBOW	OAKLAND					11	11			39
OXBOW, NORTH	MASON	*								
PAINTER	CASS	18				38				57
PAPOOSE	KALKASKA	*				31	31			54
PARK	CLINTON	8				18				46
PARKE	OAKLAND	15				17				45
PAYNE	BARRY	12				9				36
PENTWATER	OCEANA	*				*				
PERCH	HILLSDALE	10	11			14				42
PERCH	OTSEGO	19				9				36
PICKERAL	KALKASKA	4 T				3 W				<27
PICKEREL	NEWAYGO	35				16				44
PLATTE (LITTLE)	BENZIE	12	11			14	15			42
PLEASANT (BIG)	ST. JOSEPH	5				*				
PLEASANT	JACKSON					11				39
PLEASANT	WEXFORD	10				9				36
PORTAGE (BIG)	JACKSON	*				17				45
PORTAGE	WASH/LIV	12				12				40
PRETTY	MECOSTA	*								
ROBINSON	NEWAYGO	32				16	11			44
ROUND	CLINTON	16				15				43
ROUND	LENAWEE	*				7				32

APPENDIX 2
1995 ADVANCED SELF-HELP PROGRAM
SPRING TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus Results (ug/l) Volunteer Sample #1	Volunteer Sample #2	DEQ Side-by-Side
Hubbard	Alcona	8	6	
Indian	Kalamazoo	11	11	
Juno	Cass	22	28	
Keeler	Van Buren	12	12	
Klinger	St. Joseph	8	8	
Long	Ionia	15	15	
Long	Gr. Traverse	5	7	
Long	Iosco	20	21	
Mecosta	Mecosta	16	14	9
Mill #1	Van Buren	12	12	
Mill #2	Van Buren	10	10	
Mill #3	Van Buren	10	9	
Mill #4	Van Buren	9	9	
Miner	Allegan	18	16	
Moon	Gogebic	6	10	
Moore	Oakland	11	11	
N. Twin	Cass	8	9.	
Nevins	Montcalm	15	15	
Ore	Livingston	18	19	
Painter	Cass	20	20	
Pentwater	Oceana	17	16	
Robinson	Newaygo	32	33	31
Round	Mecosta	22	22	26
Sapphire	Missaukee	9	8	
School Section	Mecosta	7	5	
Selkirk #1	Allegan	13	12	
Selkirk #2	Allegan	12	11	
Shingle #1	Clare	19	20	25
		17 (DEQ)	18 (DEQ)	
Shingle #2	Clare	20	18	
		16 (DEQ)	19 (DEQ)	
Stone Ledge	Wexford	20	19	
Upper Crooked	Barry	16	14	
Upper Jetha	Van Buren	16	18	
Van Etten	Iosco	18	20	
W. Twin	Montmorency	9	8	

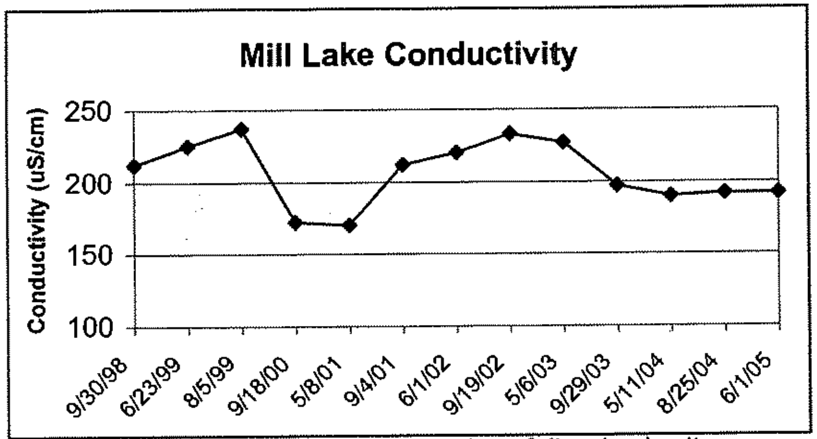
MICHIGAN LAKE & STREAM ASSOCIATIONS, INC.

1995 ADVANCED SELF-HELP PROGRAM
SPRING TOTAL PHOSPHORUS RESULTS

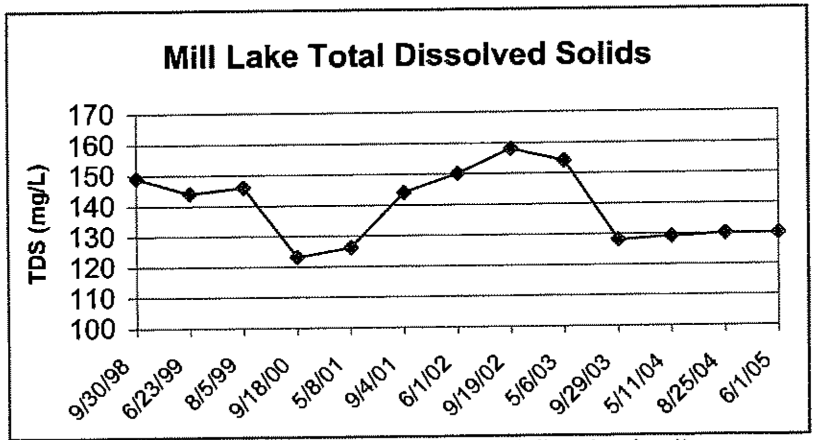
Lake	County	DATE	Total Phosphorus Results (ug/l) Volunteer Replicate #1	Volunteer Replicate #2	DNR Side-by-Side
Arbutus	Grand Traverse	4/27	8	7	
Arnold	Clare	4/27	8	8	
Avalon	Montmorency	4/27	4	3	
Bear	Kalkaska	4/27	6	6	
Big Crooked	VanBuren	4/13	10	8	
Big Pine	Kent	4/20	13	14	
Bills	Newaygo	4/20	6	6	
Blue	Mason	4/20	14	14	
Bradford	Otsego	5/4	13	14	
Cedar	VanBuren	4/13	9	9 (#1)	
			6	8 (#2)	
			9	9 (#3)	
Chemung	Livingston	4/19	21	18	
Christiana	Cass	4/13	30	25	
Clear	Jackson	4/13	7	5	
Clear	St. Joseph	4/13	11	12	
Clifford	Montmorency	4/20	18	18	
Corey	St. Joseph	4/13	8	7	
Crockery	Ottawa	4/20	42	43	
Crystal	Benzie	4/27	7	7	
Cub	Kalkaska	4/27	7	6	
Diamond	Cass	4/13	8	8	
Doc & Tom	Clare	4/27	23	18	
Donnell	Cass	4/13	9	9	
Duck	Grand Traverse	4/27	6	8	
East Twin	Montmorency	5/4	8	7	
East Twin	Roscommon	4/27	9	11	
Gravel	VanBuren	4/13	7	7	
Harper	Lake	4/27	8	7	
Higgins	Roscommon	4/27	6	6	
Hubbard	Alcona	5/4	8	6	
Indian	Kalamazoo	4/13	11	11	
Juno	Cass	4/13	22	28	
Keeler	VanBuren	4/13	12	12	
Klinger	St. Joseph	4/13	8	8	
Lake George	Clare	4/27	11	9 (#1)	
			8	8 (#2)	
			8	9 (#3)	
Long	Iosco	4/27	20	21	
Mecosta	Mecosta	4/20	16	14	
Mill	VanBuren	4/13	12	12 (#1)	
			10	10 (#2)	
			10	9 (#3)	
			9	9 (#4)	
Miner	Allegan	4/20	18	16	
Moon	Gogebic	5/11	6	10	
Moore	Oakland	4/13	11	11	
Nevins	Montcalm	4/20	15	15	
North Twin	Cass	4/13	8	9	
Ore	Livingston	4/19	18	19	
Painter	Cass	4/13	20	20	
Pentwater	Oceana	4/20	17	16	
Robinson	Newaygo	4/20	32	38	
Round	Kent	4/20	22	22	
Sapphire	Missaukee	4/27	9	8	
School Section	Mecosta	4/27	7	5	
Selkirk	Allegan	March	11 HT	12 HT (#1)	
			12 HT	13 HT (#2)	
		4/13	13	12 (#1)	
		4/13	12	11 (#2)	
Shingle	Clare	4/27	19	20 (#1)	
			20	18 (#2)	
Stone Ledge	Wexford	4/27	20	19	
Upper Crooked	Barry	4/13	16	14	
Upper Jeptha	VanBuren	4/13	16	18	
Van Etten	Iosco	4/27	18	20	
West Twin	Montmorency	5/4	9	8	

RECEIVED JUN 21, 1995 Ans'd..........

From: Ralph Bedna
DNR, Lansing



Values indicate low concentration of dissolved salts



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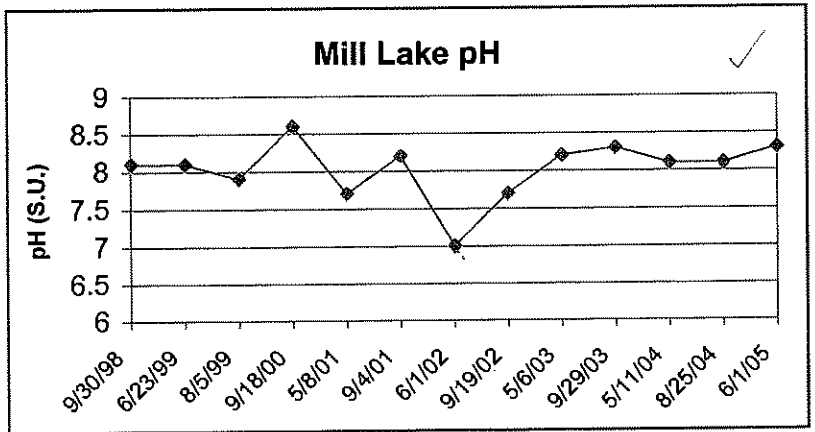
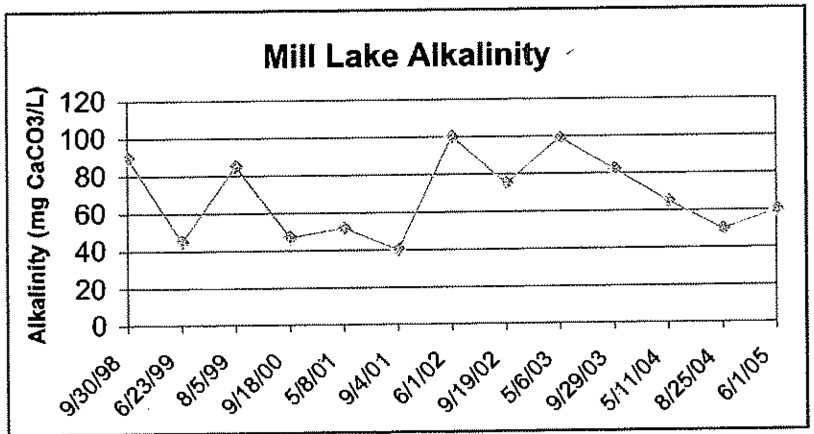
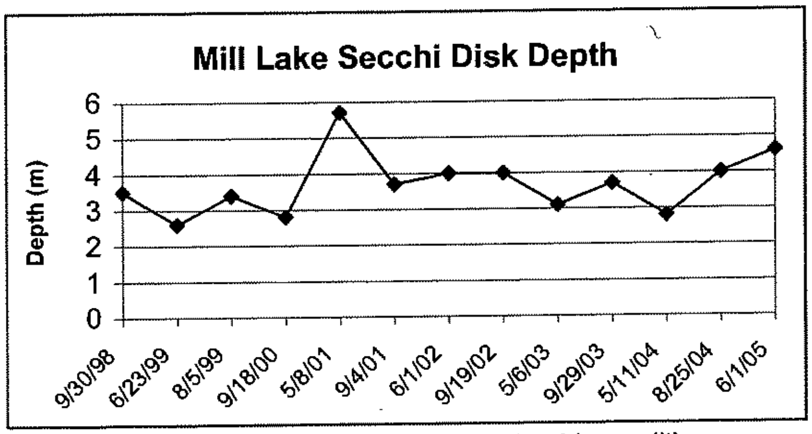


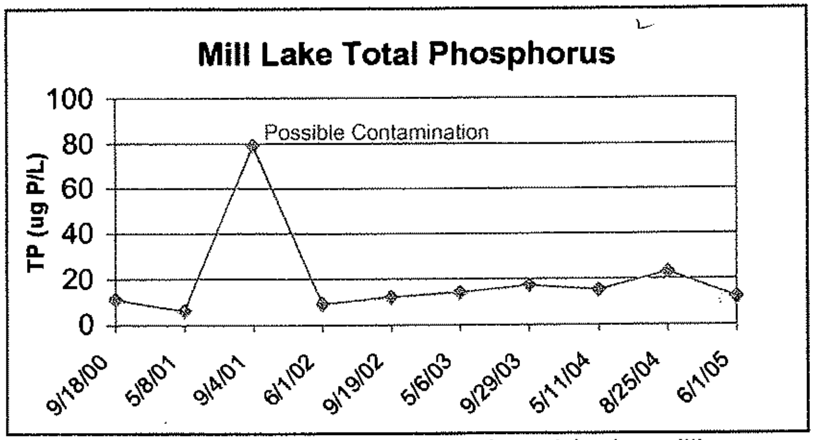
Values indicate water is slightly alkaline



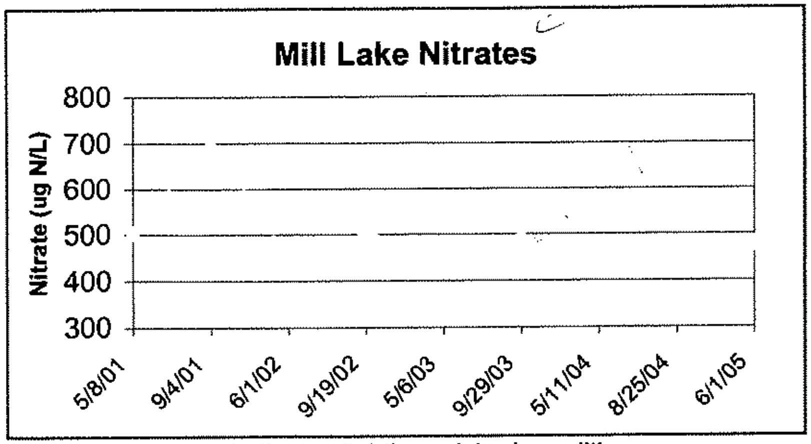
Values indicate water is soft



Water clarity depths represent mesotrophic conditions



Values indicate slightly to moderately enriched conditions



Values indicate slightly enriched conditions

P.E. 516-361-2664

MIKE OEZER

The water quality of Mill Lake has been monitored for several years by Professional Lake Management. A compilation of this data has made it possible to depict trends in the quality of the water and give the lake association an overall picture of the health of Mill Lake. Several parameters are measured at each sample date. Some of the parameters measured are; water clarity, dissolved oxygen, temperature, phosphorus and nitrates. The Secchi disk depth is a measure of water clarity, determined by measuring the depth to which a black and white disk can be seen from the surface (larger numbers represent greater water clarity.) The clearer a lake is the more sunlight can penetrate to deep growing aquatic plants. Mill Lake's water clarity is good with clarity averaging ~ 3 - 4.5 meters. The secchi depth average has slightly increased over the past five years, which indicates improving conditions on the lake. Temperature and dissolved oxygen are measured at the surface and at 1-meter intervals down to 10 meters. Dissolved oxygen is a measure of the amount of oxygen dissolved in the water. Oxygen is needed by fish and other aquatic organisms to allow them to "breath" underwater. Plants and algae produce oxygen by photosynthesizing during the day and use oxygen for respiration at night. The temperature of Mill Lake is consistent with other Southern Michigan Lakes. Dissolved oxygen values have always been more than adequate to support healthy fisheries on Mill Lake. There are two key nutrients involved in achieving a balanced aquatic ecosystem, phosphorus and nitrogen. Phosphorus is usually the nutrient that controls the amount of algal growth and nitrates control the amount of rooted plant growth in a lake. Mill Lake has low to moderate levels of both nutrients, which is great for a developed lake. Over the past 5 years the nutrients levels have not increased much and are comparable, if not better, than other lakes in the area. Phosphorus-free fertilizers should be used along the shoreline to aid in slowing down the enrichment of Mill Lake.

www.volconic.com
www.power-systems.org

2005207

Lake Check Water Quality Monitoring Report

Customer

Mill Lake
Mike Connelly
12370 Maple St
Gobles MI 49055

Waterbody

Mill Lake

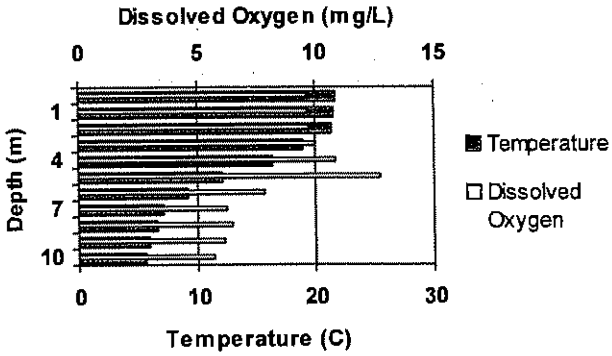
Sample Information

Date: 6/1/2005

Site: Deep Hole

On-Site Results

Depth (m)	Temperature (degrees C)	Dissolved Oxygen mg/L	%
0	21.6	9.6	80
1	21.5	9.6	82
2	21.3	9.7	82
3	18.9	10.0	81
4	16.4	10.8	83
5	12.1	12.7	89
6	9.3	7.9	51
7	7.2	6.2	39
8	6.6	6.4	39
9	6.0	6.2	37
10	5.6	5.7	34



Secchi Disk Depth 4.6 meters

Thermocline Depth 2.5 meters

Analytical Results

Parameter	Result	Units	Interpretation
Fecal Bacteria (E. coli		CFU/100 mL	N/A
Conductivity	192	uS/cm	Low concentration of dissolved salts
Total Dissolved Solids	130	mg/L	
pH	8.4	S.U.	Water is slightly alkaline
Alkalinity	60	mg CaCO3/L	Water is soft
Total Phosphorus	12	ug/L	Moderately phosphorus enriched
Nitrates	480	ug/L	Slightly nitrogen enriched
Chlorophyll	N/A		

Trophic State Evaluation

	TSI	Trophic Status
Based on Secchi Disk Depth	38	meso-oligotrophic
Based on Total Phosphorus	36	meso-oligotrophic
Based on Chlorophyll	N/A	

Conclusions

- Conditions are good for fish growth.

  Minimum dissolved oxygen is nearly low enough to adversely affect sensitive fish.
- pH is within acceptable limits.

  Sample is somewhat phosphorus enriched. Use phosphorus-free fertilizer on lakeshore lawns.
- REPEAT LakeCheck NEXT YEAR!

WARNING, condition requires immediate attention.
CAUTION, condition requires further evaluation.
OK, condition within acceptable limits.
NEUTRAL, condition neither good nor bad.

