LAKE IMPROVEMENT REPORT
FOR
MEADOW LAKE
BLOOMFIELD TOWNSHIP
OAKLAND COUNTY

Prepared by:

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TABLE OF CONTENTS

I. INTRODUCTION

Meadow Lake is a private lake located in Section 31 of Bloomfield Township in Oakland County. At present, problems are being experienced on the lake due to shallow water muck build-up and excessive aquatic plant growth. These conditions inhibit full recreational utilization and aesthetic enjoyment of the lake.

Realizing the need to remedy this situation, the Meadow Lake Farms Civic Association retained Progressive Engineering Consultants to evaluate the feasibility and cost of a lake improvement project. The purpose of this report is to define the project. Its objective will be to:

- Compile and review all available information on Meadow Lake and its watershed.
- Determine the physical characteristics of the lake and its watershed.
- Determine land use, soil types, surface drainage and degree of development in the Meadow Lake watershed.
- Prepare a theoretical nutrient budget to determine the relative importance of various nutrient inputs to the lake.
- Collect water samples to determine the present condition of the lake.
- Evaluate the hydrological and limnological condition of the lake.
- Determine aquatic plant types and general distribution.
- Conduct surveys of lake bottom to verify accuracy of existing depth contour map and estimate muck removal quantities.
- Identity potentially suitable sites for disposal of the dredged material.
- Evaluate feasibility of in-lake management alternatives for lake improvement and fisheries management.
- Evaluate feasibility of watershed management alternates to reduce the input of pollutants to Meadow Lake.
- Prepare a cost estimate for the recommended lake improvement project.
- Develop a method to spread the cost of the improvement to benefitting properties.
- Describe alternatives for organizing and financing the project.

II. RECOMMENDATIONS AND CONCLUSIONS

Contract mechanical harvesting of aquatic plants, dilution/flushing, and a watershed nutrient management program are being recommended to improve and restore conditions on Meadow Lake. Deep water aeration and spot dredging are being recommended for consideration after the aforementioned management alternatives have been implemented and evaluated.

It is proposed that the project be organized under Act 345 of 1966, the Inland Lake Improvement Act. Under provisions of this statute, a project on a private lake is initiated by petition to the local unit of government (i.e., the Township) by property owners adjacent to the lake. A Lake Board is then formed to administer the project.* If community support for the recommended improvements is demonstrated, a Special Assessment District is established from which revenue is generated to finance the lake improvement project.

It is proposed that the Special Assessment District include all buildable lots in the Meadow Lake Farms Subdivision. In order to insure that the assessments levied are proportionate to the benefits derived, it is recommended that lot size and proximity to the lake be considered in determining individual assessments. Under this plan, a "unit" assessment would be levied against lots with a mean lot width of 150 feet or less. For lots greater than 150 feet, unit numbers will be determined at 50 foot increments with .33 units added for each additional 50 feet. Lake front property owners would pay twice the second tier unit assessment, and back lot owners would pay one-half the second tier unit assessment (i.e., a 4:2:1 assessment breakdown). Additional information on the assessment criteria proposed can be found in Section IX.

With a Lake Board established and public support for the lake improvement project secured, it is recommended that an additional high capacity pumping mechanism be constructed during the fall of 1986 or spring of 1987 so dilution/flushing can be initiated during the summer of 1987. Mechanical harvesting of aquatic plants can be conducted concurrently with dilution/flushing.

In order to evaluate the impact of dilution/flushing and mechanical harvesting on the quality of Meadow Lake, it is recommended that water quality sampling be conducted on an annual basis for a minimum of 2 years. In this way, the effectiveness of these management techniques can be fully evaluated and consideration can be given to the need for spot dredging and deep water aeration. The costs associated with the recommended lake improvement alternatives are given in Table I.

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* Additional information on establishing a Lake Board can be found in the Appendix.

Table I

Improvements Proposed for Meadow Lake

Recommended Alternate	Estimated Cost	Unit Cost Breakdown	
Contract Aquatic Plant Harvesting	$ 5,000/yr	$ 69.00	Lake Front
		34.50	Second Tier
		17.25	Back Lots
Dilution/Flushing (Construction)	$12,000	$165.63	Lake Front
		82.82	Second Tier
		41.41	Back Lots
Dilution/Flushing (Operation and Maintenance)	$ 1,500/yr	$ 20.70	Lake Front
		10.35	Second Tier
		5.18	Back Lots
Water Quality Monitoring	$ 3,000/yr	$ 41.41	Lake Front
		20.70	Second Tier
		10.35	Back Lots
Administrative Costs	$ 3,000/yr	$ 41.41	Lake Front
		20.70	Second Tier
		10.35	Back Lots
Total Estimated Units Costs for 1986/1987 Season		$338.16	Lake Front 1 1ST
		$169.08	Second Tier 2
		$ 84.54	Back Lots 3
Total Estimated Unit Costs for 1988 Season (Dilution/Flushing Construction Cost subtracted)		$172.53	Lake Front 2ND -
		$ 86.26	Second Tier
		$ 43.13	Back Lots

III. BACKGROUND

Meadow Lake is a relatively small, eutrophic lake. Most of the land adjacent to the lake has been developed as single-family residential. Water from Meadow Lake drains into Franklin Creek and ultimately to Lake Erie via the Rouge and Detroit Rivers. Currently, there are 34 homes bordering the lake.

Meadow Lake has no major natural surface tributaries; however, an extensive storm sewer system which drains much of the lake watershed, discharges to the lake. A lake watershed is the land surrounding the lake from which water drains to the lake. The boundaries of the Meadow Lake watershed are graphically depicted in Figure 1. Land use activities in a lake watershed are important in that the input of pollutants from the lake watershed can contribute significantly to the rate of lake degradation or improvement.

The physical characteristics of Meadow Lake and its watershed are listed below:*

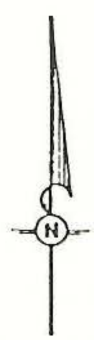
Lake Surface Area	18 acres
Lake Volume	84.6 acre-feet
Mean Depth	4.7 feet
Maximum Depth	21 feet
Water Residence Time	.31 years (estimate)
Lake Elevation	819 feet above mean sea level
Shoreline length	1 mile
Lake Shape Factor	1.68
Watershed Area	183 acres
Lake Area to Watershed Area Ratio	1 : 10.2

* Shoreline length, lake elevation, watershed and lake areas were determined by examining a United States Geological Survey topographic map of the Meadow Lake area (scale 1" = 2,000'). Lake volume, maximum and mean depth were derived from a Department of Natural Resources depth contour map of Meadow Lake (see Figure 2). An aerial photograph of the study area was utilized to delineate land use types (Soil Conservation Service, 1980). All area measurements were made with a compensating polar planimeter.

The lake water residence time estimate was determined by utilizing standard runoff coefficients and precipitation data for Oakland County (National Biocentric, 1978; Soil Conservation Service, 1980).

Land uses in the immediate watershed include:

Land Use	Acres	% of Total
Urban/Residential	144	79%
Golf Course	39	21%
	183	100%



WATERSHED AREA

183 ACRES

MEADOW LAKE

WATERSHED MAP

SCALE: 1" = 2000'

FIGURE 1

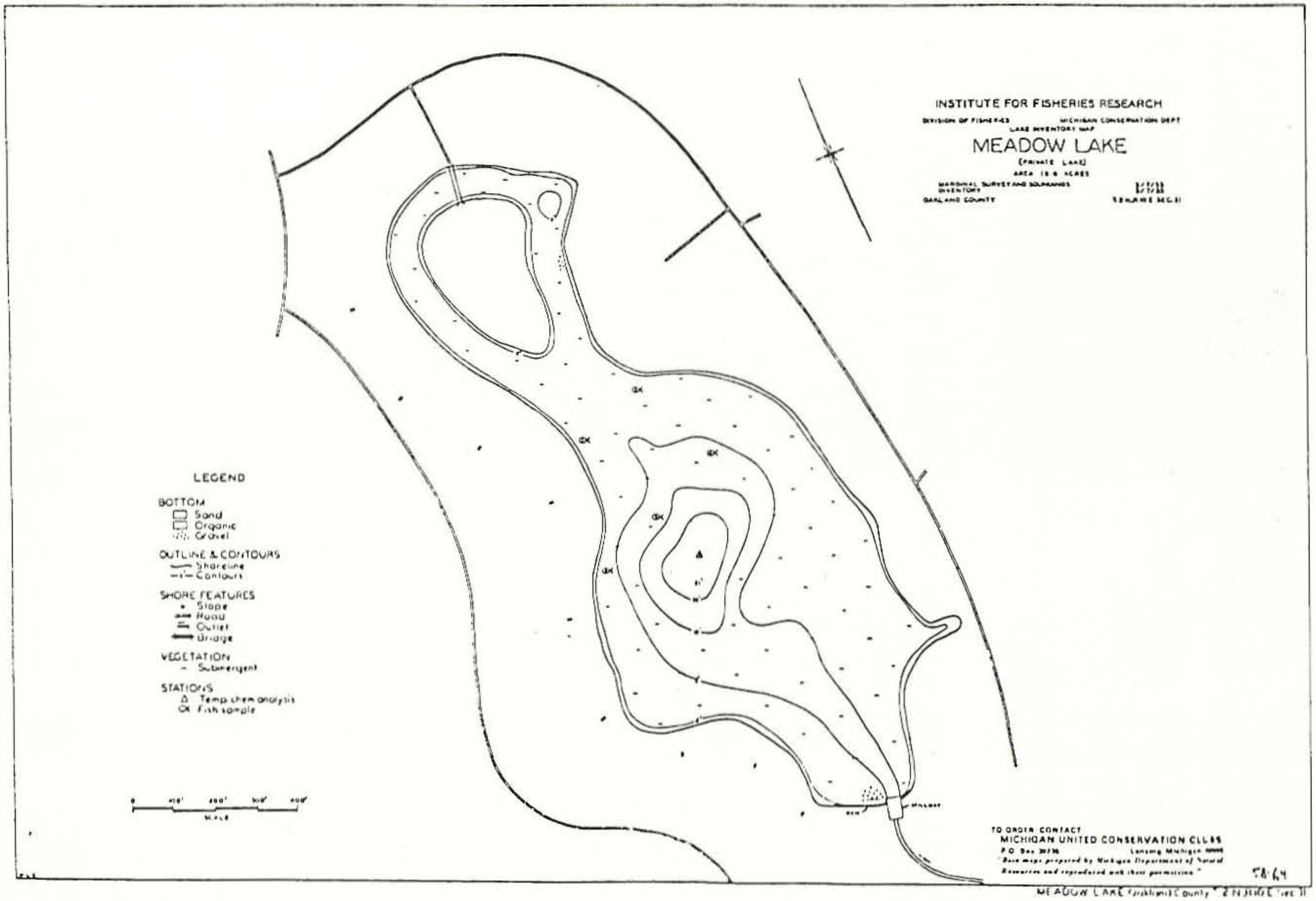

INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN CONSERVATION DEPT
LAKE INVENTORY MAP
MEADOW LAKE
(PRIVATE LAKE)
MARGINAL SURVEY AND SOUNDINGS
INVENTORY
OAKLAND COUNTY
LEGEND
BOTTOM
Sand
Organic
Gravel
OUTLINE & CONTOURS
Shoreline
Contours
SHORE FEATURES
Slope
Road
Outlet
Bridge
VEGETATION
Submergent
STATIONS
Temp. chem. analysis
Fish sample
TO ORDER CONTACT
MICHIGAN UNITED CONSERVATION CLUBS
Lansing Michigan
58-64

FIGURE 2

IV. THE NUTRIENT BUDGET ANALYSIS

A nutrient budget is calculation of nutrient inputs to the lake based on land use and other conditions in the lake drainage basin. This data can be used to determine if excessive nutrient loading to the lake is occurring and will allow formulation of planning and management priorities. This analysis has focused on the control of phosphorus for two reasons:

1. Phosphorus is usually the major nutrient in shortest supply relative to the nutritional needs of aquatic plants. Therefore, phosphorus is the nutrient which controls eutrophication (lake aging).