Notes

Report describes conditions at the time the sample was collected.

Approved by Jaimee Conroy
Mrs. Jaimee Conroy, Technical Services Manager

Date 10/27/2005

FROM YOUR WQ PRO DEALER

Professional Lake Management
P.O. Box 132
Caledonia MI 49316-

Phone: (616) 891-1294

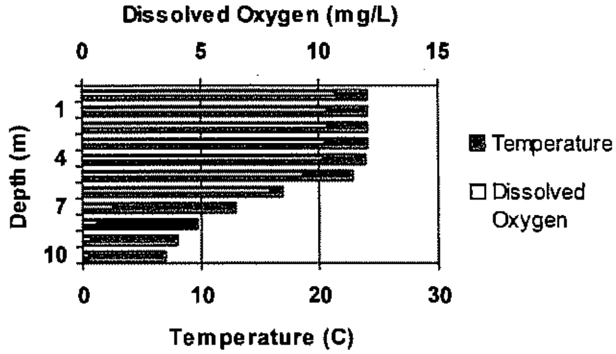
2005208

LAKE CHECK Water Quality Monitoring Report

Customer	Waterbody	Sample Information
Mill Lake Mike Connelly 12370 Maple St Gobles MI 49055	Mill Lake	Date: 9/15/2005 Site: Deep Hole

On-Site Results

Depth (m)	Temperature (degrees C)	Dissolved Oxygen mg/L	Dissolved Oxygen %
0	24.0	10.6	122
1	24.0	10.3	122
2	24.1	10.3	122
3	24.0	10.2	121
4	23.9	10.1	120
5	22.9	9.3	109
6	16.8	7.9	82
7	12.9	1.3	13
8	9.7	0.6	5
9	7.9	0.3	3
10	6.9	0.3	2



Secchi Disk Depth 4.0 meters

Thermocline Depth 5.5 meters

Analytical Results

Parameter	Result	Units	Interpretation
Fecal Bacteria (E. coli		CFU/100 mL	N/A
Conductivity	188	uS/cm	Low concentration of dissolved salts
Total Dissolved Solids	122	mg/L	
pH	8.1	S.U.	Water is slightly alkaline
Alkalinity	70	mg CaCO3/L	Water is soft
Total Phosphorus	123	ug/L	Phosphorus polluted
Nitrates	480	ug/L	Slightly nitrogen enriched
Chlorophyll	N/A		

Trophic State Evaluation

	TSI	Trophic Status
Based on Secchi Disk Depth	40	mesotrophic
Based on Total Phosphorus	69	hypereutrophic
Based on Chlorophyll	N/A	

Conclusions

Conditions for fish growth are FAIR. (see cautions/warnings below)

Minimum dissolved oxygen is nearly low enough to adversely affect sensitive fish.

Bottom water is deoxygenated, preventing fish from living in cooler water at bottom of lake.

pH is within acceptable limits.

Sample is highly phosphorus enriched. Consider nutrient abatement measures.

Deep water sample indicates possible internal loading of nutrients.

REPEAT LakeCheck NEXT YEAR!

WARNING. condition requires immediate attention.
CAUTION. condition requires further evaluation.
OK. condition within acceptable limits.
NEUTRAL. condition neither good nor bad.

Notes

Late summer sample for nutrients is taken from under the thermocline to determine if internal loading is occurring on the lake. Internal loading is the release of nutrients from the sediment when deep water is void of oxygen.

Report describes conditions at the time the sample was collected.

Approved by Jaimee Conroy Date 10/27/2005
Mrs. Jaimee Conroy, Technical Services Manager

FROM YOUR WQ PRO DEALER

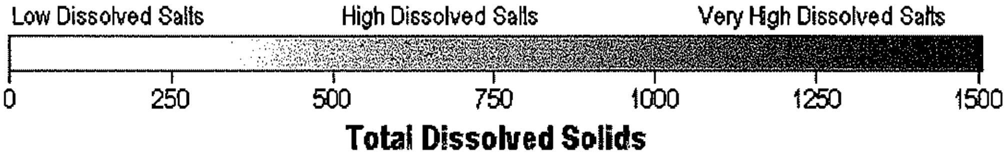
PROFESSIONAL LAKE MANAGEMENT

Professional Lake Management
P.O. Box 132
Caledonia MI 49316-

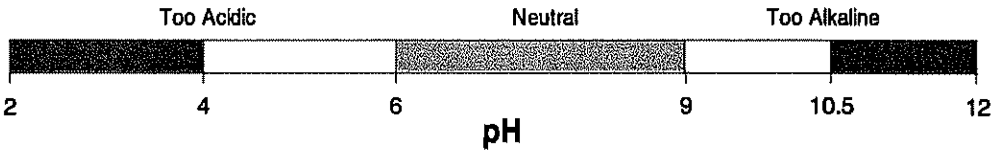
Phone: (616) 891-1294

LAKE CHECK WATER QUALITY MEASUREMENTS

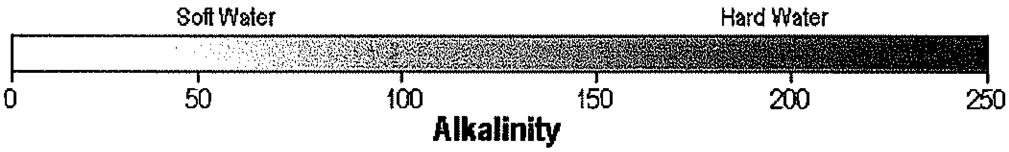
Conductivity and **Total Dissolved Solids (TDS)** measure the total amount of material dissolved in the water. Higher values indicate potentially richer, more productive water, whereas lower values indicate potentially cleaner, less productive water. Localized increases in conductivity and TDS may indicate inputs of groundwater or other nutrient-enriched water. [Note: Human activities that result in nutrient pollution (e.g., fertilizer runoff) can increase the productivity of algae and other organisms without raising conductivity/total dissolved solids very much. If nutrient pollution is occurring, the total phosphorus concentration is a much better indicator of potential productivity.]



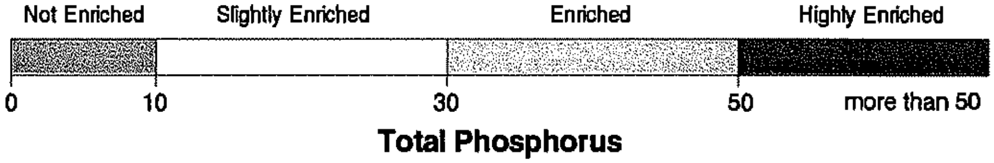
pH describes the balance between acids and bases in the water. Neutral values of pH (between 6 and 9) are desirable. Low pH values typically result either from the growth of bog vegetation (such as peat moss), acid precipitation ("acid rain"), or acid runoff (as in acid mine drainage). Excessive growth of certain plants and algae can raise pH values above 9.0 or 10.0.



Alkalinity measures the concentration of carbonates and bicarbonates in the water. These compounds and other ions associated with them make water "hard". High alkalinity lakes are hardwater lakes, while low alkalinity lakes are softwater lakes. Different kinds of plants, algae, and other aquatic organisms live in hardwater than in softwater. Alkalinity also influences the effectiveness of some herbicides and algicides. Alkalinity is a basic characteristic of water, but is neither inherently good nor bad.



Total Phosphorus measures the total (organic and inorganic, dissolved and particulate) amount of phosphorus in the water. Phosphorus is usually the plant nutrient (i.e., fertilizer) that controls the amount of algal growth in lakes and ponds. Most Midwestern lakes have more phosphorus and more algae than is desirable, so lower values are generally better, though very unproductive water bodies typically support little fish production.



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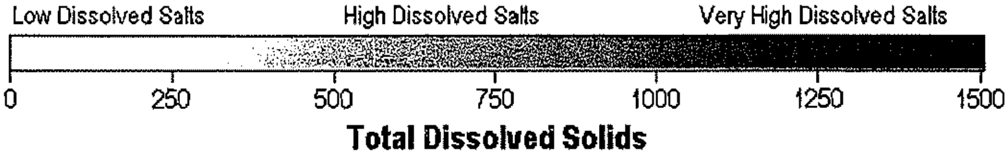

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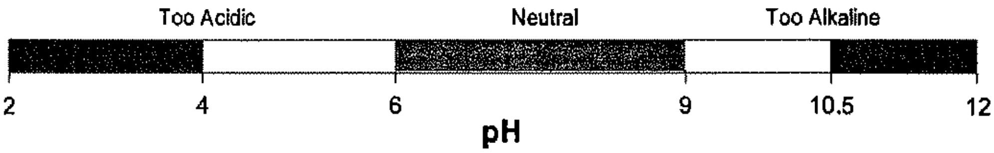

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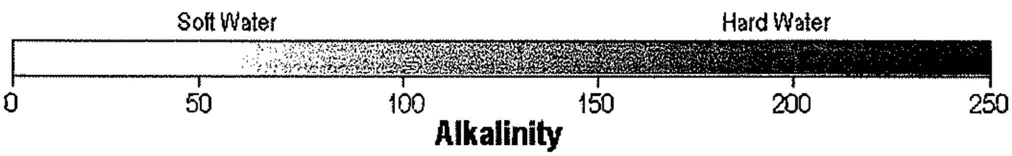

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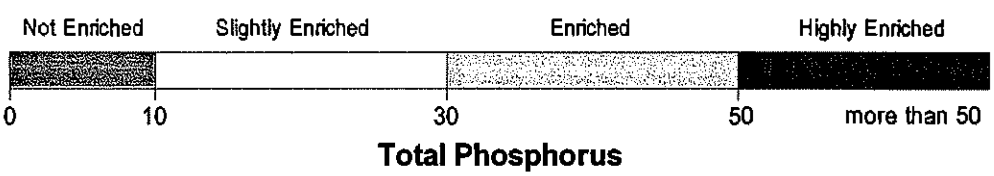
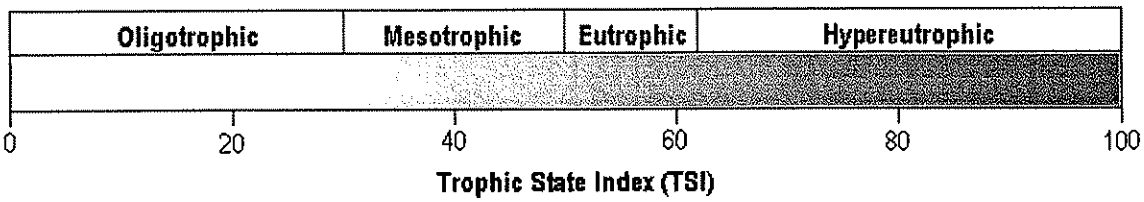


8865 100th Street SE
Alto, MI 49302
Phone 800-382-4434

Lake Trophic States and Eutrophication

Lakes are often categorized according to their Trophic Status. Trophic Status is a measure of nutrient richness and productivity (i.e., the ability to grow plants and animals). Lakes in different trophic categories also differ in a variety of other characteristics important to lake users and lake managers. Commonly used Trophic Status categories include: Oligotrophic, Mesotrophic, Eutrophic and Hypereutrophic. These may be further subdivided into intermediate categories, such as meso-oligotrophic, to describe lakes that have characteristics in between those of the major categories.

Trophic State Index (TSI) values are used to describe the trophic status of individual lakes. Indices typically rank lakes from 1 to 100, based on such parameters as Secchi disk depth, total phosphorus concentrations, and chlorophyll levels.



Characteristics Typical of Different Trophic States

	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Water Clarity	excellent	Good	fair-poor	very poor
Nutrients	low	Moderate	high	very high
Algae	few	Moderate	blooms likely	severe blooms probable
Plants	few	Moderate	abundant	few, in shallows
Fishery	cold water possible	cold water possible	warm water only	rough fish often dominate

Oligotrophic Lakes have low nutrient levels, clear water and low productivity. High dissolved oxygen levels in cooler bottom waters allow the survival of cold water fish.

Mesotrophic Lakes have moderate nutrient levels, clear water and moderate productivity. Rooted plants may be abundant. Moderate dissolved oxygen levels in cooler bottom waters allow the survival of cold water fish.

Eutrophic Lakes have high nutrient levels, turbid water and high productivity. Algal blooms are likely and may sometimes be severe. Rooted plants may be very abundant. Dissolved oxygen is depleted from bottom waters, restricting fish populations to warm water species.

Hypereutrophic Lakes have very high nutrient levels, extremely turbid water, and very high algal productivity. Severe blooms of noxious blue-green algae are likely. High turbidity and luxuriant growth of filamentous algae restrict rooted plant growth. Turbidity tolerant plant species (e.g., sago pondweed,

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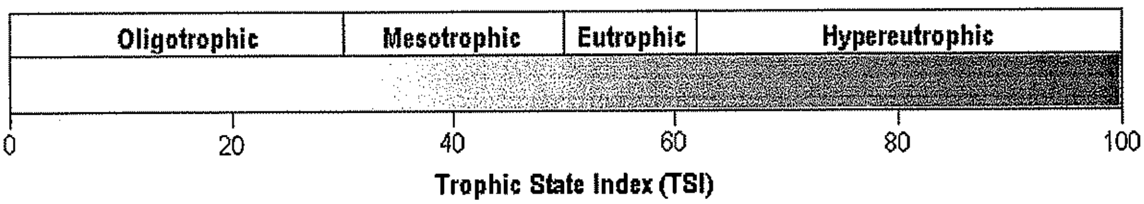

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Eurasian watermilfoil, curly leaf pondweed) may persist in shallow areas. Periods of dissolved oxygen depletion may restrict fish populations to rough fish species (e.g. carp, mudminnows, etc.).

Human Activities and Eutrophication

Lakes naturally progress from oligotrophic to eutrophic, a process known as "eutrophication". Human activities can dramatically speed this process by increasing the input of nutrients (phosphorus and nitrogen) and sediment. Rapid eutrophication caused by human activities is called "cultural eutrophication". Most lake residents prefer the characteristics of oligotrophic lakes to those of more productive (i.e., mesotropic, eutrophic or hypereutrophic) lakes; thus controlling or preventing cultural eutrophication is a major concern for lake managers. Preventing eutrophication is far easier and less expensive than restoring lakes damaged by cultural eutrophication. The following recommendations can help lakes evaluate cultural eutrophication and decide when action is necessary.

- Monitor phosphorus and nitrogen (and, ideally, chlorophyll) concentrations so that the progress of eutrophication can be evaluated.
- Encourage best management practices for lakeshore properties, including:
  - Use of phosphorus-free lawn fertilizer.
  - Effective barriers for controlling soil erosion and runoff at construction sites.
  - Disposal of grass clippings, leaves and other plant debris away from the lakeshore.
- If concentrations of the parameters listed above are found to be elevated and/or increasing:
  - Evaluate sources of nutrients entering the lake (construct a nutrient budget).
  - Investigate possible nutrient/runoff abatement measures for critical nutrient/sediment sources identified by the budget

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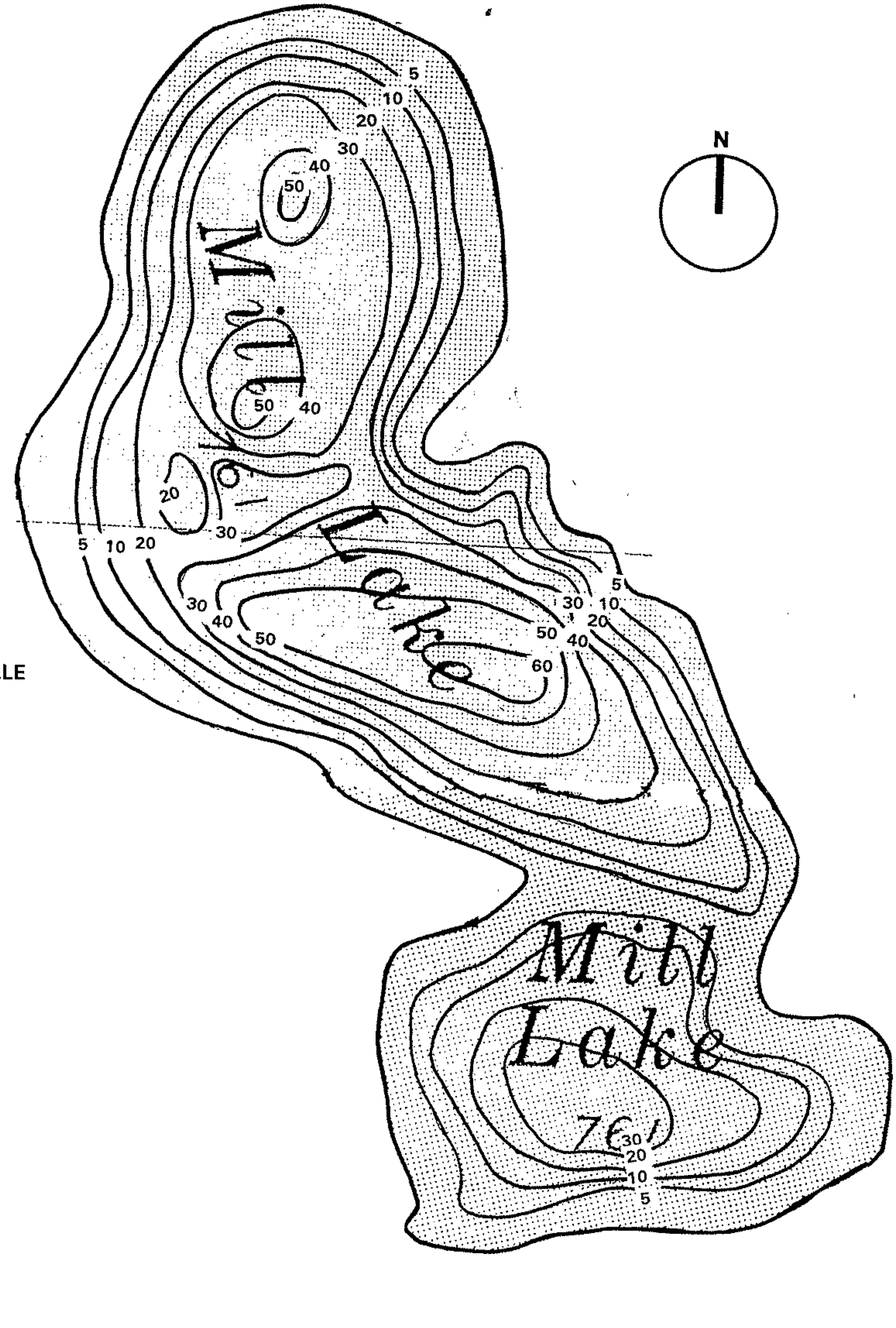
MILL LAKE

VAN BUREN COUNTY

APPROXIMATE DEPTH CONTOUR MAP



NO SCALE

LAKE CLASSIFICATION CRITERIA

LAKE CLASSIFICATION	TOTAL PHOSPHORUS (μg/L)	CHLOROPHYLL-*a* (μg/L)	SECCHI TRANSPARENCY (feet)
OLIGOTROPHIC	less than 10	less than 2.2	greater than 15.0
MESOTROPHIC	10 to 20	2.2 to 6.0	7.5 to 15.0
EUTROPHIC	greater than 20	greater than 6.0	less than 7.5

Notes:

1. The criteria listed above are guidelines for the upper midwest and northeast regions of the U.S. that have been generally accepted by water resource management professionals. These guidelines do not represent standards adopted by the Michigan Department of Natural Resources, but rather criteria for evaluating water quality.
2. Oligotrophic lakes are generally deep, clear, and have little aquatic plant growth. Eutrophic lakes are generally shallow, turbid, and have a great abundance of aquatic plants. Mesotrophic lakes are intermediate in water quality.
3. Phosphorus is the nutrient that most often stimulates the growth of aquatic plants. Chlorophyll-*a* is the pigment that makes plants green in color. A rough estimate of the quantity of algae in lake water can be made by measuring the amount of chlorophyll-*a* in a water sample.
   A Secchi disk is a flat, circular disk, 8 inches in diameter, the surface of which is divided into 4 pie-shaped sections with the alternating sections painted black and white. The Secchi disk is used to estimate water clarity.
4. μg/L = micrograms per liter, or parts per billion.