2. Of the major nutrients, phosphorus inputs are more subject to control through management practices.

In order to determine the total annual phosphorus input into Meadow Lake, it was necessary to determine the phosphorus contribution from all sources - surface runoff, atmospheric deposition (both wet and dryfall), and near shore septic systems. Since, it is extremely difficult and cost prohibitive to directly measure non-point, diffuse sources of phosphorus loading such as septic seepage and surface runoff, 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 which would be representative of the watershed conditions observed at Meadow Lake. The values selected were based largely on a comprehensive review of the phosphorus mass transported to surface water bodies from various land uses (Reckhow, et al. 1980). The phosphorus loading values used in this analysis are given in Table II.

TABLE II

Source	Phosphorus Export Coefficient (kg/ha/yr)
Urban/Residential	1.1
Golf Course*	1.1
Atmospheric Deposition**	.34

* It was assumed the golf course phosphorus contribution per hectare (1 hectare = 2.47 acres) would equal the residential phosphorus input (per hectare).

** The "atmospheric deposition" loading value was derived from lakes with geography and climate similar to Meadow Lake (see Appendix).

When calculating the phosphorus input from septic systems, the Michigan ban on phosphate-based detergent was taken into account, and it was assumed 3.0 persons occupied each residence 60% of the year (Bureau of Census Data 1980). Only septic systems directly abutting the lake were counted in this analysis. Soil types, soil drainage, the soil phosphorus adsorption capacity and groundwater levels were all considered when estimating the degree of phosphorus immobilization that would occur between the septic drainfield and the lake. Based on the criteria and assumptions above, the total septic input was estimated to be 24 kg/yr (see Appendix).

The total mass input of phosphorus to Meadow Lake was estimated by summing the annual phosphorus contribution from each source (see Table III).

TABLE III

Source	Total Phosphorus Input (kg/yr)	% of Total
Urban/Residential Runoff	64.0	60%
Golf Course Runoff	17.0	16%
Atmospheric Deposition	2.5	2%
Septic Input	24.0	22%
	107.5	100%

Watershed Management

Eutrophication is the term used to describe the complex aging process in lakes that is initiated by the enrichment of lake waters with plant nutrients. The rate at which a lake ages and becomes more eutrophic is dependent, to a large extent, on the quantity of nutrients and sediment entering the lake from its watershed.

When classifying lakes, scientists use the board categories oligotrophic, mesotrophic and 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 periods of maximum thermal stratification to support cold water fish like trout and whitefish. By contrast, eutrophic lakes are generally shallow, turbid and support abundant aquatic plant growth. In eutrophic lakes deep enough to exhibit thermal stratification, the cool bottom waters usually contain little dissolved oxygen. Therefore, these lakes can only support warm water fish like bass and pike. Lakes which fall between these two extremes are called mesotrophic lakes.

Various criteria have been developed which relate phosphorus loading to lake trophic state (i.e. oligotrophic to eutrophic) (Reckhow et al. 1980 and others). While these relationships are not refined to a point that an absolute permissible loading rate can be determined, they do allow an approximation to be made of how much phosphorus loading must be reduced to attain improved water quality conditions. For Meadow Lake, it is estimated that phosphorus loading must be reduced by at least 60% to achieve an acceptable loading rate (i.e., a loading rate in which excessive aquatic plant growth would not occur) (Reckhow et al. 1980). Under certain conditions, phosphorus can generate several hundred times its weight in plant biomass (Wetzel, 1983). Therefore, a watershed nutrient management program is an essential component of the Meadow Lake improvement program.

It is apparent from the data presented in Table III that the largest controllable source of phosphorus loading are surface runoff (from residential areas and the golf course) and septic seepage. These sources respectively contribute 76% and 22% of the total phosphorus load. If steps were taken to reduce these controllable sources of phosphorus input, the annual phosphorus load could be reduced to within the acceptable range (i.e., a reduction of about 60%).

The phosphorus load from residential areas could be substantially reduced if the use of phosphorus based fertilizers was curtailed in areas which drain directly to the lake. This would include most of the Meadow Lake Farms Subdivision since much of the drainage from the subdivision is carried and discharged to the lake via an extensive network of storm water drains. A further reduction in phosphorus loading could be achieved if a greenbelt vegetative buffer strip was established around the lake perimeter.

The septic phosphorus contribution could be reduced if near shore septic systems were properly maintained and serviced. Specific recommendations on lakefront lawn care, greenbelt landscaping and septic system maintenance can be found in the Appendix.

Virtually all the runoff that enters Meadow Lake from the golf course is carried by a drainage pipe which passes under Maple Avenue after first transversing a condominium development under construction just north of Maple. The developer of this condominium project is planning to build a water retention pond on the property through which the runoff from the golf course will be discharged prior to draining to Meadow Lake. Since phosphorus is often transported adhered to soil particles, a portion of the phosphorus load from the area north of Maple Avenue will settle out in the retention pond prior to discharging to Meadow Lake. The pond may have to be cleaned periodically so the basin does not become hydraulically overloaded and lose its retention capability.

Although a quantitative estimate of the phosphorus input from area geese is not possible, it is probable that geese which frequent Meadow Lake are contributing a significant pollution load to the lake. It is strongly recommended that area residents not feed the geese and an attempt should be made to discourage geese colonization. The Department of Natural Resources Wildlife Division has a program in which geese are captured and released at remote locations. The geese are captured during their feather molt when they are unable to fly. On private lakes, DNR staff will assist lake residents with the removal of geese if a petition is signed by 70% of the lakeshore owners. Information on the Department of Natural Resources Nuisance Geese Program has been included in the Appendix.

V. LAKE WATER QUALITY

A water quality sampling program was conducted to evaluate the present condition of Meadow Lake. Water samples were collected in late summer over the deeper portion of the lake and at several locations along the shoreline. Samples collected over the deep basin of the lake were analyzed for the following parameters:*

- Dissolved Oxygen
- Temperature
- Total Phosphorus
- pH
- Nitrate
- Alkalinity
- Conductivity

In addition, near shore fecal coliform bacteria levels were determined. The results of the sampling program are given in Table IV. Sampling locations are depicted in Figure 3.

When evaluating the limnological (i.e., the physical, chemical and biological) condition of a lake, temperature/dissolved oxygen relationships and total phosphorus concentration are of primary importance in that these parameters will permit an assessment to be made of the overall trophic condition of the lake. By collecting bacteria samples, it is often possible to identify sources of fecal contamination. A discussion of the significance of these key water quality parameters is as follows.**

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* For comparative purposes, samples were collected under winter ice cover over the deepest portion of the lake to determine dissolved oxygen and total phosphorus concentrations.