DISSOLVED OXYGEN REQUIREMENTS

FOR WARMWATER AND COLDWATER FISH

Warmwater fish: 5 milligrams per liter (parts per million) or greater
Coldwater fish: 7 milligrams per liter or greater

TABLE 1
MILL LAKE
DEEP BASIN WATER QUALITY DATA
JULY 3, 1997

Sample Location	Sample Depth (feet)	Temp. (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (μg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L as $CaCO_3$)
1	1	79.0	7.4	11	8.2	54
	12	70.0	7.4	---	---	---
	24	54.0	7.0	---	---	---
	36	46.0	5.3	14	7.6	62
	48	44.0	4.8	---	---	---
	60	43.0	3.8	29	7.3	67

The Secchi transparency measurement was 9.5 feet at the time of the sampling.

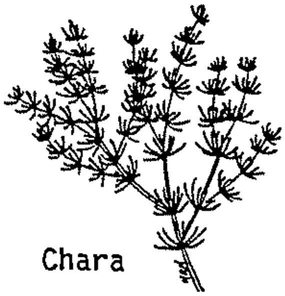
---

[1] mg/L = milligrams per liter = parts per million.

[2] μg/L = micrograms per liter = parts per billion.

TABLE 2
MILL LAKE
AQUATIC PLANTS
JULY 3, 1997

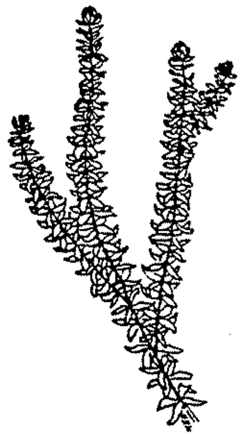
Common Name	Scientific Name	Group	Occurence
Eurasian milfoil	*Myriophyllum spicatum*	Submersed	Common
Large-leaf pondweed	*Potamogeton amplifolius*	Submersed	Common
Illinois pondweed	*Potamogeton illinoensis*	Submersed	Sparse
Northern milfoil	*Myriophyllum heterophyllum*	Submersed	Sparse
Yellow waterlily	*Nuphar* sp.	Floating-leaved	Common
White waterlily	*Nymphea odorata*	Floating-leaved	Common
Water shield	*Brasenia schreberi*	Floating-leaved	Sparse
Swamp loosestrife	*Decodon verticillatus*	Emergent	Common
Cattail	*Typha* sp.	Emergent	Common
Arrowhead	*Sagittaria latifolia*	Emergent	Sparse
Pickerelweed	*Pontederia cordata*	Emergent	Sparse
Hardstem bulrush	*Scirpus acutus*	Emergent	Sparse



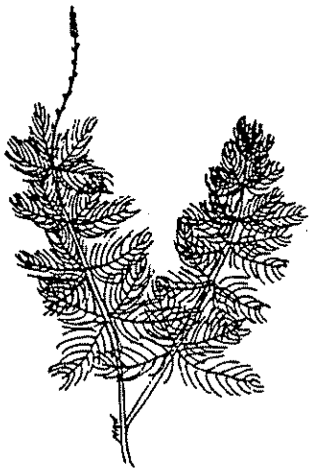
Chara

Coontail

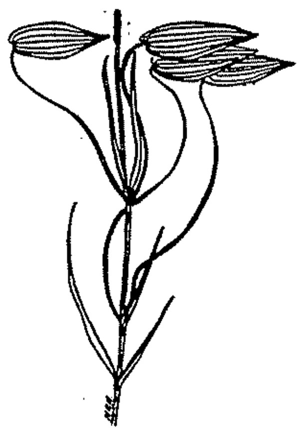
Clasping-leaf Pondweed



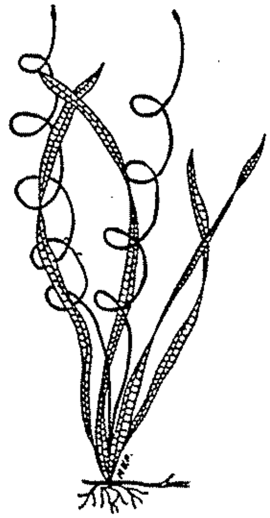
American elodea



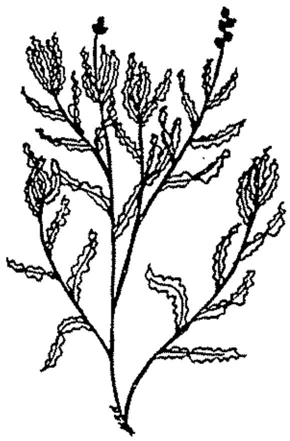
Watermilfoil



Floating-leaf Pondweed

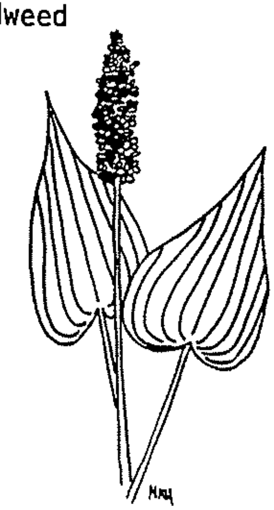


Wild Celery

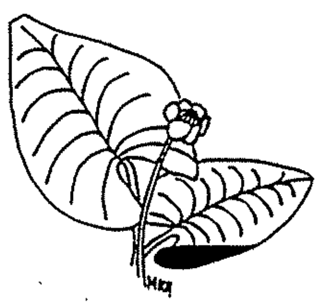


Curly-leaf Pondweed

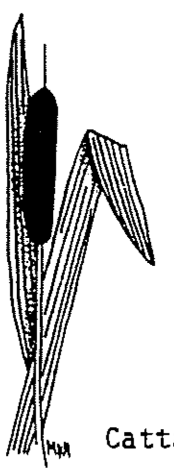
Large-leaf Pondweed



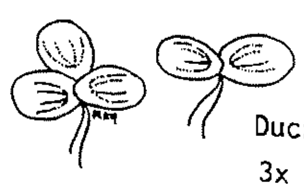
Pickerelweed



Yellow Water Lily

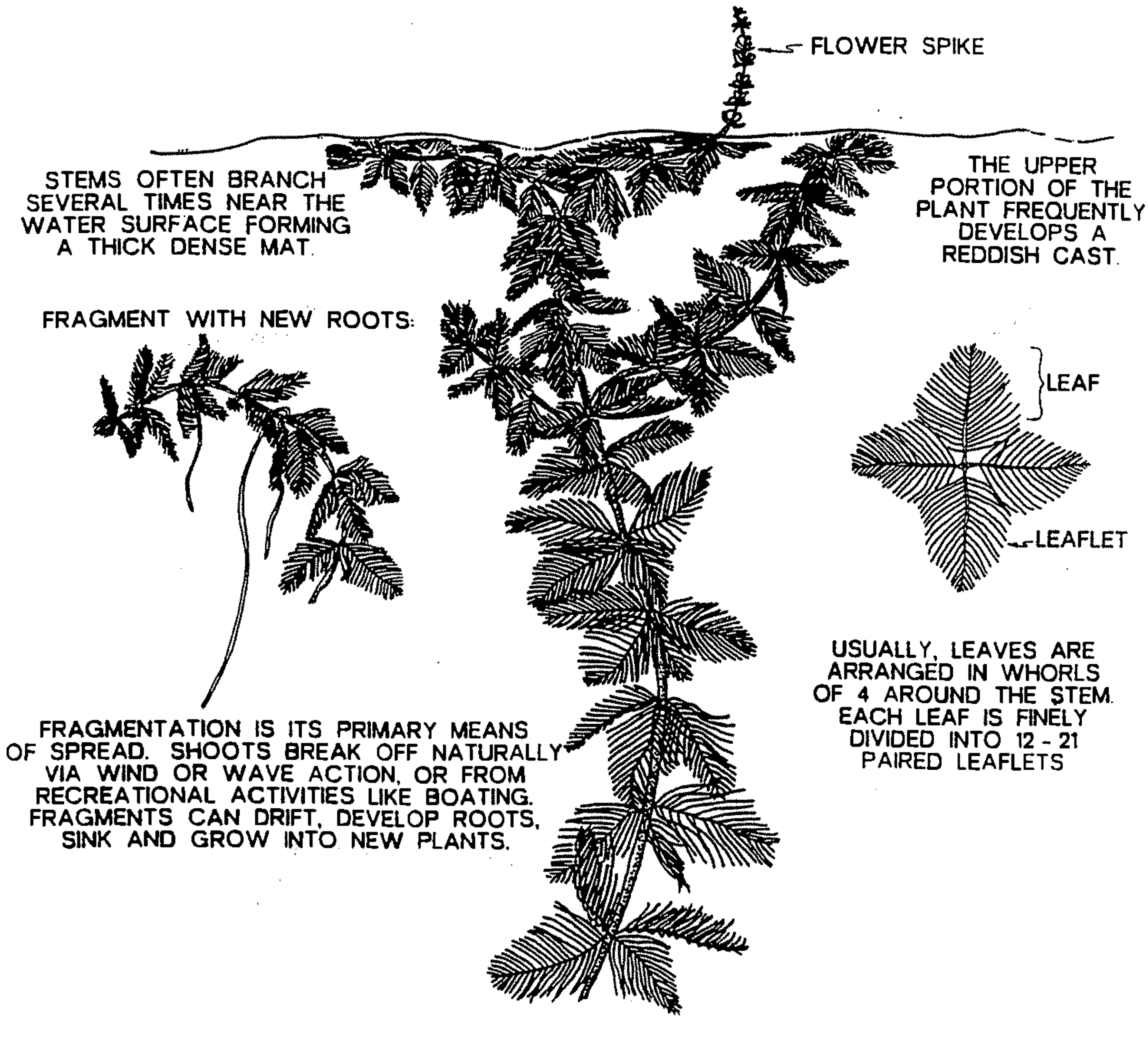


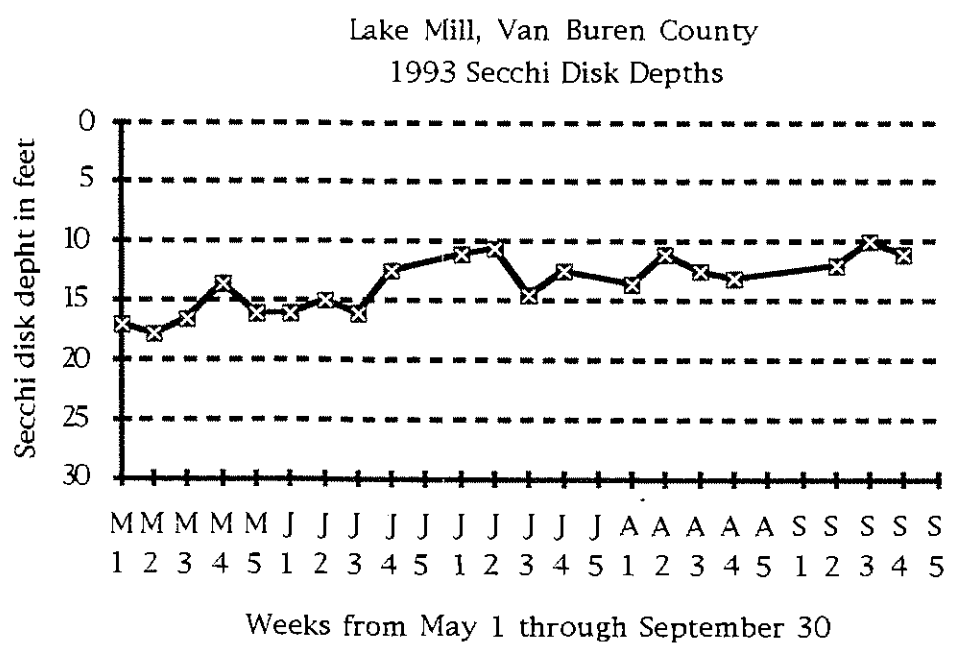
Cattail



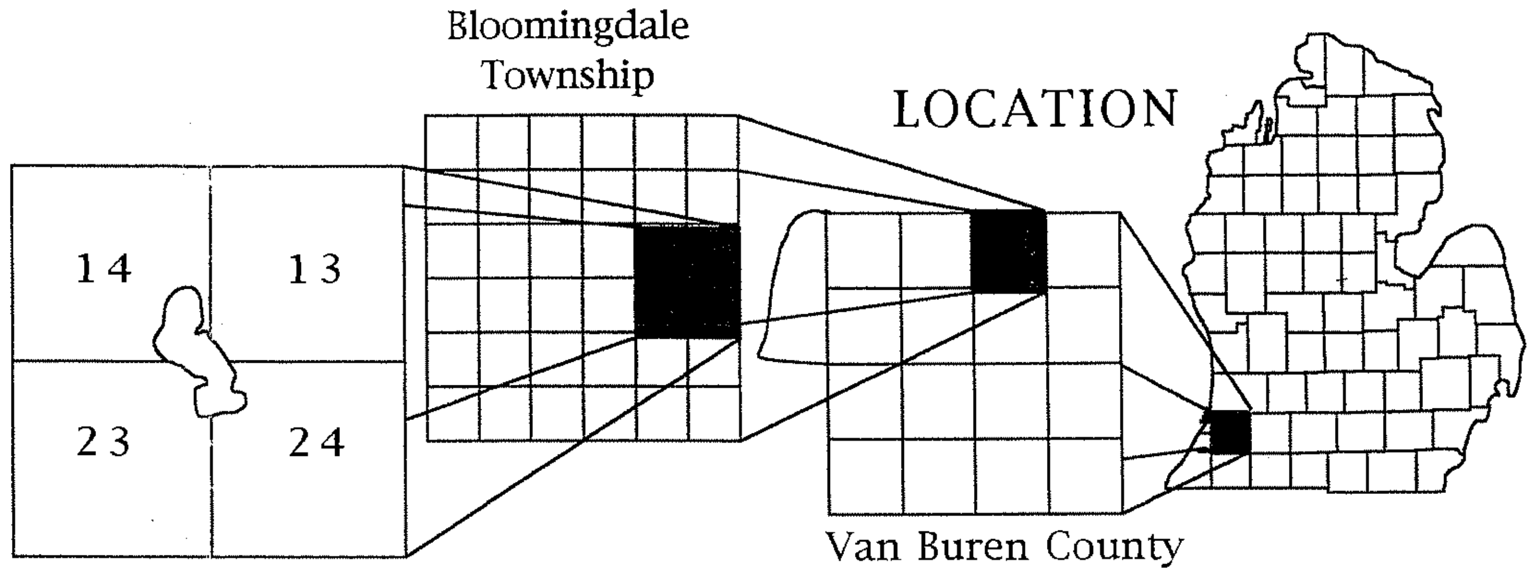
Duckweed
3x actual size

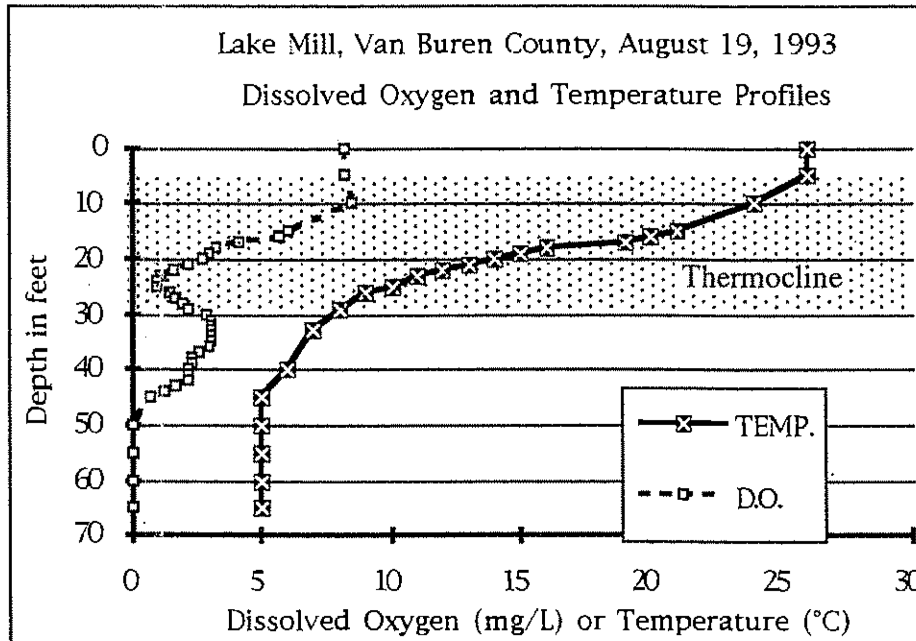
WATER MILFOIL



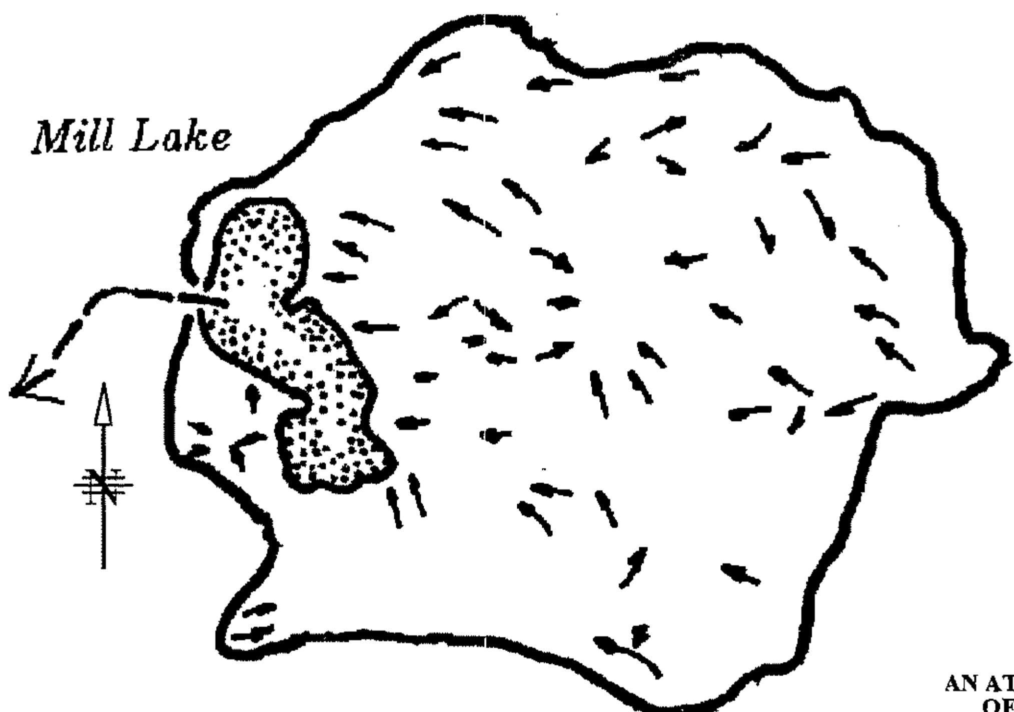


MAY	17	17.7	16.5	13.5	16
JUN	16	15	16	12.5	.
JUL	11	10.5	14.5	12.5	.
AUG	13.5	11	12.5	13	.
SEP	.	12	10	11	.





Temp.	Depth	D.O.	Depth	D.O.	Depth
26	0	8.2	0	3.1	34
26	5	8.2	5	3.1	35
24	10	8.5	10	3.0	36
21	15	6.1	15	2.6	37
20	16	5.7	16	2.3	38
19	17	4.2	17	2.3	39
16	18	3.3	18	2.2	40
15	19	3.0	19	2.2	41
14	20	2.7	20	2.2	42
13	21	2.2	21	1.7	43
12	22	1.6	22	1.3	44
11	23	1.1	23	0.7	45
10	25	1.0	24	0	50
9	26	1.0	25	0	55
8	29	1.5	26	0	60
7	33	1.7	27	0	65
6	40	2.0	28		
5	45	2.2	29		
5	50	2.9	30		
5	55	3.1	31		
5	60	3.1	32		
5	65	3.1	33		



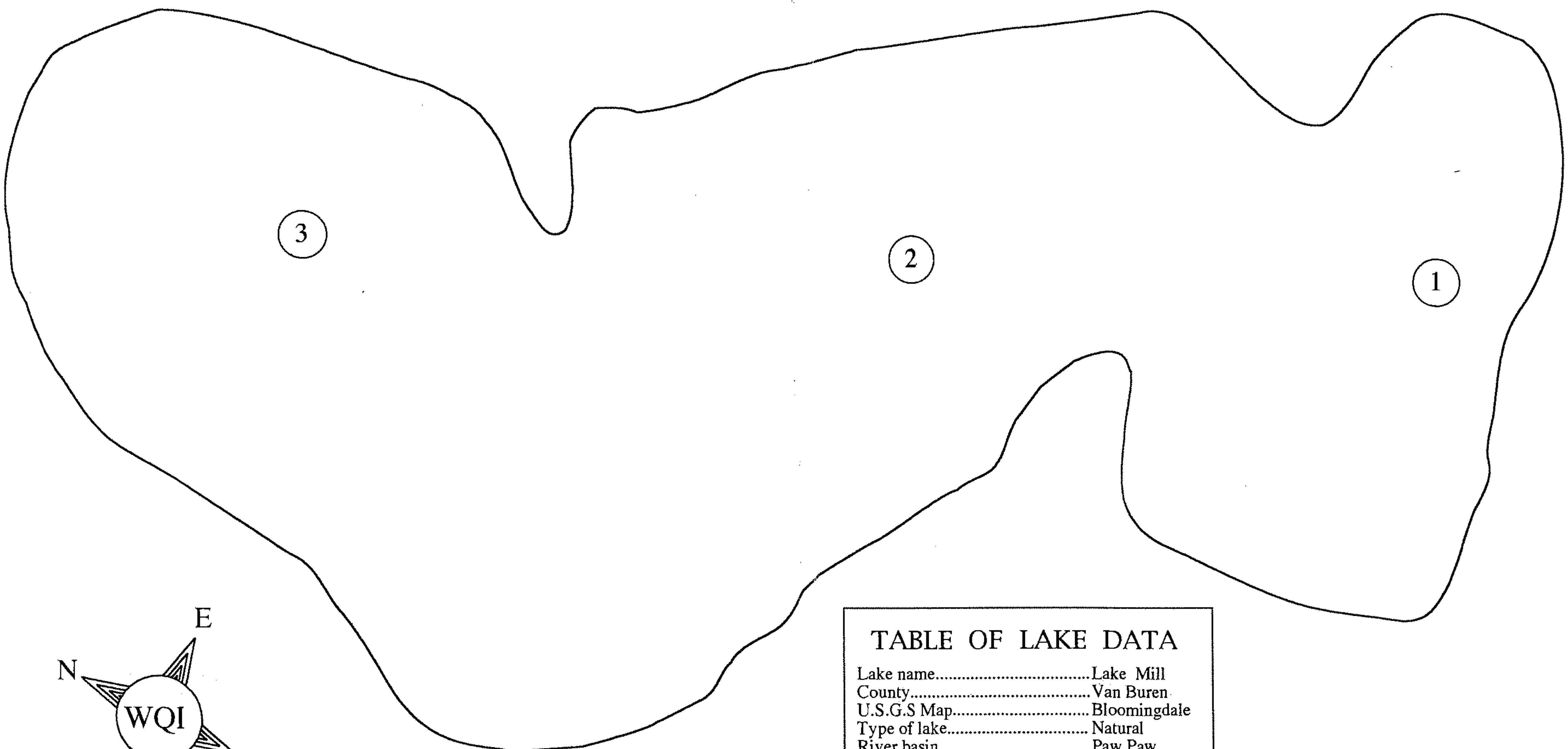
Drainage area map

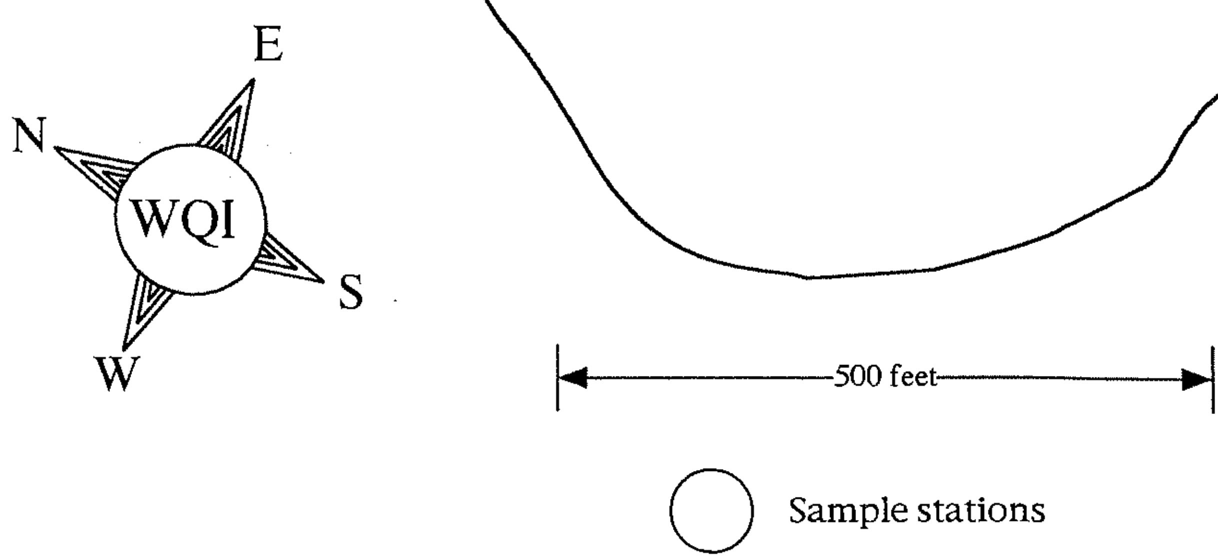
Lake Mill
Section 13, 14, 23, & 24
Bloomingdale Township
T1S R14W
Van Buren County

**AN ATLAS AND GAZETTEER
OF MICHIGAN LAKES
VOLUME 3, 1993
Water Quality Investigators
9200 Dexter Chelsea Road
Dexter, Michigan 48130
(313) 426-8972
WQI ©1993**

Surface Lake Water Quality Data

Date	Sample Station Number	Temperature °C	Dissolved Oxygen (mg/L)	Dissolved Oxygen Percent Saturation	Chlorophyll a ug/L	Secchi Disk Depth (feet)	Total Nitrate Nitrogen Ug/L	Alkalinity mg/L	pH	Conductivity umhos per cm at 25°C	Total Phosphorus ug/L	Lake Water Quality Index	Grade
4/27/93	1	---	---	---	1.5	18	41	67	7.6	240	8	97	A
4/27/93	2	---	---	---	2.2	18	46	63	7.6	235	7	96	A
4/27/93	3	---	---	---	2.4	18	46	63	7.6	235	9	96	A
8/19/93	1	26	8.3	101	2.9	13	33	65	7.8	215	15	93	A
8/19/93	2	26	8.2	100	2.2	13	27	65	7.8	215	16	94	A
8/19/93	3	26	8.3	101	2.6	13	30	65	7.8	220	20	93	A





No hydrographic map available

TABLE OF LAKE DATA

Lake name	Lake Mill
County	Van Buren
U.S.G.S Map	Bloomingdale
Type of lake	Natural
River basin	Paw Paw
Lake area (acres)	100
Maximum depth (feet)	65
Mean depth (feet)	Unknown
Lake volume (acre feet)	Unknown
Watershed area (acres)	1415
Drainage area (acres)	1517
Watershed to lake ratio	13.87
Flushing rate	Unknown
Elevation	761
Longest dimension	2108 feet
Spring LWQI	97, 96, 96
Summer LWQI	93, 94, 93
Bottom Sediments	Unknown
Official lake monitor	Dennis Hurlbut

Lake Mill
Section 13, 14, 23, & 24
Bloomingdale Township
T1S R14W
Van Buren County

AN ATLAS AND GAZETTEER
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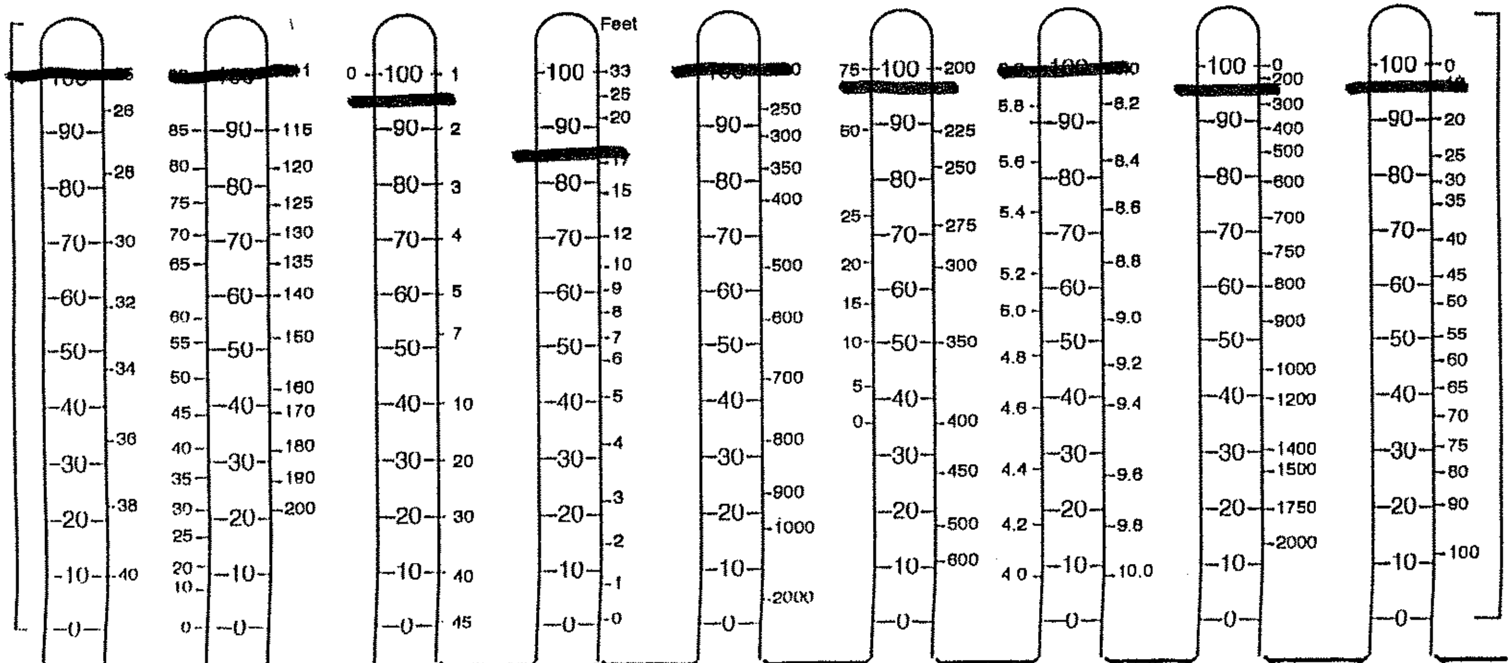
CALCULATION SHEET FOR THE UNWEIGHTED MULTIPLIC ATIVE LAKE WATER QUALITY INDEX

W. Fusilier, Ph.D.

QUALITY RATING CURVES
(Individual Quality Ratings never exceed 100)

Temperature in degrees C	Dissolved Oxygen, % Saturation	Chlorophyll a ug/L	Secchi Disk Depth in feet	Nitrate-N ug/L	Alkalinity mg/L	pH S. U.	Specific Conductivity umhos/cm@ 25C	Total Phosphorus ug/L
	/	1.5	18	41	67	7.6	240	8
100	100	95	86	100	98	100	95	98



$\sqrt[9]{100 \times 100 \times 95 \times 86 \times 100 \times 98 \times 100 \times 95 \times 98} = 97$

LWQI: 97

Lake to watershed ratio:

Flushing rate:

Drainage Basin:

Drainage Area:

Lake Volume:

County and State: Van Buren MI

Township: Bloomingdale

Analyst: WQI

Lake Depth: 60'

Lake Area:

SET THE PARAMETER QUALITY RATING AT 1 IF THE EXTERNAL EXTREME VALUE RANGE IS EXCEEDED

LAKE WATER QUALITY INDEX

0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
Red	Red Orange	Orange	Orange Yellow	Yellow	Yellow Green	Green	Blue Green	Blue

DATE 27 April 1993

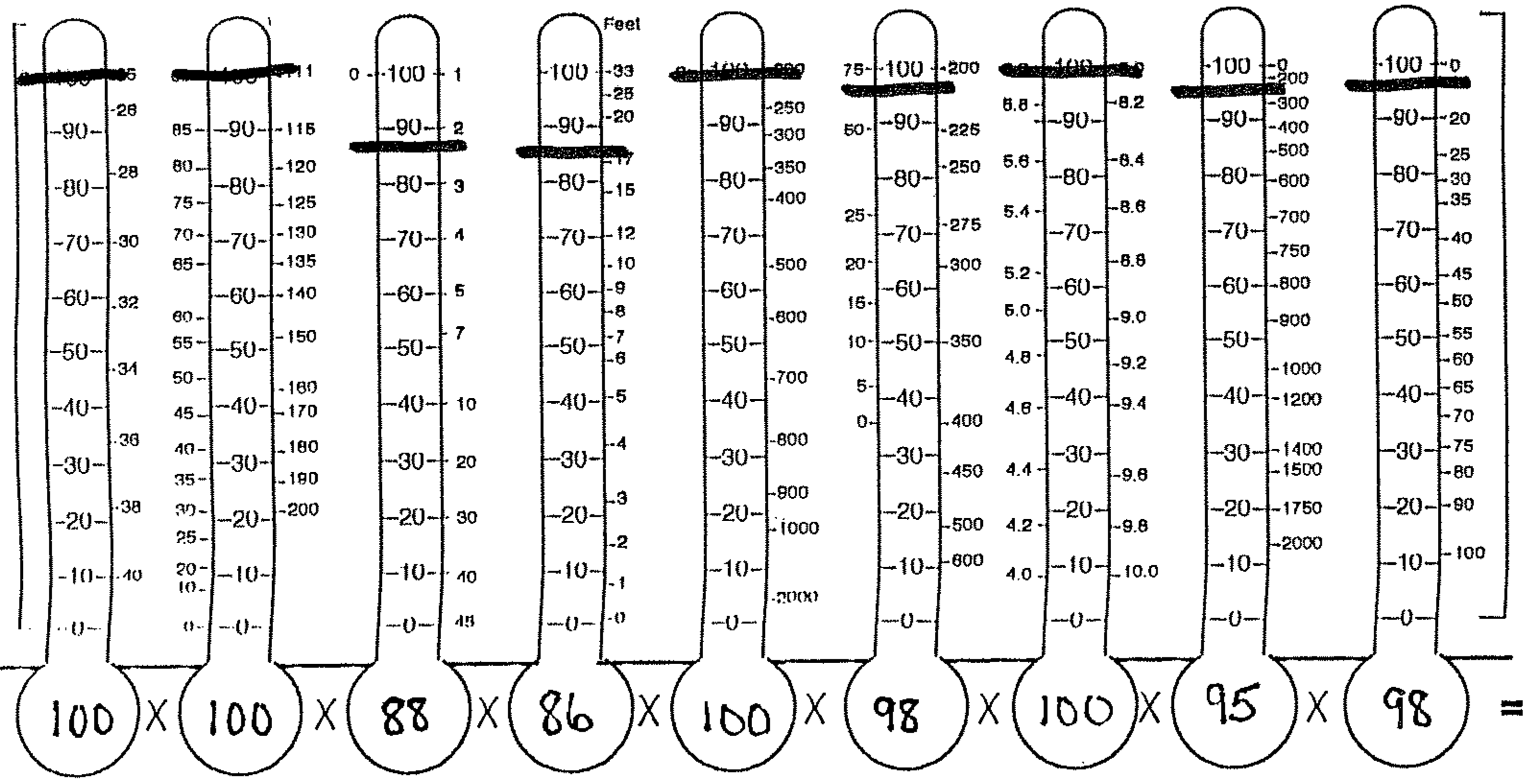
STATION 1

LAKE Mill

CALCULATION SHEET FOR THE UNWEIGHTED MULTIPLIC ATIVE LAKE WATER QUALITY INDEX

W. Fusilier, Ph.D.

Temperature In degrees C	Dissolved Oxygen, % Saturation	Chlorophyll a ug/L	Secchi Disk Depth In feet	Nitrate-N ug/L	Alkalinity mg/L	pH S. U.	Specific Conductivity umhos/cm@ 25C	Total Phosphorus ug/L
		2.2	18	46	63	7.6	235	7