** A brief discussion of the other parameters sampled can be found in the Appendix.

Table IV
Meadow Lake
Water Quality Data
September 12, 1985

	Sample Depth (feet)	Temperature (°C)	Dissolved Oxygen (mg/l)
Site A (Mid-Lake)	Surface	23	7.6
	2	23	7.8
	4	23	7.4
	6	23	7.4
	8	22	7.4
	10	22	7.2
	12	22	5.5
	14	21	1.7
	16	19	.8
	18	16	.6
	20	14	.5

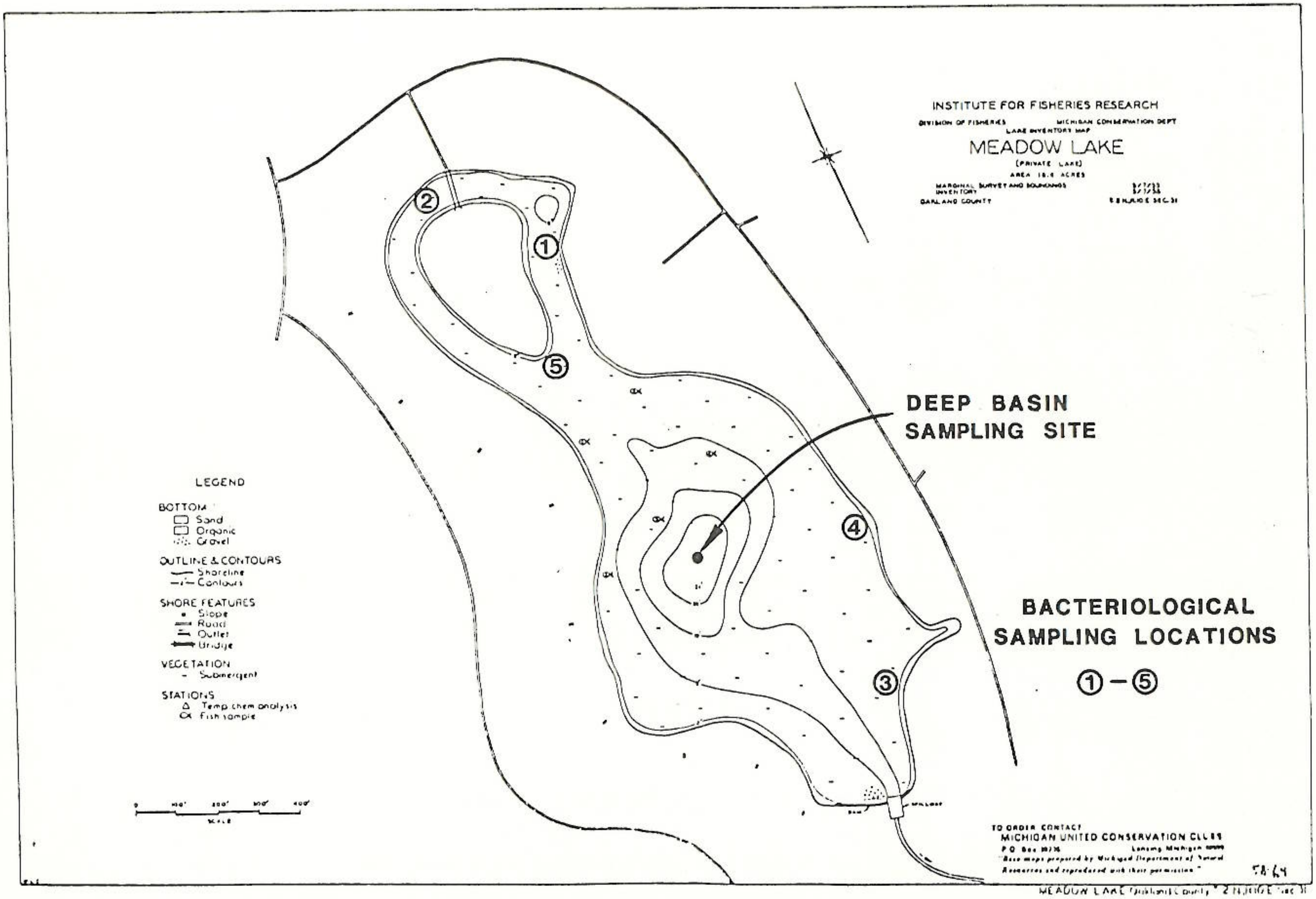
Table IV
Meadow Lake
Water Quality Data (Continued)
September 12, 1985

	Sample Depth (feet)	Total Phosphorus (ug/l)	pH	Total Nitrate (ug/l)	Alka-linity (mg/l)	Conduc-tivity (umhos/cm)
Site A (Mid-Lake)	1	9	8.3	3	137	600
	5	9	8.4	3	137	600
	10	10	8.0	3	137	590
	15	9	8.0	3	162	640
	20	92	7.9	3	205	680

	Near-Shore Fecal Coliforms (bacteria/100 ml)
Site 1	156
Site 2	9
Site 3	154
Site 4	44
Site 5	226

January/February, 1986

	Sample Depth (feet)	Dissolved Oxygen (mg/l)	Total Phosphorus (ug/l)
Site A (Mid-Lake)	1	5.9	44
	5	1.9	42
	10	1.9	44
	15	1.9	45
	20	1.9	42



MEADOW LAKE SAMPLING SITE LOCATIONS

FIGURE 3

Thermal Stratification/Dissolved Oxygen/Phosphorus

As the ice cover breaks up on a lake in the spring, the water temperature is more or less uniform from the surface to the bottom. This period is referred to as "spring turnover" when mixing of the water column occurs prior to thermal stratification. As the surface waters warm and become less dense, deeper lakes exhibit a phenomenon known as thermal stratification in which the warm surface waters of the lake are underlain by a colder, more dense strata of water. Once thermal stratification occurs, there is little mixing of the warm surface waters with the cool, dark bottom waters. The transition layer which separates these layers is referred to as the "thermocline". As fall approaches, the warm surface waters begin to cool and become more dense. Eventually, the surface temperature drops to a point where the density gradient breaks down and the lake undergoes complete mixing. This period is referred to as "fall overturn". As the season progresses and ice begins to form on the lake, the lake will again stratify. However, during winter stratification, the surface waters (at or near 32°F) are underlain by slightly warmer water (about 39°F). This is often referred to as inverse stratification and occurs because water is most dense at a temperature of about 39°F (4°C). These stratification cycles are repeated year after year.

An important factor which influences water quality is the quantity of oxygen dissolved in the water column. Dissolved oxygen is of major significance to the survival of fish populations and will affect many chemical reactions. An oxygen level of about 5 mg/l is required to support warm water fish. In lakes deep enough to exhibit thermal stratification, oxygen levels are often reduced or depleted in the bottom waters of the lake once the lake has stratified. This is due to the fact that oxygen has been consumed, in large part, by bacteria which utilize oxygen as they break down organic matter (plant and animal remains) which enter the bottom waters from the more productive regions of the lake. Bottom water oxygen loss is a common occurrence in eutrophic and some mesotrophic lakes. This is why these lake types cannot support cold water fish--the cool, deep waters (which the fish require to live) do not contain sufficient oxygen.

Oxygen is also important in that it influences the distribution of nutrients in the lake. The quantity of phosphorus present in the water column is especially important since phosphorus is generally the nutrient which will control aquatic plant growth and the rate at which a lake ages and becomes more eutrophic. In lakes which maintain dissolved oxygen throughout the water column, the movement of phosphorus is unidirectional towards the sediments (Wetzel 1983). In other words, 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.

From the data presented in Table IV, it can be seen that on September 12th the water column over the deep basin of Meadow Lake was thermally stratified (i.e., the water from the surface to 12 feet was 23°C to 22°C, while the bottom water was 14°C). The thermocline, where temperature drops rapidly with depth, occurred between 14 and 18 feet. The oxygen level of the bottom waters was less than 5 mg/l,; therefore, fish were not able to utilize the deep water regions of the lake due to the reduced oxygen levels.

Phosphorus levels in Meadow Lake during the September 12th sampling period did not exceed 10 ug/l to a depth of 15 feet*. An elevated phosphorus level of 92 ug/l was observed in the oxygen deficient bottom waters. As was previously discussed, this is related in part to the fact that in an oxygen deficient aquatic environment, chemical conditions are such that phosphorus is released from the underlying sediments. In general, lakes with a phosphorus concentration of 20 ug/l or greater are classified as eutrophic (Chapra and Reckhow 1979; Dillon and Rigler 1975). The phosphorus concentration measured at various depths under winter ice cover in January (when oxygen levels were low) ranged from 42 ug/l to 45 ug/l**.

Bacteria of the coliform group are the primary indicators of fecal contamination. The Michigan Water Quality Standard requires waters of the state protected for total body contact recreation to contain not more than 200 fecal coliforms per 100 milliliters of water. Fecal coliform levels at sites 1, 3, 4 and 5 are suspiciously high and are most likely caused by the geese population which frequents the area.

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* Since most of the phosphorus present in the water column is contained in living algal cells, it is likely that the near surface phosphorus levels observed in Meadow Lake during the summer months would have been substantially higher had the lake not been treated with chemical algicides prior to the September sampling period.

** A discussion of the potential impact reduced winter dissolved oxygen levels may have on the fish population can be found in Section VI-C.

VI. LAKE IMPROVEMENT ALTERNATIVES

As has been previously discussed, a watershed nutrient management program is an essential component of the Meadow Lake improvement program. In order to reduce phosphorus loading to a point where excessive aquatic plant growth will not occur, steps must be taken to reduce the controllable sources of phosphorus input such as septic seeptage and excessive lawn fertilization.

In this section, recommended lake management alternatives are examined and discussed.

A. Mechanical Harvesting

The distribution and abundance of aquatic plants is 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.

Although too many of the wrong type of plants can limit enjoyment of a lake, it is important to realize that aquatic plants play an important roll ecologically. They produce oxygen during photosynthesis, provide food and habitat for fish and other organisms, and help stabilize shoreline and bottom sediments. Therefore, the objective of a sound aquatic plant control program is to remove plants only from problem areas where excessive growth is occurring. Under no circumstance should an attempt be made to remove all plants from the lake.

The shallow mean depth of Meadow Lake creates conditions ideal for aquatic plant colonization and growth. Due to the fact Meadow Lake had received repeated algicide/herbicide treatments prior to the September sampling period, a detailed plant identification survey was not possible. However, it appears that Milfoil (Myriophyllum), Naiad (Najas) and various species of Pondweeds (Potamogeton) are the dominant problem macrophytes in Meadow Lake. In addition, Chara algae (a macrophyte that adheres to and grows on the lake bottom substrate) was observed throughout the central portion of the lake. Chara is not generally a cause for concern in that it rarely grows to a height that interferes with the recreational use of the lake. In fact, Chara may be beneficial in that it can prevent colonization of other less desirable plants (such as Milfoil) and will inhibit the resuspension of the lake bottom sediment through wind and wave action.

Mechanical harvesting and chemical herbicides are methods commonly utilized to control excessive macrophyte growth. However, it should be noted that mechanical harvesting has several advantages over the use of chemical herbicides. These advantages include:

1. Harvesting plants will prevent dead plant material from decomposing on the lake bottom, adding to the buildup of sediment.

2. Plants removed from the water will not deplete dissolved oxygen supplies upon decay.

3. Nutrients are removed with harvested plants. Repeated harvesting over the years can reduce nutrient supplies in the lake.

4. Cutting at times of major growth weakens plants and regrowth after cutting is slower than normal. Multiple harvests in one year may reduce regrowth in subsequent years.

5. No foreign substances are introduced in the lake and recreational activity is restored immediately after harvesting.

Since many aquatic plant species can reproduce by vegetative propagation, harvesting must accompany cutting so plant fragments do not drift and become established in other parts of the lake. Once harvested, plants should be disposed of away from the lake's edge to prevent the leaching of nutrients back to the lake as the plants break down and decompose.

Although herbicides have the advantage of being easily applied, the following drawbacks have been associated with herbicide use in large scale aquatic plant control:

1. Plants killed by herbicides are not removed from the water. Dead plants sink to the bottom adding to the buildup of organic sediment.