$\sqrt[9]{100 \times 100 \times 88 \times 86 \times 100 \times 98 \times 100 \times 95 \times 98} = 96$

LWQI: 96

Lake to watershed ratio

Flushing rate

Drainage Basin

Drainage Area

Lake Volume

Van Buren MI
County and State

Bloomingdale
Township

WQI
Analyst

Lake Depth

Lake Area

SET THE PARAMETER QUALITY RATING AT 1 IF THE EXTERNAL EXTREME VALUE RANGE IS EXCEEDED

LAKE WATER QUALITY INDEX

0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
Red	Red Orange	Orange	Orange Yellow	Yellow	Yellow Green	Green	Blue Green	Blue

DATE 27 April 1993

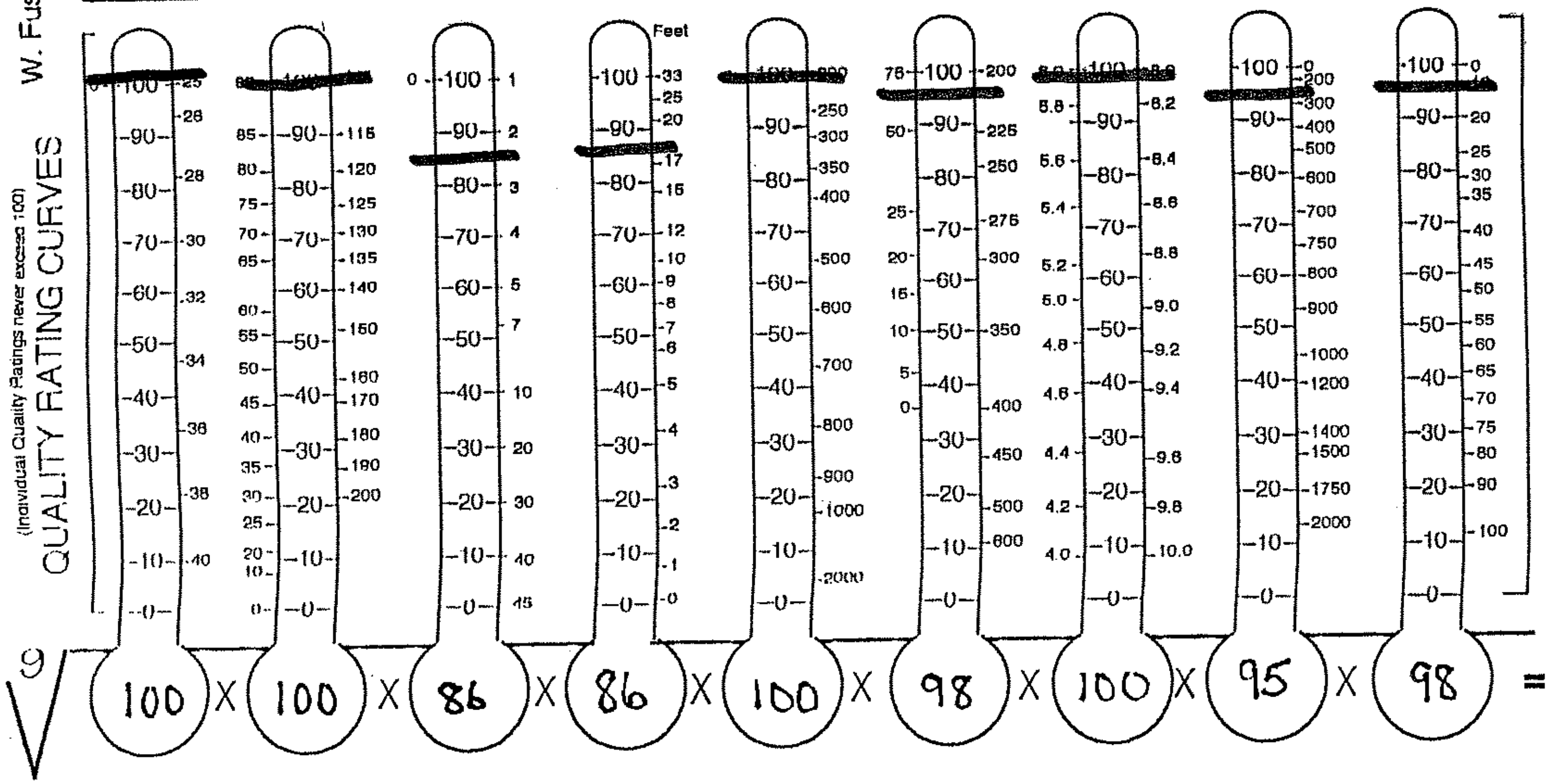
STATION 2

LAKE Mill

CALCULATION SHEET FOR THE UNWEIGHTED MULTIPLIC ATIVE LAKE WATER QUALITY INDEX

W. Fusilier, Ph.D.

Temperature in degrees C	Dissolved Oxygen, % Saturation	Chlorophyll a ug/L	Secchi Disk Depth in feet	Nitrate-N ug/L	Alkalinity mg/L	pH S. U.	Specific Conductivity umhos/cm@ 25C	Total Phosphorus ug/L
		2.4	18	46	63	7.6	235	9



$$\sqrt[9]{100 \times 100 \times 86 \times 86 \times 100 \times 98 \times 100 \times 95 \times 98} = 96$$

LWQI: 96

Lake to watershed ratio ______

Flushing rate ______

Drainage Basin ______

Drainage Area ______

Lake Volume ______

County and State: Van Buren MI

Township: Bloomingdale

Analyst: WQI

Lake Depth ______

Lake Area ______

SET THE PARAMETER QUALITY RATING AT 1 IF THE EXTERNAL EXTREME VALUE RANGE IS EXCEEDED

LAKE WATER QUALITY INDEX

0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
Red	Red Orange	Orange	Orange Yellow	Yellow	Yellow Green	Green	Blue Green	Blue

DATE: 27 April 1993

STATION: 3

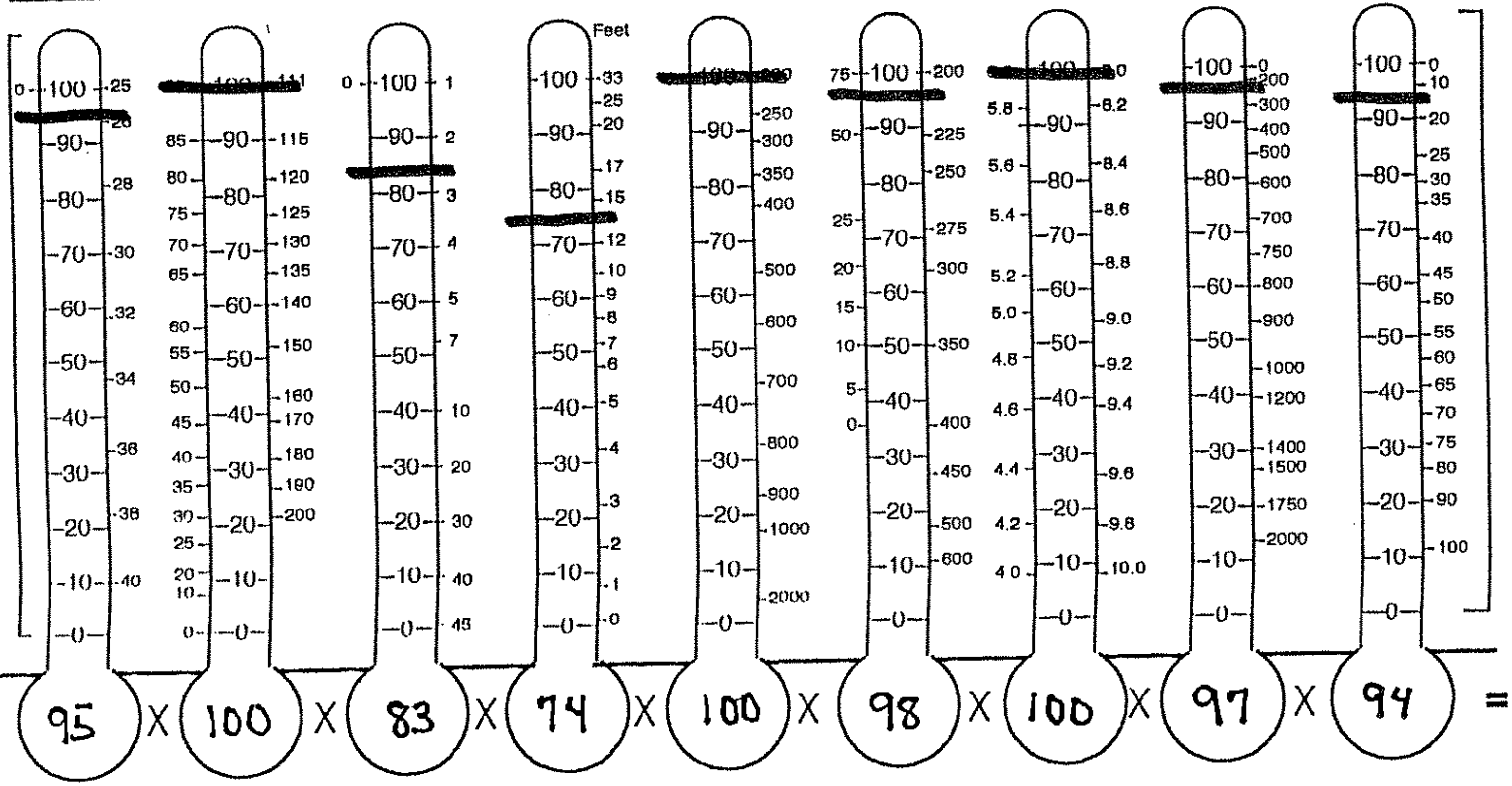
LAKE: Mill

CALCULATION SHEET FOR THE UNWEIGHTED MULTIPLIC ATIVE LAKE WATER QUALITY INDEX

W. Fusilier, Ph.D.

Parameter	Measured value	Quality rating
Temperature in degrees C	26°	95
Dissolved Oxygen, % Saturation	8.3/8.2 101	100
Chlorophyll a ug/L	2.7	83
Secchi Disk Depth in feet	13	74
Nitrate-N ug/L	33	100
Alkalinity mg/L	65	98
pH S. U.	7.8	100
Specific Conductivity umhos/cm@ 25C	215	97
Total Phosphorus ug/L	15	94

QUALITY RATING CURVES
(Individual Quality Ratings never exceed 100)



$$\sqrt[9]{95 \times 100 \times 83 \times 74 \times 100 \times 98 \times 100 \times 97 \times 94} = 93$$

LWQI: 93

Lake to watershed ratio ______

Flushing rate ______

Drainage Basin ______

Drainage Area ______

Lake Volume ______

County and State: Van Buren MI

Township: Bloomingdale

Analyst: WQI

Lake Depth ______

Lake Area ______

SET THE PARAMETER QUALITY RATING AT 1 IF THE EXTERNAL EXTREME VALUE RANGE IS EXCEEDED

LAKE WATER QUALITY INDEX

0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
Red	Red Orange	Orange	Orange Yellow	Yellow	Yellow Green	Green	Blue Green	Blue

DATE 19 August 1993

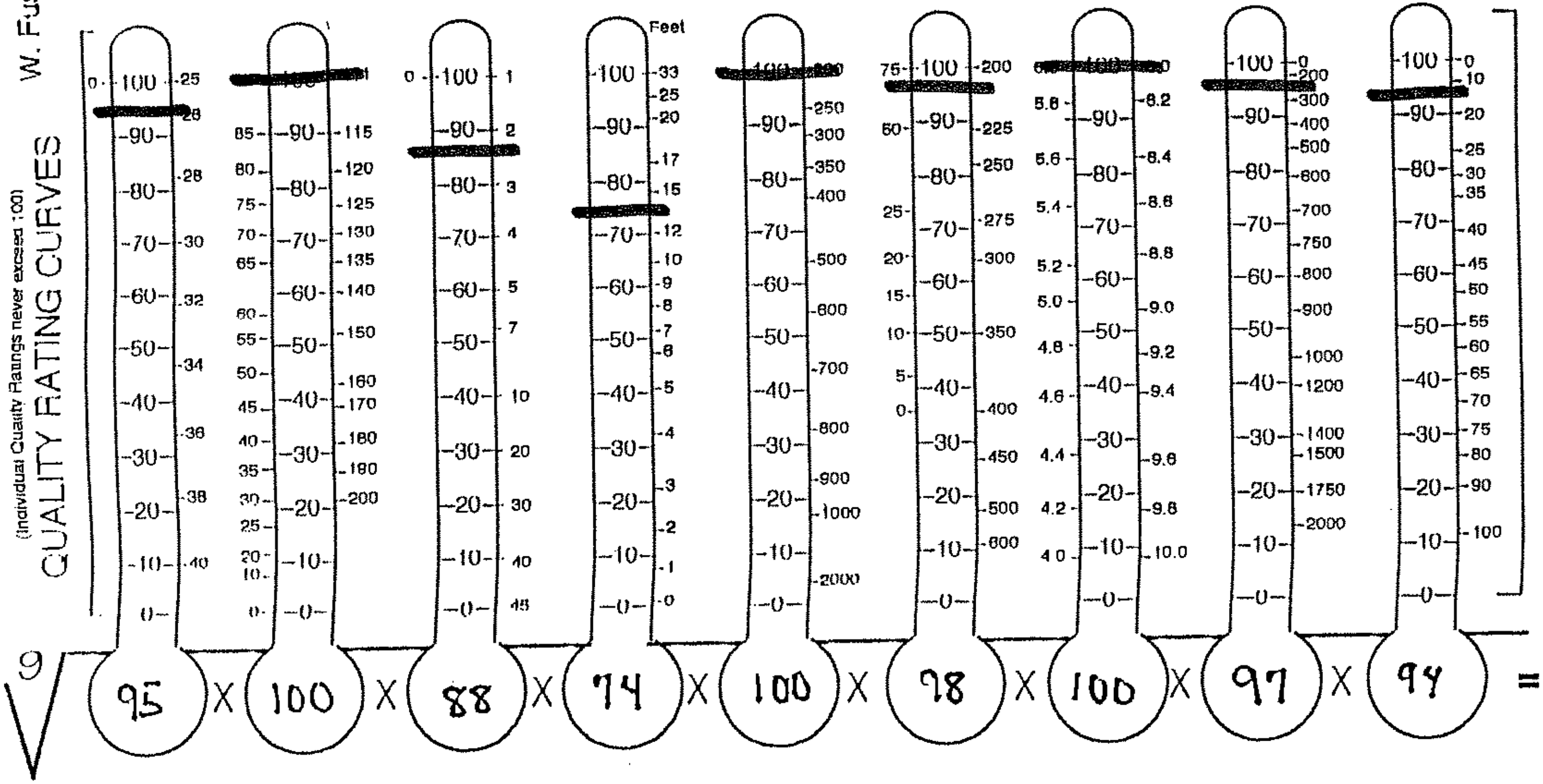
STATION 1

LAKE Mill

CALCULATION SHEET FOR THE UNWEIGHTED MULTIPLIC ATIVE LAKE WATER QUALITY INDEX

W. Fusilier, Ph.D.

Parameter	Value	Quality rating
Temperature in degrees C	26°	95
Dissolved Oxygen, % Saturation	8.3/8.2 / 100	100
Chlorophyll a ug/L	2.2	88
Secchi Disk Depth in feet	13	74
Nitrate-N ug/L	27	100
Alkalinity mg/L	65	98
pH S. U.	7.8	100
Specific Conductivity umhos/cm@ 25C	215	97
Total Phosphorus ug/L	16	94



LWQI: 94

Lake to watershed ratio ____

Flushing rate ____

Drainage Basin ____

Drainage Area ____

Lake Volume ____

County and State: Van Buren MI

Township: Bloomingdale

Analyst: WQI

Lake Depth ____

Lake Area ____

SET THE PARAMETER QUALITY RATING AT 1 IF THE EXTERNAL EXTREME VALUE RANGE IS EXCEEDED

LAKE WATER QUALITY INDEX

0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
Red	Red Orange	Orange	Orange Yellow	Yellow	Yellow Green	Green	Blue Green	Blue

DATE 19 August 1993

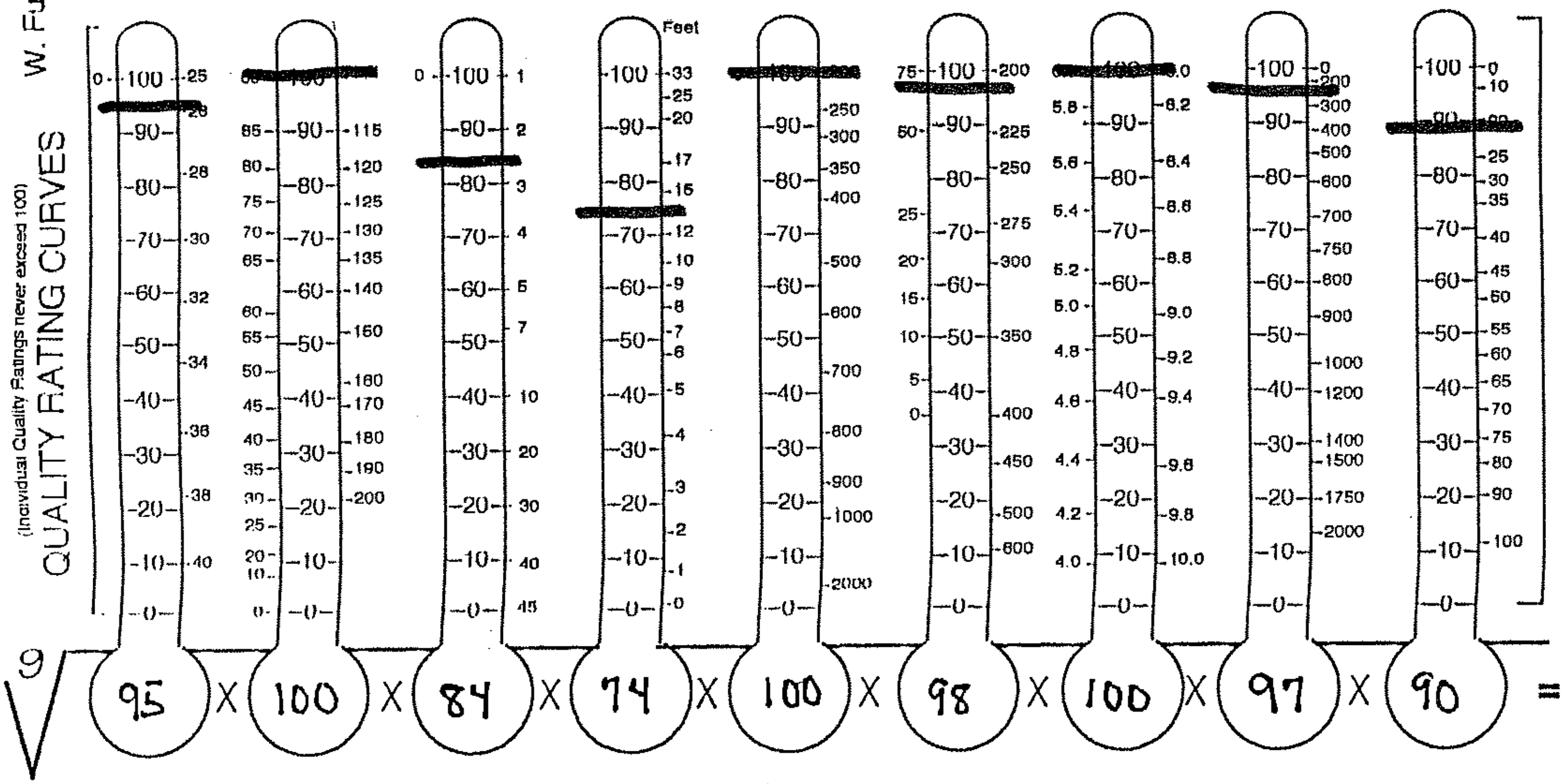
STATION 2

LAKE Mill

CALCULATION SHEET FOR THE UNWEIGHTED MULTIPLIC ATIVE LAKE WATER QUALITY INDEX

W. Fusilier, Ph.D.

Temperature in degrees C	Dissolved Oxygen, % Saturation	Chlorophyll a ug/L	Secchi Disk Depth in feet	Nitrate-N ug/L	Alkalinity mg/L	pH S. U.	Specific Conductivity umhos/cm@ 25C	Total Phosphorus ug/L
26°	8.3/8.2 101	2.6	13	30	65	7.8	220	20