2. Upon decay, dead plants can deplete dissolved oxygen supplies.

3. As the plants slowly break down, they release nutrients back into the lake which can support new plant growth.

4. Herbicides give only annual relief. To be effective, the treatments will have to be repeated year after year.

5. Herbicides are hard to restrict to a given area and can drift and affect unintended areas.

6. Swimming, fishing and other activities are restricted for some time after application.

7. Long-term effects of herbicide application have yet to be fully evaluated.

In light of these considerations, it is recommended that mechanical harvesting be conducted on an annual basis for macrophyte control. To insure maximum effectiveness, a lakewide harvest should be conducted a minimum of two times during the active growing season. Typically, harvests are conducted during the months of June and August.

The cost of harvesting aquatic plants from Meadow Lake twice during the active growing season is estimated to be $5,000 per year.

B. <u>Dilution/Flushing</u>

Dilution/flushing is accomplished by replacing nutrient-rich lake water with nutrient poor water. Field observations of the Meadow Lake outlet indicate little outflow from the lake occurs during the mid to late summer months. During this period, surface and subsurface drainage to the lake roughly equals evaporation from the lake surface. The lake flushing rate could be substantially increased if a large volume of nutrient poor groundwater was pumped into the lake. Water sampled from the existing well on Anchor Island shows the phosphorus concentration of the groundwater to be sufficiently low (less than 20 ug/l) that the dilution effect could reduce algal growth. A preliminary review of available well log data indicates that sufficient groundwater is available to operate an additional high capacity pump (i.e., a 300 gpm well). It is recommended that the second well be constructed at the north end of the island just east of the bridge (see Figure 4). Aerator nozzles should be put on both pumps so the groundwater is sufficiently aerated before being discharged to the lake. The pumps should be operated on alternate 8-hour cycles throughout much of the ice-free period (April thru October). By operating the pumps in this fashion, approximately three quarters of the total lake volume would be replaced on an annual basis. The resultant increased circulation of water should greatly reduce plant growth in the immediate vicinity of the island.

It should be noted that while dilution/flushing can reduce planktonic (free floating) algae growth throughout the lake, macrophyte growth may not be substantially reduced since the macrophytes are able to obtain the nutrients necessary for growth from the underlying sediments. In addition, nutrient release from the lake sediments to the open waters may partially negate the effect of dilution/flushing. However, repeated harvesting over several years may reduce the nutrient supply of the lake sediments to a point where both macrophyte growth and sediment nutrient release are mitigated.

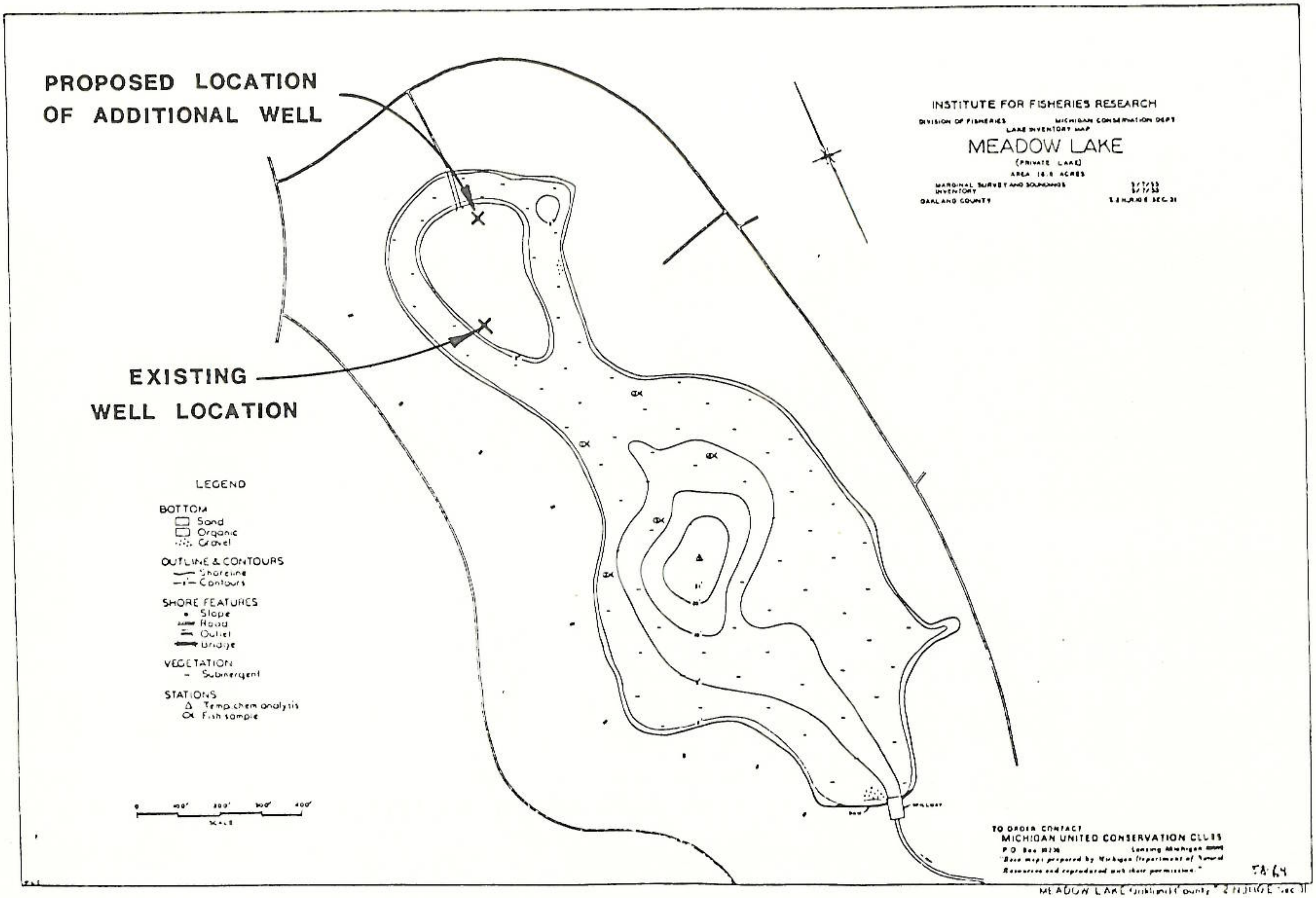
The cost of sinking an additional well and installing a 300 gpm submersible pump is estimated to be $12,000. The annual operation and maintenance cost is estimated to be $1,500.

C. <u>Deep Water Aeration</u>

Although not recommended at the present time, the installation of a deep water aerator should be considered after the aforementioned management alternatives (i.e., nutrient curtailment, mechanical harvesting and dilution/flushing) have been implemented and fully evaluated. Deep water aeration can be accomplished by utilizing a shore based compressor which delivers air to a perforated diffuser box located in deep water. The diffuser would be located at the deepest point of the central lake basin (see Figure 2).

As was discussed in Section V, samples collected in late summer over the deepest portion of the lake were oxygen deficient below a depth of about 12 feet. Samples collected under winter ice cover indicate reduced oxygen levels below a depth of 5 feet (see Table IV). Under thick winter ice cover, as was experienced last winter, photosynthetic oxygen production and atmospheric replenishment of oxygen are minimal. Therefore, winter dissolved oxygen levels can be reduced via bacterial respiration as natural bacteria breakdown organic matter (plant and animal remains) which settle out of the water column. Most often, oxygen depletion caused by bacterial decomposition is most apparent at the sediment-water interface.

In highly productive lakes, such as Meadow Lake, bacteriological activity can reduce oxygen levels to a point where fish are stressed and large quantities of phosphorus (which have settled out of the water column) are redistributed back to the open water to be utilized by aquatic plants for growth. Under extreme conditions, a "winter kill" of fish populations can



DILUTION/FLUSHING WELL LOCATION

FIGURE 4

occur. Oxygen levels observed on Meadow Lake during the winter sampling period are such that there exists a significant potential for a "winter kill".

It is possible that by initiating a comprehensive watershed nutrient management program in conjunction with mechanical harvesting and dilution/flushing, the productive capacity of Meadow Lake can be reduced to a level that will mitigate the potential for a winter kill to occur. By monitoring the dissolved oxygen levels under winter ice cover on a monthly basis for 2 to 3 years, an evaluation of the need for deep water aeration can be made.

Typically, a deep water aeration system will cost $4,000, and annual operation and maintenance (assuming the aerator is operating during both winter and summer) will cost $1,000.

D. Spot Dredging

Although dredging is not being recommended at present, a spot dredging project may be required if the lake management alternatives recommended do not adequately improve the overall condition of Meadow Lake*. Site constraints and the lack of suitable dredge spoil disposal sites in the vicinity of the lake make a large scale dredging project infeasible. Sediment thickness surveys conducted during late summer indicate that much of the main body of the lake has a relatively firm bottom (though it is overlain by a mat of the aquatic plant Chara). However, the area surrounding Anchor Island contains muck from 3 to over 6 feet in thickness**. In order to deepen the shallow water areas adjacent to the island (which are presently about 3 feet in depth) to a maximum depth of 5 feet to 6 feet, approximately 4,000 cubic yards of lake sediment would have to be removed.

In general, dredging can be accomplished with a land based crane or by utilizing a floating hydraulic dredge. It does not appear that the bridge leading out to Anchor Island can support the weight of a crane or the dump trucks that will be required to haul away dredged material.

If dredging was conducted with a shore based dredge, many of the trees on the island would have to be removed to permit the crane to operate in an efficient manner. Also, the power lines would have to be temporarily dropped.

In order to insure that the structural stability of the bridge was not impaired, a temporary roadway would have to be constructed across the channel to permit heavy machinery (i.e., the crane and dump trucks) to be transported to and from the island. This would require that an easement be acquired from a riparian property owner in the immediate vicinity of the island. In light of these considerations, it is recommended that a hydraulic dredge be utilized to spot dredge the area around Anchor Island.

---

* Under provisions of Act 346 of 1972, the Inland Lake and Streams Act, a permit must be acquired from the Michigan Department of Natural Resources before a dredging project can be initiated.

** Sediment thickness was determined by establishing a grid pattern on the lake during winter ice cover and measuring sediment depth with a calibrated range pole.