$\sqrt[9]{95 \times 100 \times 84 \times 74 \times 100 \times 98 \times 100 \times 97 \times 90} = 93$

LWQI: 93

Lake to watershed ratio: ____

Flushing rate: ____

Drainage Basin: ____

Drainage Area: ____

Lake Volume: ____

County and State: Van Buren MI

Township: Bloomingdale

Analyst: WQI

Lake Depth: ____

Lake Area: ____

SET THE PARAMETER QUALITY RATING AT 1 IF THE EXTERNAL EXTREME VALUE RANGE IS EXCEEDED

LAKE WATER QUALITY INDEX

0–15	15–25	25–35	35–45	45–55	55–65	65–75	75–85	85–100
Red	Red Orange	Orange	Orange Yellow	Yellow	Yellow Green	Green	Blue Green	Blue

DATE 19 August 1993

STATION 3

LAKE Mill

United States Department of the Interior

GEOLOGICAL SURVEY
Water Resources Division
6520 Mercantile Way, Suite 5
Lansing, Michigan 48910

September 24, 1980

Mr. Dennis A. Hurlbut
R 1, Mill Lake
Gobles, Michigan 49055

Dear Mr. Hurlbut:

Enclosed are three copies of the observer contract for once daily readings of gage for Mill Lake near Gobles, Michigan, at the rate of $5.00 per month. Effective date of this contract will be October 1, 1980.

Please sign all three copies of the contract in the place designated by a red check mark, and return the original and one copy to this office in the envelope provided. The remaining copy is for your records.

We appreciate your cooperation in this matter.

Sincerely yours,

T. Ray Cummings
District Chief

cc: Branch of Financial Management
J. B. Miller
J. R. Smithson
J. M. Moore

FORM 9-1338
(REV. 3-1962)

U. S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CONTRACT FOR GAGE READING, SAMPLING, OBSERVING AND SIMILAR SERVICES

AGREEMENT, made this 1st day of October 1980, by and between

Dennis A. Hurlbut, hereinafter called CONTRACTOR, and the UNITED STATES GEOLOGICAL SURVEY, to perform services as outlined below.

ITEM NO.	SERVICES	RATE	PER
	Once daily readings of gage. All readings for Mill Lake near Gobles, Michigan, are to be recorded onto Form 9-176. Form 9-176 is to be mailed to Lansing at the close of each week, and Form DI-8 at the close of each quarter in the envelope provided. Payment for above services are made quarterly ending December, March, June and September.	5.00	MO

SPECIAL INSTRUCTIONS

Reports of gage readings, observations, well measurements, recorder readings, and/or other required reports are to be mailed to:

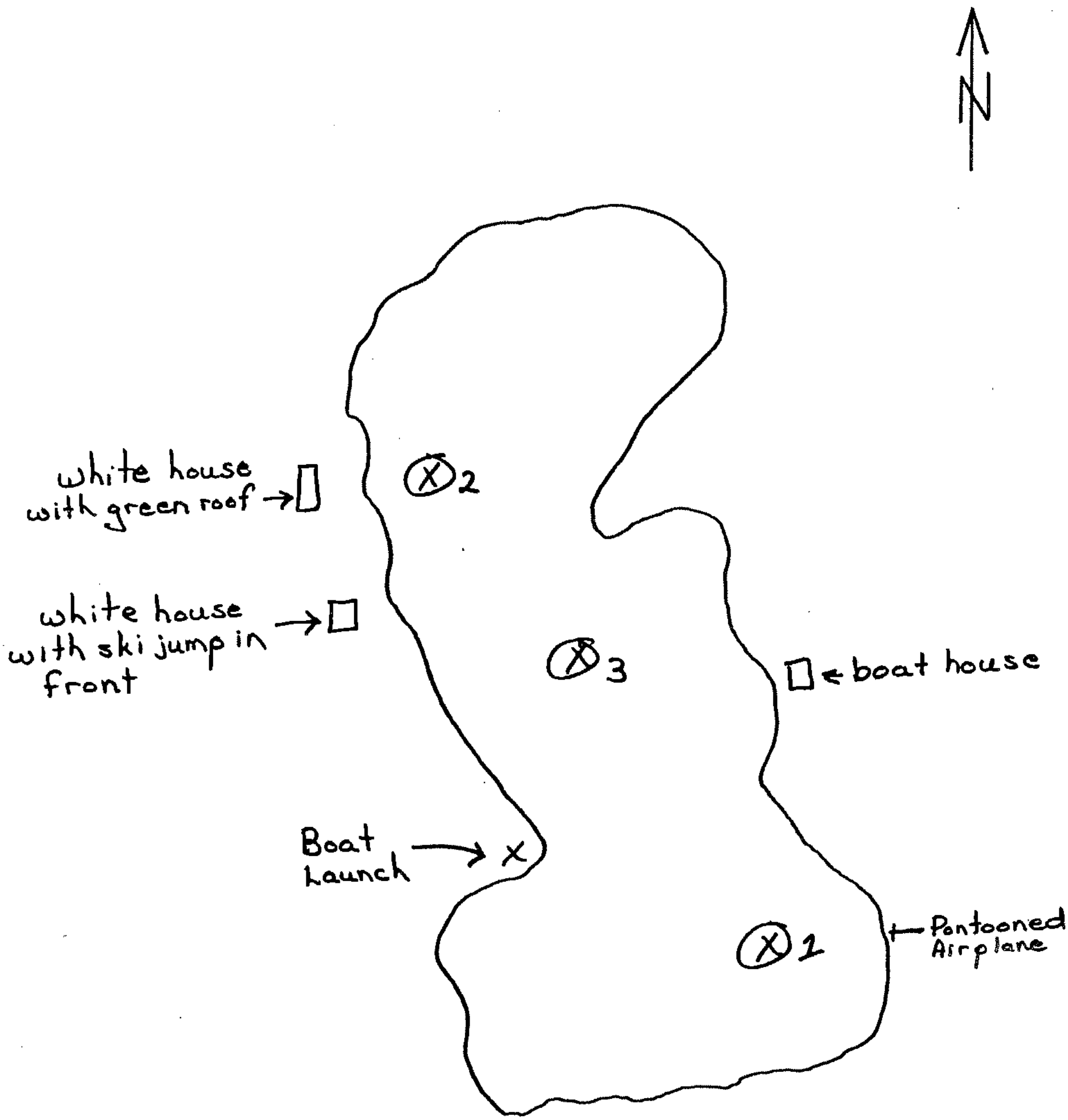
U.S. Geological Survey, WRD
6520 Mercantile Way, Suite 5
Lansing, Michigan 48910

Samples are to be shipped to:

(See reverse side)

Accepted as to items and general provisions outlined above and on the reverse side.	U. S. GEOLOGICAL SURVEY
PHONE: 616-628-2944	ADDRESS: 6520 Mercantile Way, Suite 5
CONTRACTOR'S SIGNATURE: ✓ Dennis A. Hurlbut	ADDRESS: Lansing, Michigan 48910
ADDRESS: R 1, Mill Lake	CONTRACTING OFFICER'S SIGNATURE: for T. Ray Cummings
ADDRESS: Gobles, Michigan 49055	CONTRACTING OFFICER'S TITLE: District Chief

Mill Lake


N
white house
with green roof
white house
with ski jump in
front
2
3
boat house
Boat
Launch
1
Pontooned
Airplane

422219085535000 MILL LAKE, SITE 1, NEAR GOBLES, MI

LAT 42-22-19 LONG 085-53-50 SEQ 00

AGENCY : USGS
STATE CODE : 26

JUNE 22, 1977
1345 HOURS

IDENTIFICATION OF PHYTOPLANKTON

9,900 CELLS/ML

ORGANISM NAME	COMMON NAME	CELLS/ML	PER CENT	
CHLOROPHYTA	GREEN ALGAE			
.CHLOROPHYCEAE				
..CHLOROCOCCALES				
...BOTRYOCOCCACEAE				
....BOTRYOCOCCUS		450	5	
...OOCYSTACEAE				
....DIMORPHOCOCCUS		96	1	
....OOCYSTIS		80	1	
...SCENEDESMACEAE				
....SCENEDESMUS		32	0	
..TETRASPORALES				
...COCCOMYXACEAE				
....ELAKATOTHRIX		24	0	
..ZYGNEMATALES				
...DESMIDIACEAE	PLACODERM DESMIDS			
....STAURASTRUM		8	0	
	TOTALS	690	7	1.6=DIVERSITY
CHRYSOPHYTA				
.BACILLARIOPHYCEAE	DIATOMS			
..PENNALES	PENNATE			
...NITZSCHIACEAE				
....NITZSCHIA		40	0	
	TOTALS	40	0	0.0=DIVERSITY
.CHRYSOPHYCEAE	YELLOW-BROWN ALGAE			
..CHRYSOMONADALES				
...OCHROMONADACEAE				
....DINOBRYON		16	0	
	TOTALS	16	0	0.0=DIVERSITY
CYANOPHYTA	BLUE-GREEN ALGAE			
.MYXOPHYCEAE				
..CHROOCOCCALES	COCCOID			
...CHROOCOCCACEAE				
# ....ANACYSTIS		6,300	64	
# ....GOMPHOSPHAERIA		2,600	26	
..OSCILLATORIALES	FILAMENTOUS			
...OSCILLATORIACEAE				
....OSCILLATORIA		220	2	
	TOTALS	9,100	92	1.0=DIVERSITY
EUGLENOPHYTA	EUGLENOIDS			
.CRYPTOPHYCEAE	CRYPTOMONADS			
..CRYPTOMONIDALES				
...CRYPTOCHRYSIDACEAE				
....CHROOMONAS		56	1	
	TOTALS	56	1	0.0=DIVERSITY
PYRRHOPHYTA	FIRE ALGAE			
.DINOPHYCEAE	DINOFLAGELLATES			
..GYMNODINIALES				
...GYMNODINIACEAE				
....GYMNODINIUM		24	0	
	TOTALS	24	0	0.0=DIVERSITY

NOTE: CELL/ML VALUES ARE BASED ON ACTUAL COUNTS AND REPORTED TO TWO(2) SIGNIFICANT FIGURES
- DOMINANT ORGANISM; GREATER OR EQUAL TO 15%
ANALYSIS METHOD: GLASS CHAMBER(12MM CIRC), INVERTED MICROSCOPE
DIVERSITY INDICES, BASED ON ACTUAL COUNTS:
PHYL/DIV 0.5
CLASS 0.5
ORDER 0.7
FAMILY 0.7
GENERA 1.5

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 01/25/78

422219085535000 - MILL LAKE, SITE 1, NEAR GOBLES, MI DISTRICT CODE 26

WATER QUALITY DATA, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977

DATE	TIME	DEPTH TO BOTTOM OF SAMPLE INTERVAL (FT) (72016)	DEPTH OF RESERVOIR (FT) (72025)	DEPTH TO TOP OF SAMPLE INTERVAL (FT) (72015)	SPECIFIC CONDUCTANCE (MICROMHOS) (00095)	PH (UNITS) (00400)	TEMPERATURE (DEG C) (00010)	TRANSPARENCY (SECCHI DISK) (IN) (00077)	DISSOLVED OXYGEN (MG/L) (00300)	PERCENT SATURATION (00301)	IMMEDIATE COLIFORM (COL. PER 100 ML) (31501)	FECAL COLIFORM .7UM-MF (COL./100 ML) (31625)
JUN 22...	1345	10	10	.00	154	8.3	23.5	102	7.2	86	81500	87

DATE	TOTAL NITRATE (N) (MG/L) (00620)	TOTAL NITRITE (N) (MG/L) (00615)	TOTAL NITRITE PLUS NITRATE (N) (MG/L) (00630)	TOTAL AMMONIA NITROGEN (N) (MG/L) (00610)	TOTAL ORGANIC NITROGEN (N) (MG/L) (00605)	TOTAL KJELDAHL NITROGEN (N) (MG/L) (00625)	TOTAL NITROGEN (N) (MG/L) (00600)	TOTAL NITROGEN (NO3) (MG/L) (71887)	TOTAL PHOSPHORUS (P) (MG/L) (00665)	TOTAL ORTHO PHOSPHORUS (P) (MG/L) (70507)	TOTAL PHYTOPLANKTON (CELLS PER ML) (60050)
JUN 22...	.00	.00	.00	.03	.37	.40	.40	1.8	.01	.00	9900

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 01/25/78

422243085541300 - MILL LAKE, SITE 2, NEAR GOBLES, MI DISTRICT CODE 26

WATER QUALITY DATA, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977

DATE	TIME	DEPTH TO BOTTOM OF SAMPLE INTERVAL (FT) (72016)	DEPTH OF RESERVOIR (FT) (72025)	DEPTH TO TOP OF SAMPLE INTERVAL (FT) (72015)	SPECIFIC CONDUCTANCE (MICROMHOS) (00095)	PH (UNITS) (00400)	TEMPERATURE (DEG C) (00010)	TRANSPARENCY (SECCHI DISK) (IN) (00077)	DISSOLVED OXYGEN (MG/L) (00300)	PERCENT SATURATION (00301)	IMMEDIATE COLIFORM (COL. PER 100 ML) (31501)
JUN 22...	1400	12	12	.00	154	8.3	23.5	120	7.8	93	2000

DATE	FECAL COLIFORM .7UM-MF (COL./100 ML) (31625)	TOTAL NITRATE (N) (MG/L) (00620)	TOTAL NITRITE (N) (MG/L) (00615)	TOTAL NITRITE PLUS NITRATE (N) (MG/L) (00630)	TOTAL AMMONIA NITROGEN (N) (MG/L) (00610)	TOTAL ORGANIC NITROGEN (N) (MG/L) (00605)	TOTAL KJELDAHL NITROGEN (N) (MG/L) (00625)	TOTAL NITROGEN (N) (MG/L) (00600)	TOTAL NITROGEN (NO3) (MG/L) (71887)	TOTAL PHOSPHORUS (P) (MG/L) (00665)	TOTAL ORTHO PHOSPHORUS (P) (MG/L) (70507)
JUN 22...	81	.00	.00	.00	.06	.39	.45	.45	2.0	.01	.00

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY

422236085540600 - MILL LAKE, SITE 3, NEAR GOBLES, MI

PROCESS DATE 01/25/78

DISTRICT CODE 26

WATER QUALITY DATA, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977

DATE	TIME	DEPTH TO BOTTOM OF SAMPLE INTERVAL (FT) (72016)	DEPTH OF RESERVOIR (FT) (72025)	DEPTH TO TOP OF SAMPLE INTERVAL (FT) (72015)	SPECIFIC CONDUCTANCE (MICROMHOS) (00095)	PH (UNITS) (00400)	TEMPERATURE (DEG C) (00010)	COLOR (PLATINUM-COBALT UNITS) (00080)	TRANSPARENCY (SECCHI DISK) (IN) (00077)	DISSOLVED OXYGEN (MG/L) (00300)	PERCENT SATURATION (00301)
JUN											
22...	1200	10	60	10	153	8.7	21.0	10	126	8.2	92
22...	1300	44	60	44	142	7.0	6.5	10	--	3.3	27

DATE	HARDNESS (CA,MG) (MG/L) (00900)	NONCARBONATE HARDNESS (MG/L) (00902)	DISSOLVED CALCIUM (CA) (MG/L) (00915)	DISSOLVED MAGNESIUM (MG) (MG/L) (00925)	DISSOLVED SODIUM (NA) (MG/L) (00930)	DISSOLVED POTASSIUM (K) (MG/L) (00935)	BICARBONATE (HCO3) (MG/L) (00440)	CARBONATE (CO3) (MG/L) (00445)	ALKALINITY AS CACO3 (MG/L) (00410)	CARBON DIOXIDE (CO2) (MG/L) (00405)	DISSOLVED SULFATE (SO4) (MG/L) (00945)
JUN											
22...	66	20	17	5.6	5.1	1.3	56	0	46	.2	T.2
22...	67	16	18	5.3	5.1	1.3	62	0	51	9.9	8.3

DATE	DISSOLVED CHLORIDE (CL) (MG/L) (00940)	DISSOLVED FLUORIDE (F) (MG/L) (00950)	DISSOLVED SILICA (SIO2) (MG/L) (00955)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L) (70300)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L) (70301)	TOTAL NITRATE (N) (MG/L) (00620)	TOTAL NITRITE (N) (MG/L) (00615)	TOTAL NITRITE PLUS NITRATE (N) (MG/L) (00630)	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L) (00631)	TOTAL AMMONIA NITROGEN (N) (MG/L) (00610)
JUN										
22...	11	.0	.2	112	75	.01	.00	.01	.00	.02
22...	11	.0	.8	105	82	.17	.00	.17	.22	.01

DATE	TOTAL ORGANIC NITROGEN (N) (MG/L) (00605)	TOTAL KJELDAHL NITROGEN (N) (MG/L) (00625)	TOTAL NITROGEN (N) (MG/L) (00600)	TOTAL NITROGEN (NO3) (MG/L) (71887)	TOTAL PHOSPHORUS (P) (MG/L) (00665)	TOTAL ORTHO PHOSPHORUS (P) (MG/L) (70507)	DISSOLVED ORTHO. PHOSPHORUS (P) (MG/L) (00671)	DISSOLVED ORTHO PHOSPHATE (PO4) (MG/L) (00660)	DISSOLVED IRON (FE) (UG/L) (01046)	DISSOLVED MANGANESE (MN) (UG/L) (01056)
JUN										

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY

USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Numbe
LA9220

Official Laboratory Report

Report To: DENNIS A HURLBUT
36146 CHERRY ST
GOBLES MI 49055

System Name/Owner:	DENNIS A HURLBUT	WSSN/Pool ID:	
Collection Address:	36146 CHERRY ST,GOBLES	Source:	Single Family Dwelling
Collected By:	DENNIS HURLBUT	Site Code:	
Township/Well#/Section:	BLOOMINGDALE//	Collector:	Other
County:	Van Buren	Date Collected:	06/19/2006 07:00
Sample Point:	EXPERIOR SPICKET	Date Received:	06/20/2006 08:00
Water System:	Untreated Private Well	Purpose:	Routine Monitoring

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Coliform Organisms per 100 mL	**Not Detected**	**06/20/2006**			**SM 9223 B**	**TC-00-B**

Explanation of Coliform Results:
Not Detected = Coliform and E. coli bacteria were not found
Positive = Total Coliform was found and E. coli bacteria was not found
EC Positive = Coliform and E. Coli bacteria were found

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U.S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Van Buren/Cass County Health Dept.
57418 County Rd. 681, Suite A
Hartford, MI 49057
269 621-3143

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminent Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Sandy Kems
Systems Mgmt. Unit Mgr: George Krisztian

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY
USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LA92207

Official Laboratory Report

Report To: WILLIAM N BOODT
36092 CHERRY STREET
GOBLES MI 49055

System Name/Owner:	WILLIAM N BOODT	WSSN/Pool ID:	
Collection Address:	36092 CHERRY STREET,GOBLES	Source:	Single Family Dwelling
Collected By:		Site Code:	
Township/Well#/Section:	BLOOMINGDALE//	Collector:	Private Citizen
County:	Van Buren	Date Collected:	
Sample Point:	KITCHEN	Date Received:	06/20/2006 08:00
Water System:	Other	Purpose:	Routine Monitoring

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Coliform Organisms per 100 mL	**Not Detected**	**06/20/2006**			**SM 9223 B**	**TC-00-B**

Sample collection date is not given or incorrect date given. Coliform result is possibly invalid for testing done more than 30 hours after sample collection.

Explanation of Coliform Results:
Not Detected = Coliform and E. coli bacteria were not found
Positive = Total Coliform was found and E. coli bacteria was not found
EC Positive = Coliform and E. Coli bacteria were found

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U.S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Van Buren/Cass County Health Dept.
57418 County Rd. 681, Suite A
Hartford, MI 49057
269 621-3143

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminent Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Sandy Kerns
Systems Mgmt. Unit Mgr: George Krisztian

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY
USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LA87432

Official Laboratory Report

Report To: SCOTT D CLEMENT
11 PROSPECT STREET
SAINT IGNACE MI 49781

System Name/Owner:	SCOTT CLEMENT	WSSN/Pool ID:	
Collection Address:	FEELEY AVE,GOBLES	Source:	Single Family Dwelling
Collected By:	SCOTT CLEMENT	Site Code:	
Township/Well#/Section:	BLOOMINGDALE//	Collector:	Private Citizen
County:	Van Buren	Date Collected:	05/29/2006 14:00
Sample Point:	KITCHEN	Date Received:	05/31/2006 08:17
Water System:	Untreated Private Well	Purpose:	Routine Monitoring

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Coliform Organisms per 100 mL	**Not Detected**	**05/31/2006**			**SM 9223 B**	**TC-00-B**

Sample was more than 30 hours old when analyzed. Coliform result is possibly invalid for testing done more than 30 hours after sample collection.

Explanation of Coliform Results:
Not Detected = Coliform and E. coli bacteria were not found
Positive = Total Coliform was found and E. coli bacteria was not found
EC Positive = Coliform and E. Coli bacteria were found

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U.S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Van Buren/Cass County Health Dept.
57418 County Rd. 681, Suite A
Hartford, MI 49057
269 621-3143

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminent Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Sandy Kerns
Systems Mgmt. Unit Mgr: George Krisztian

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY

USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LA93129

Copy

Official Laboratory Report

Report To: TED HUIZENGA
35720 MILL LAKE RD
GOBLES MI 49055

System Name/Owner:	TED HUIZENGA	WSSN/Pool ID:	
Collection Address:	35706,GOBLES	Source:	Single Family Dwelling
Collected By:	JOAN HUIZENGA	Site Code:	
Township/Well#/Section:	BLOOMINGDALE//	Collector:	Other
County:	Van Buren	Date Collected:	06/20/2006 12:30
Sample Point:	KITCHEN - COLD	Date Received:	06/22/2006 08:19
Water System:	Untreated Private Well	Purpose:	Routine Monitoring

Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Coliform Organisms per 100 mL	**Not Detected**	**06/22/2006**			**SM 9223 B**	**TC-00-B**

Sample was more than 30 hours old when analyzed. Coliform result is possibly invalid for testing done more than 30 hours after sample collection.

Explanation of Coliform Results:
Not Detected = Coliform and E. coli bacteria were not found
Positive = Total Coliform was found and E. coli bacteria was not found
EC Positive = Coliform and E. Coli bacteria were found

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U.S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Van Buren/Cass County Health Dept.
57418 County Rd. 681, Suite A
Hartford, MI 49057
269 621-3143

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminent Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Sandy Kerns
Systems Mgmt. Unit Mgr: George Krisztian

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY

USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Copy

Sample Number
LA92728

Official Laboratory Report

Report To: TED HUIZENGA
35720 MILL LAKE RD
GOBLES MI 49055

System Name/Owner:	TED HUIZENGA	WSSN/Pool ID:	
Collection Address:	35720 MILL LAKE RD,GOBLES	Source:	Single Family Dwelling
Collected By:	JOAN HUIZENGA	Site Code:	
~~Township/Well#/Section:~~	~~BLOOMINGDALE//~~	~~Collector:~~	~~Private Citizen~~
County:	Van Buren	Date Collected:	06/20/2006 12:30
Sample Point:	KITCHEN- COLD	Date Received:	06/21/2006 08:47
Water System:	Untreated Private Well	Purpose:	Routine Monitoring

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Coliform Organisms per 100 mL	**Not Detected**	**06/21/2006**			**SM 9223 B**	**TC-00-B**

Explanation of Coliform Results:
Not Detected = Coliform and E. coli bacteria were not found
Positive = Total Coliform was found and E. coli bacteria was not found
EC Positive = Coliform and E. Coli bacteria were found

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U.S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

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Van Buren/Cass County Health Dept.
57418 County Rd. 681, Suite A
Hartford, MI 49057
269 621-3143

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MCL : Maximum Contaminent Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Sandy Kerns
Systems Mgmt. Unit Mgr: George Krisztian

2004073

Water Quality Monitoring Report

LAKE CHECK

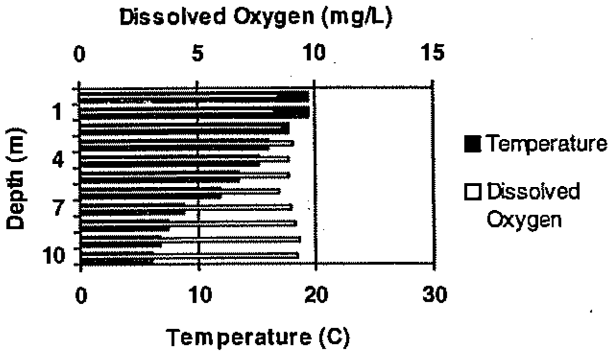
Customer	Waterbody	Sample Information
Mill Lake Mike Connelly 12370 Maple St Gobles MI 49055	Mill Lake	Date: 5/11/2004 Site: Deep Hole

On-Site Results

Depth (m)	Temperature (degrees C)	Dissolved Oxygen mg/L	Dissolved Oxygen %
0	19.4	8.4	95
1	19.4	8.3	94
2	17.8	8.6	94
3	16.0	9.1	96
4	15.1	8.9	93
5	13.4	8.9	90
6	11.9	8.5	81
7	8.9	8.9	81
8	7.5	9.1	83
9	6.8	9.3	79
10	6.2	9.2	79

Secchi Disk Depth 2.8 meters

Thermocline Depth 1.5 meters



Analytical Results

Parameter	Result	Units	Interpretation
Fecal Bacteria (E. coli		CFU/100 mL	N/A
Conductivity	190	uS/cm	Low concentration of dissolved salts
Total Dissolved Solids	129	mg/L	
pH	8.1	S.U.	Water is slightly alkaline
Alkalinity	65	mg CaCO3/L	Water is soft
Total Phosphorus	15	ug/L	Moderately phosphorus enriched
Nitrates	470	ug/L	Slightly nitrogen enriched
Chlorophyll	N/A		

Trophic State Evaluation

	TSI	Trophic Status
Based on Secchi Disk Depth	45	mesotrophic
Based on Total Phosphorus	39	mesotrophic
Based on Chlorophyll	N/A	

2004074

Water Quality Monitoring Report

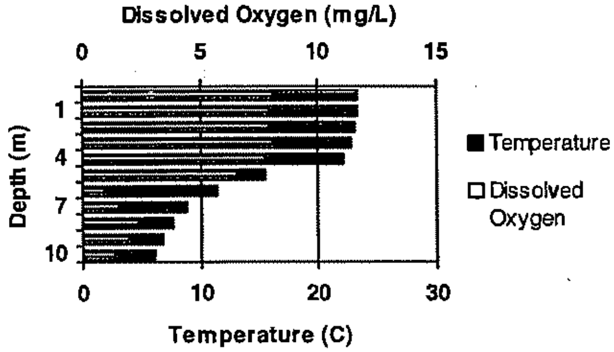
Customer	Waterbody	Sample Information
Mill Lake Mike Connelly 12370 Maple St Gobles MI 49055	Mill Lake	Date: 8/25/2004 Site: Deep Hole

On-Site Results

Depth (m)	Temperature (degrees C)	Dissolved Oxygen mg/L	Dissolved Oxygen %
0	23.4	8.1	110
1	23.3	7.9	111
2	23.2	7.9	111
3	22.9	8.1	111
4	22.1	7.8	106
5	15.5	6.6	80
6	11.4	0.9	9
7	8.8	1.5	16
8	7.7	2.4	24
9	6.8	1.9	19
10	6.1	1.4	14

Secchi Disk Depth 4.0 meters

Thermocline Depth 4.5 meters



Analytical Results

Parameter	Result	Units	Interpretation
Fecal Bacteria (E. coli		CFU/100 mL	N/A
Conductivity	192	uS/cm	Low concentration of dissolved salts
Total Dissolved Solids	130	mg/L	
pH	8.1	S.U.	Water is slightly alkaline
Alkalinity	50	mg CaCO3/L	Water is very soft
Total Phosphorus	23	ug/L	Moderately phosphorus enriched
Nitrates	480	ug/L	Slightly nitrogen enriched
Chlorophyll	N/A		

Trophic State Evaluation

	TSI	Trophic Status
Based on Secchi Disk Depth	40	mesotrophic
Based on Total Phosphorus	45	mesotrophic
Based on Chlorophyll	N/A	

LAKE CHECK Water Quality Monitoring Results

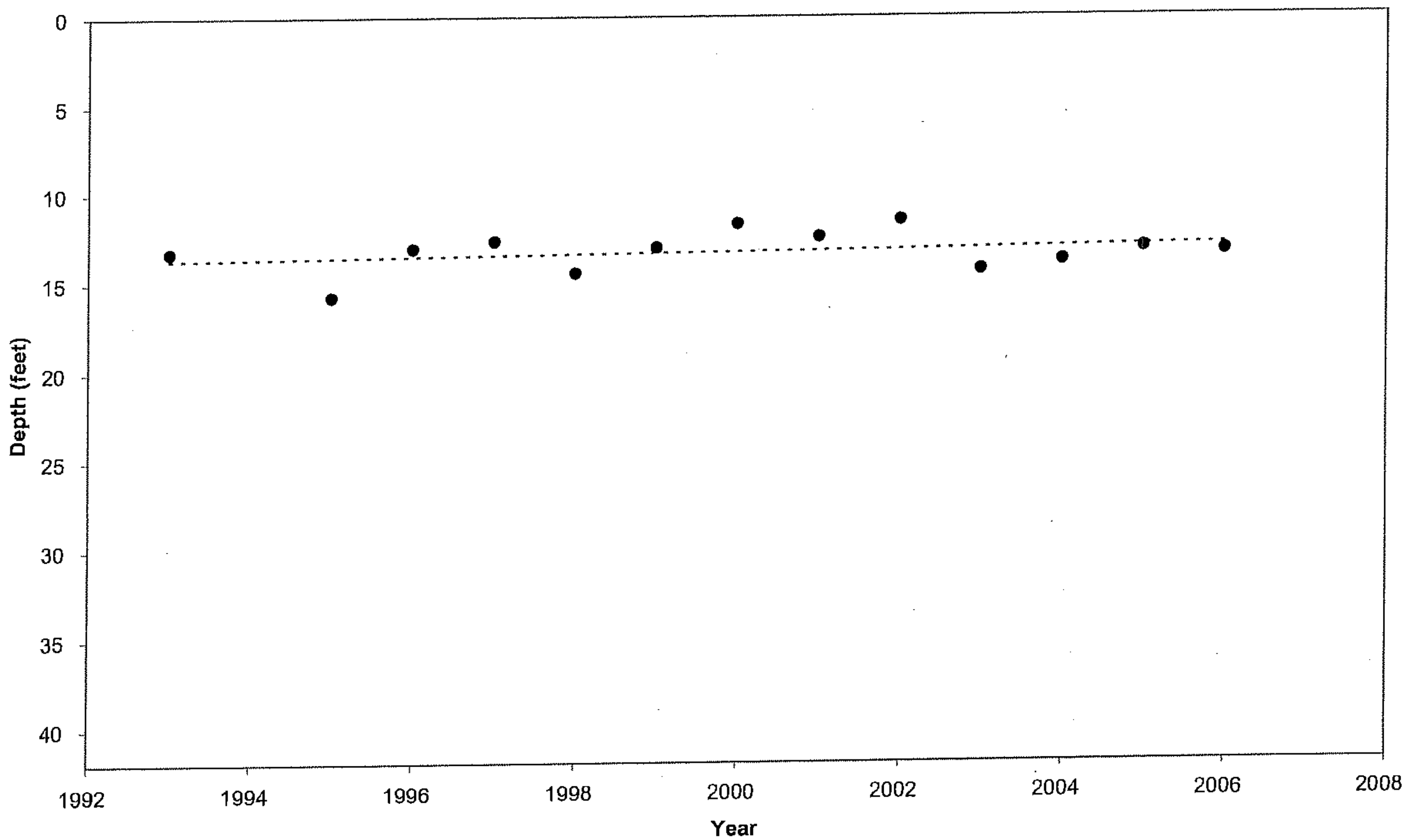
Mill Lake

Location	Type*	Secchi Disk Depth (meters)	Conductivity (uS/cm)	Total Dissolved Solids (mg/L)	pH (S.U.)	Alkalinity (mg CaCO3/L)	Total Phosphorus (ug P/L)	Nitrates (ug N/L)	Chlorophyll (ug/L)	Fecal Bacteria (CFU/100 mL)
SampleDate: 9/18/2000										
Middle	S	2.8	172	123	8.6	47	11.3	9640		
SampleDate: 5/8/2001										
Middle	D	5.7	170	126	7.7	5.2	6	504		
SampleDate: 9/4/2001										
Middle	D	3.7	212	144	8.2	40	79	710		
SampleDate: 6/1/2002										
Deep Hole	S	4.0	220	150	7.0	100	9	450		
Inlet	I	0.6 B	218	148	7.0	100	7	450		
SampleDate: 9/19/2002										
Middle	S	4.0	233	158	7.7	75	12	500		
SampleDate: 5/6/2003										
Midle	S	3.1	227	154	8.2	99	14	480		
SampleDate: 9/29/2003										
Middle	I	3.7	197	128	8.3	82	17	490		
SampleDate: 5/11/2004										
Deep Hole	S	2.8	190	129	8.1	65	15	470		
SampleDate: 8/25/2004										
Deep Hole	D	4.0	192	130	8.1	50	23	480		

*Sample Types are S = surface, D = Deep (hypolimnion) and In = inflow

COOPERATIVE LAKES MONITORING PROGRAM
SUMMER MEAN TRANSPARENCY

Mill Lake (Van Buren Co.)



Appendix C

Nutrient Budget Calculations

PHOSPHORUS LOADING DATA

Atmospheric Deposition

Bulk precipitation includes both wet and dry atmospheric fallout. It is essential that both components be considered when determining the magnitude of atmospheric deposition since dryfall alone may account for 70 to 90 percent of the total load (Heany and Sullivan 1971; Chapin and Uttormark 1973).

The atmospheric fallout loading estimate for Mill Lake was derived from lakes of similar geography and climate (Table C1).

TABLE C1
DATA USED TO ESTIMATE THE ATMOSPHERIC INPUT OF PHOSPHORUS TO MILL LAKE

Atmospheric Loading (lbs/acre/yr)	Geographic Location	Reference
0.35	Lobdell Lake Genesee County, MI	Rodiek 1979
0.30	Gull Lake Kalamazoo County, MI	Tague 1977
0.28	Houghton Lake Roscommon County, MI	Richardson and Merva 1976

Mean = 0.31 lbs/acre/year

Septic Contribution

The rationale used for estimating the septic contribution to the nutrient budget is as follows:

1. Estimate the average phosphorus load from household wastewater discharged to septic systems:

   3.26 lbs/capita/year (Table C2).

   Reduce the estimate by 50 percent to account for the Michigan ban on phosphorus detergents (Sawyer 1962; Rodiek 1979):

   0.50 x 3.26 = 1.6 lbs/capita/year.

2. Multiply the estimate in Item No. 1 by the average capita per residence and the average occupancy rate in the local municipality:

   1.6 lbs/capita/year x 2.85 capita/residence[1] x .064 occupancy[2] = 2.93 lbs/residence/year.

3. Estimate the quantity of phosphorus from septic system effluent that is retained by the soil (Table C3) for each household adjacent to the lake (Table C4). Estimate the quantity of phosphorus that is not retained by the soil and leaches to the lake (Table C5).

[1] Source: U.S. Census Data 2000.
[2] Based on count of seasonal and year-round occupancy by Jim Cusack, Mill Lake.

TABLE C2
PHOSPHORUS LOADS FOR HOUSEHOLD WASTEWATER DISCHARGED TO SEPTIC SYSTEMS
(lbs/capita/year)

Total Phosphorus	Reference
3.29	Ligman et al. 1974
3.15	Laak 1975
1.63	Chan 1978
3.51	Ellis and Childs 1973
3.29	Siegrist et al. 1976
6.62	Bernhard 1975
1.76	Otis et al. 1975
2.82	U.S. EPA 1974

Mean = 3.26

Standard Deviation = ± 1.53

TABLE C3
SOIL EFFICIENCY RATING FOR IMMOBILIZING PHOSPHORUS FROM SEPTIC SYSTEMS[1]

Drainage	Phosphorus Adsorption Capacity (lbs/acre-ft)	Retention Coefficient (R.C.)	Fraction Of Phosphorus Not Retained By Drainfield Soil (1 - R.C.)
Good	High - Very High 480 - 650	0.75	0.25
Good	Medium 380 - 480	0.55	0.45
Good	Low - Very Low 325 - 380	0.35	0.65
Poor	High - Very High 480 - 650	0.65	0.35
Poor	Medium 380 - 480	0.45	0.55
Poor	Low - Very Low 325 - 380	0.25	0.75

[1] Schneider and Erickson 1972; Ellis and Childs 1973.

TABLE C4
NUMBER OF RESIDENCES PER SOIL TYPE
FROM SEPTIC SYSTEMS[1]

Soil Type	Number of Residences[2]
Oshtemo sandy loam	22
Glendora sandy loam	1
Morocco loamy sand	2
Brems sand	23
Adrian muck	7
Kingsville loamy sand	7
Riddles sandy loam	14
Total	76

TABLE C5
ESTIMATE OF ANNUAL SEPTIC CONTRIBUTION TO MILL LAKE

Soil Type[3]	Drainage[4]	Phosphorus Adsorption[4]	(1 - R.C.)[5]	Number Of Residences Per Soil Type[3]	Load To Septic Systems (lbs/res/yr)	Phosphorus Loading Per Soil Type (lbs/yr)
Oshtemo sandy loam	Good	Low	0.65	22	2.93	42
Glendora sandy loam	Poor	Low	0.75	1	2.93	2
Morocco loamy sand	Poor	Low	0.65	2	2.93	4
Brems sand	Poor	Very low	0.75	23	2.93	51
Adrian muck	Poor	Very low	0.75	7	2.93	15
Kingsville loamy sand	Poor		0.55[6]	7	2.93	11
Riddles sandy loam	Good		0.45[6]	14	2.93	18
TOTAL				76		144 lbs/yr

[1] Source: Soil Survey Geographic Database for Van Buren County, based on data from U.S. Department of Agriculture Natural Resources Conservation Service.

[2] Only residences abutting the lake were counted in this analysis.

[3] Table C4.

[4] Schneider and Erickson 1972.

[5] Table C3

[6] Phosphorus adsorption data were not available for these soils. Therefore, median values were chosen for retention of coefficients give the drainage characteristics.

Appendix D

Michigan Department of Environmental Quality Procedures for Aquatic Vegetation Surveys

DEQ

DEPARTMENT OF ENVIRONMENTAL QUALITY
PROCEDURES FOR AQUATIC VEGETATION SURVEYS

These aquatic vegetation survey procedures have been designed to ensure easily replicable surveys of aquatic plant communities. The methods are easy to use, and they are flexible enough to be used on many different types of lakes, regardless of the extent of littoral zone and shoreline sinuosity. The individual(s) using these methods should be proficient in the identification of aquatic plants. For a listing of recommended aquatic plant identification reference materials, contact the Aquatic Nuisance Control and Remedial Action Unit.

A survey is carried out by sampling individual Aquatic Vegetation Assessment Sites (AVAS's) throughout a lake's littoral zone. The locations of AVAS's are determined by dividing up a lake's shoreline into segments approximately 100 to 300 feet in length. Each AVAS is sampled by using visual observations, dependent upon water clarity, and weighted rake tows. Each separate plant species found in each AVAS is recorded along with an estimate of each species' density. Plant species are identified by numbers designated on the survey map's plant species list, and densities are recorded by using the following code:

- **(a) = found**: one or two plants of a species found in an AVAS, equivalent to ***less than 2%*** of the total AVAS surface area.
- **(b) = sparse**: scattered distribution of a species in an AVAS, equivalent to ***between 2% and 20%*** of the total AVAS surface area.
- **(c) = common**: common distribution of a species where the species is easily found in an AVAS, equivalent to ***between 21% and 60%*** of the total AVAS surface area.
- **(d) = dense**: dense distribution of a species where the species is present in considerable quantities throughout an AVAS, equivalent to ***greater than 60%*** of the total AVAS surface area.

AVAS's should not be confined solely to a lake's shoreline. In cases where a lake possesses an extensive littoral zone, additional AVAS's should be drawn out near the extent of submergent vegetation growth. This can be done by drawing transect lines divided in proportion to the shoreline AVAS's or by inserting individually drawn boxes with their dimensions proportional to the shoreline AVAS's (see attached sample map). AVAS's should also be drawn around the shoreline of any islands if present.

PRE-SURVEY PROCEDURES

A. Obtain a map of the lake to be surveyed. Bathymetric maps are preferred; however, if bathymetric maps cannot be located, enlarged copies of United States Geological Survey topographical maps may be used. If a pre-drawn map of the lake does not exist, hand-drawn maps will suffice, as long as they accurately depict the shape of the lake and are drawn to scale. Make a larger format (11" x 17") photocopy of the lake map for ease of editing and survey recording.

B. Designate the location of the separate AVAS's by drawing lines perpendicular to the lake shoreline (see the attached sample map) every 100 to 300 feet. Keep the AVAS lengths consistent throughout the lake, and add any additional AVAS's where necessary, based upon lake bathymetry. If additional AVAS's are not added at this time, they may be added during the actual survey, based upon current lake conditions.

C. Attach a copy of a plant species list identifying common species of aquatic plants directly to the survey map. This list should include either the common or scientific names of common aquatic plants corresponding to a specific number for each separate species. The corresponding numbers will be used to record the presence of a species in an AVAS.

D. Make several copies of the competed lake map for future use, to maintain consistency, and in case multiple maps are necessary during the survey due to inclement weather.

FIELD SURVEY PROCEDURES

A. Initiate the survey by determining your exact location on the lake. It is helpful to take this time to familiarize yourself with the dominant plant species of the lake that you are surveying. Do this by making several rake tows and identify all of the species found. Morphological variations occur in several species of aquatic plants due to differing lake conditions and hybridization; therefore, identification to species can be difficult. If specific identification is unattainable, group similar species, such as thin leaf pondweeds (*Potamogeton spp.*) or native milfoils (*Myriophyllum spp.*).

B. Begin the survey by recording the date, time, weather conditions, your name, names of assistants, and any other pertinent information directly on the survey map.

C. Locate the beginning AVAS, and survey each successive AVAS by documenting the presence and density of both emergent and submergent aquatic plants. Drive the survey boat in a zig-zag pattern through each AVAS so that a majority of each AVAS can be effectively surveyed. It is important to make use of rake tows even in clear water, since many low-growing species of submergent plants are not readily noticeable by visual observation alone.

D. Document each species found utilizing the corresponding plant species list number and the appropriate density code. Repeat this for each separate AVAS until all of the AVAS's have been surveyed. If an AVAS is found to be void of any vegetation, record "none" in the respective location on the survey map. Include these AVAS's in the final AVAS count when summarizing the survey data. If an AVAS is dominated by emergent vegetation to the point that boat access is impossible, document the plant species present and draw the extent of the edge of the emergent vegetation as it extends out into the lake.

SURVEY SUMMARY PROCEDURES

A. Number each AVAS sequentially from beginning to end on the survey map. Record the density codes for each species found on the attached Standard Aquatic Vegetation Assessment Site Species Density Sheets. Each AVAS number corresponds to the column numbers found on the attached Standard Aquatic Vegetation Assessment Site Species Density Sheets.

B. Sum the numbers of each of the separate density codes for each of the plant species found on the Standard Aquatic Vegetation Assessment Site Species Density Sheets and transfer these totals to the appropriate columns 1 through 4 (A, B, C, and D) on the attached Standard Aquatic Vegetation Summary Sheet.

C. Multiply these totals by the appropriate constants (A = 1, B = 10, C = 40, and D = 80) and transfer the calculations to the calculations columns 5 through 8.

D. Add the results of these calculated columns (5, 6, 7, and 8) for each species and transfer the totals to column 9.

E. Divide the values of column 9 by the total number of AVAS's surveyed (column 10), and transfer these values to column 11. These values represent the cumulative cover percentages for each of the plant species found in the survey. Make sure that you use the total number of AVAS's surveyed on the lake for column 10 and not the total number of AVAS's where each individual plant species was found.

F. Write a summary of the notes recorded during the field survey and attach it to the completed species density and summary sheets, along with the survey map and any other survey documentation.

INSTITUTE FOR FISHERIES RESEARCH

DIVISION OF FISHERIES MICHIGAN CONSERVATION DEPT.

LAKE INVENTORY MAP

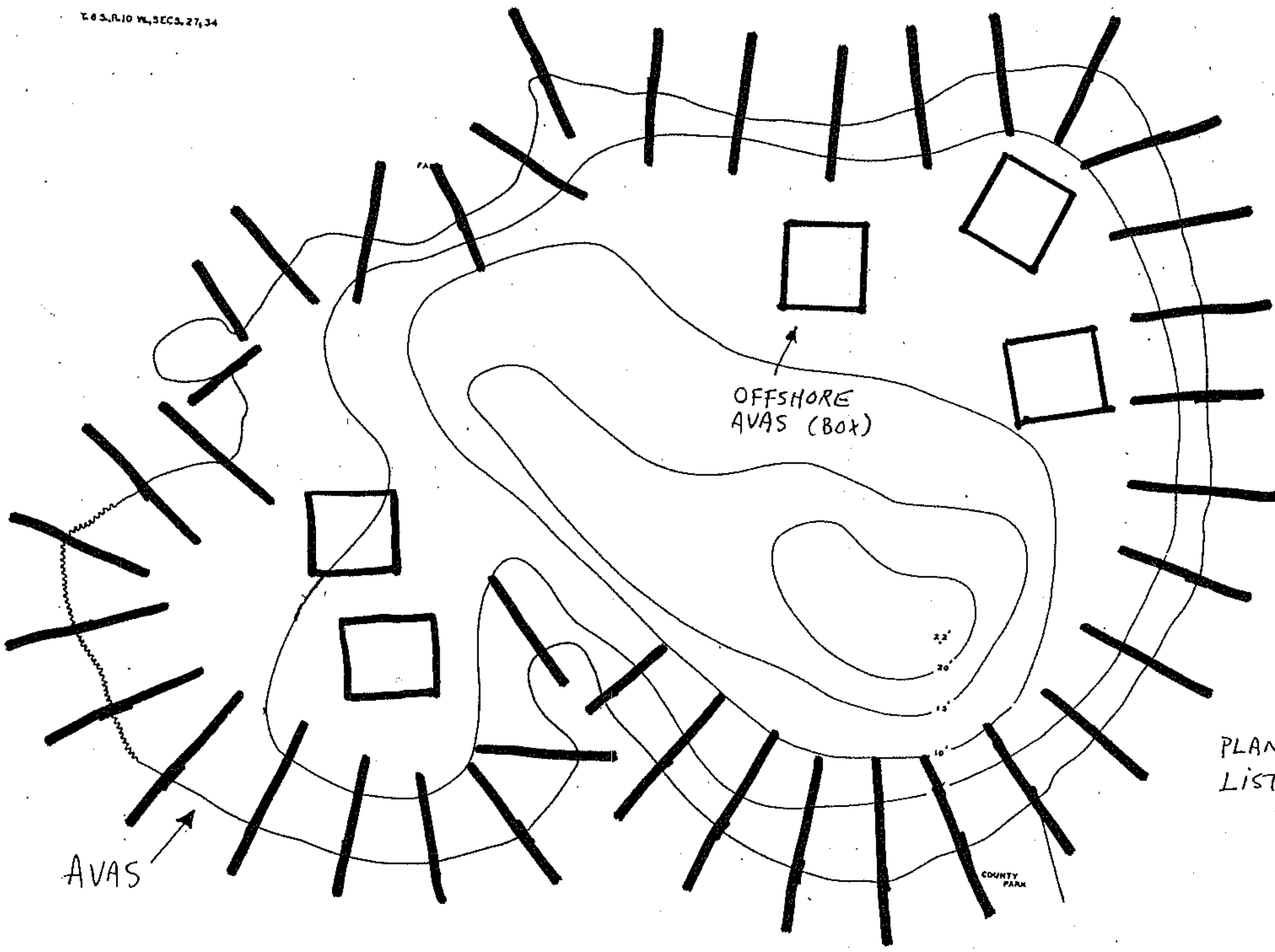
SAND LAKE

AREA 102 ACRES

MARGINAL SURVEY AND SOUNDINGS 1/27/53

ST. JOSEPH COUNTY T.6S.,R.10 W.,SECS. 27,34

1 Eurasian milfoil
2 Curly leaf pondweed
3 Chara
4 Thinleaf pondweed
5 Flatstem pondweed
6 Robbins pondweed
7 Variable pondweed
8 Whitestem pondweed
9 Richardsons pondweed
10 Illinois pondweed
11 Large leaf pondweed
12 American pondweed
13 Potomogeton natans
14 Water stargrass
15 Wild celery
16 Sagittaria
17 Northern milfoil
18 M. verticillatum (Green)
19 M. herterophyllum
20 Coontail
21 Elodea
22 Utricularia vulgaris
23 Bladderwort – mini
24 Buttercup
25 Southern naiad
26 Brittle naiad
27 Sago pondweed
28
29
30 Nymphea
31 Nuphar
32 Brasenia
33 Lemna minor
34 Spirodela
35 Watermeal
36 Arrowhead
37 Pickerelweed
38 Arrow arum
39 Cattails
40 Bulrushes
41 Iris
42 Swamp Loosestrife
43 Purple Loosestrife



Survey personnel:

Survey date:

Survey time:

Conditions:

Transparency:

Water color:

A = Found – < 2% coverage per AVAS
B = Sparse – 2-20% coverage per AVAS
C = Moderate – 21-60% coverage per AVAS
D = Dense – 61-100% coverage per AVAS

AVAS = Aquatic Vegetation Assessment Site

1 Eurasian milfoil
2 Curly leaf pondweed
3 Chara
4 Thinleaf pondweed
5 Flatstem pondweed
6 Robbins pondweed
7 Variable pondweed
8 Whitestem pondweed
9 Richardsons pondweed
10 Illinois pondweed
11 Large leaf pondweed
12 American pondweed
13 Potomogeton natans
14 Water stargrass
15 Wild celery
16 Sagittaria
17 Northern milfoil
18 M. verticillatum (Green)
19 M. herterophyllum
20 Coontail
21 Elodea
22 Utricularia vulgaris
23 Bladderwort – mini
24 Buttercup
25 Southern naiad
26 Brittle naiad
27 Sago pondweed
28
29
30 Nymphea
31 Nuphar
32 Brasenia
33 Lemna minor
34 Spirodela
35 Watermeal
36 Arrowhead
37 Pickerelweed
38 Arrow arum
39 Cattails
40 Bulrushes
41 Iris
42 Swamp Loosestrife
43 Purple Loosestrife

0 150' 300' 450' 600'

Appendix E

Sample Phosphorus Fertilizer Ordinance

SAMPLE ORDINANCE

AN ORDINANCE TO REGULATE THE APPLICATION OF PHOSPHORUS FERTILIZERS IN ______________ TOWNSHIP

Section 1. Authority

This Ordinance is adopted under the authority of the Township Ordinances Act, PA 246 of 1945, MCL 41.181 *et seq*.

Section 2. Title

The Ordinance shall be known and cited as the ______ Township Phosphorus Fertilizer Ordinance.

Section 3. Intent and Purpose

_____ Township finds that the Township's water resources are a vital community asset, and protecting these resources is essential to protecting public health, safety, and general welfare. Phosphorus contained in lawn fertilizers can wash into lakes and streams and cause excessive and accelerated growth of aquatic plants and algae. It is the purpose and intent of this Ordinance to regulate the use and application of lawn fertilizers containing phosphorus to protect the Township's water resources.

Section 4. Definitions

Lawn means non-crop land planted in closely mowed, managed grasses including, but not limited to, residential property, commercial property, and golf courses. Lawn does not mean pasture, hay, turf grown on turf farms, or any other form of agricultural production.

Lawn fertilizer means any fertilizer distributed for nonagricultural purposes such as lawns, golf courses, and parks. Lawn fertilizer does not include fertilizer products intended for gardens, indoors uses, or farmlands.

Soil test means a set of scientific measurements that determine the basic texture of soil, the pH of the soil, and levels of nutrients such as nitrogen, phosphorus, potassium, and other constituents for the purpose of providing a recommendation regarding the amount of nutrients and rate of application of nutrients for lawn growth.

Soil testing service means an entity such as Michigan State University that performs soil tests and recommends fertilizer application rates.

Section 5. Regulation of the use and application of lawn fertilizer

Lawn fertilizers containing phosphorus shall not be applied to any lawn in the Township except as provided in Section 6.

Section 6. Exceptions for the use and application of lawn fertilizer

Lawn fertilizer containing phosphorus can only be used within the Township under the following conditions:

1) A soil test performed by a soil testing service within the last year indicates that the level of phosphorus in the soil is not sufficient to support a lawn. The application of lawn fertilizer under this section shall not exceed the application rate of phosphorus recommended by the soil testing service.
2) Lawn that is being established from seed or sod during the first growing season.

Section 7. Violations; Penalties; Enforcement

1) Violation of this Ordinance is a municipal civil infraction, for which the fine shall be not less than $250.00 nor more than $500.00 for the first offense, and not less than $500.00 nor more than $1,000 for a subsequent offense, in the discretion of the Court, and in addition to all other costs, damages, expenses and actual attorney fees incurred by the Township in enforcing the Ordinance or remedying the violation of the Ordinance. For the purposes of this Section, "subsequent offense" means a violation of this Ordinance committed with respect to a separate incident by the same person within 12 months after a previous violation of the Ordinance for which the person admitted responsibility or was adjudicated to be responsible. Each day of the violation shall constitute a separate offense.
2) A violation of this Ordinance is declared to be a nuisance *per se*. In addition to other penalties and remedies, the Township may seek injunctive relief against the violator, in addition to other relief provided by law.

Section 8. Appeals

Any person aggrieved by a decision or determination made by the Township under this Ordinance shall have the right to appeal to the Township Board.

1) The appeal may be commenced by filing with the Township Board a written statement containing the specific reasons for the appeal within 30 days following the date of the decision being appealed.
2) The Township Board shall consider the appeal at a public meeting. The Township Board shall affirm, affirm with conditions, or reverse the decision or determination being appealed, consistent with the terms of this Ordinance.
3) The decision of the Township Board shall be set forth in writing and a copy thereof shall be given to the party appealing. If the appeal is denied, the written decision shall include the reasons for denial.

Section 9. Severability

The various parts, sentences, paragraphs and clauses of this Ordinance are severable. If any part, sentence, paragraph, section, or clause is adjudged unconstitutional or invalid by a court of competent jurisdiction, the remainder of the Ordinance shall not be affected.

Section 10. Adoption and Effective Date

This Ordinance was approved and adopted by the Township Board of the Township of ________, ________ County, Michigan on __________ and is ordered to take effect 30 days after publication of the Ordinance in a newspaper of general circulation in the Township.

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