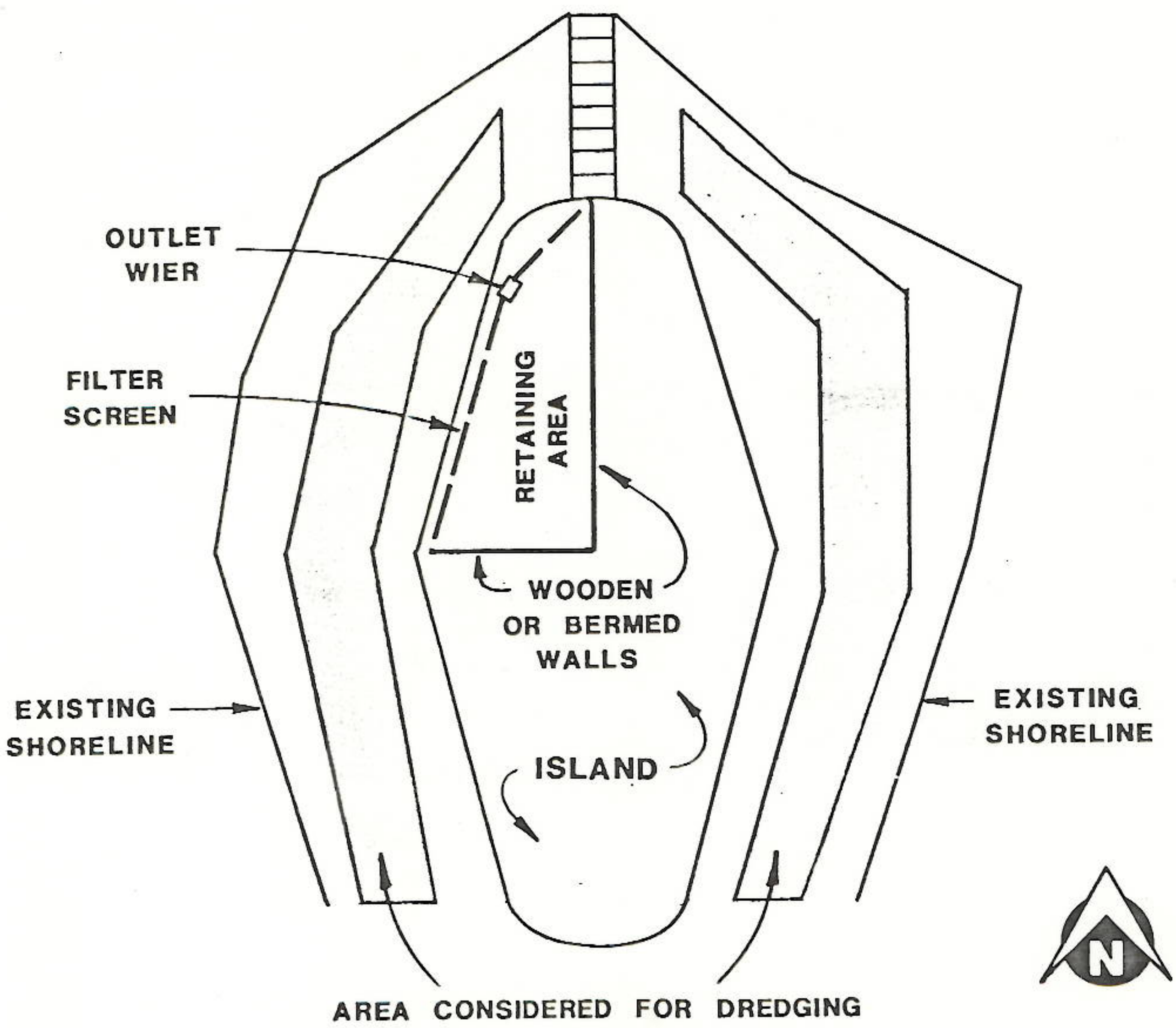
A floating hydraulic dredge has more operational flexibility than a shore based dredge and would cause considerably less physical disruption to the island. Material excavated with a hydraulic dredge is pumped through a floating pipeline to the point of disposal. A temporary retaining structure approximately .40 acres in area would need to be constructed on Anchor Island. The retaining area would be constructed by erecting an enclosure 5 to 6 feet in height with either earthen berm or wooden retaining walls. The lakeside wall would be made of a permeable filter screen material which would allow water to drain back into the lake while retaining solid dredge material on site. A wier type outflow structure may be required to insure the retaining area can be efficiently drained (see Figure 5).

Once deposited and sufficiently dried, the retaining structure would be dismantled and the disposal area graded and seeded. The limited size of the retaining area will require the dredging contractor to time or phase dredging to accomodate drying and consolidation. This will invariably involve down-time between periods of actual dredging. It is estimated the dredging phase of the program will take two months to complete. The estimated costs associated with various phases of the dredging project are given in Table V.

Table V
Cost Breakdown of Dredge Project Work Items

Activity	Cost	Total
Dredge Phase (includes move-in and move-out of dredge, labor and materials)	4,000 cu yds @ $10	$40,000
Retaining Area Construction/Site Restoration (includes retaining walls, outflow structures, final grading, etc.)		$15,000
Engineering/Administrative and Contingencies	25% of Construction	$14,000
Total		$69,000

Progressive — Progressive Engineering Consultants of Grand Rapids, Inc. 2942 Fuller Avenue, N.E., Grand Rapids, MI 49505 616-361-2664	ENGR : 8508-05 ARCH : OWNER : DATE : APRIL 1986
MEADOW LAKE OAKLAND COUNTY, MICHIGAN	REMARKS : DREDGING SCHEMATIC



APPROX. SCALE: 1" = 100'

DREDGING SCHEMATIC

FIGURE 5

VII. WATER QUALITY MONITORING

In order to evaluate the effectiveness of the lake management alternatives proposed, it is recommended that key water quality parameters be monitored on an annual basis for a minimum of two years. By continuing to collect water samples in a systematic manner over time, a data base can be compiled that will permit seasonal trends in the quality of Meadow Lake to be discerned.

Samples should be collected at 5 foot intervals surface to bottom over the deepest portion of the lake during spring turnover, mid and late summer. Samples collected should be analyzed to determine the following:

Temperature
Dissolved Oxygen Concentration
Total Phosphorus Concentration

In addition, surface water chlorphyll-a levels should be determined and a measurement made of water transparency. During the late summer sampling period, a minimum of 10 samples should be collected to determine near-shore fecal coliform bacteria levels.

During winter, samples should be collected under ice cover on a monthly basis to measure dissolved oxygen and total phosphorus levels.

The cost of water quality monitoring and data interpretation is estimated to be $3,000 per year.

A detailed discussion of the water quality data acquired during the initial sampling survey of Meadow Lake can be found in Section V.

VIII FISHERIES MANAGEMENT

In order to assess the condition of the fishery in Meadow Lake, a fish population survey was conducted during October, 1985. The survey was conducted by Mr. James W. Merna, a fisheries biologist employed by the Fisheries Research Division of the Michigan Department of Natural Resources. A copy of the Meadow Lake Fish Survey is contained in the Appendix.

A very limited distribution of fish species was found in the lake. The author outlined several options which could be utilized to enhance the fishery. These options are outlined as follows:

1. Eliminate the entire fish population and restock the lake with largemouth bass and bluegills. A technique of poisoning fish under the ice during winter has been developed which eliminates most of the undesirable attributes of fish poisoning. No fish pick-up is necessary since the fish disappear under the ice before spring. There would be no damage to the lake from allowing the fish to decay away.

2. If the population is not eliminated, bluegill should be stocked and an attempt made to enhance the bass population. All bass fishing should be eliminated for two years and then bass larger than 14 inches should voluntarily be returned to the lake. These large bass will promote reproduction and also control numbers of bluegills and sunfish. Smaller bass are not efficient predators.

3. Periodically, a few tiger musky or walleye could be stocked in the lake. Neither of these would reproduce, but survival of just a few could produce exciting fishing and help control numbers of panfish.

4. The lake is seriously over-enriched by geese frequenting the lake and lawns. This enrichment is the cause of excessive plant and algae growth which is smothering fish habitat.

The cost of a fish poisoning program for Meadow Lake is estimated to be $500.00. The cost of restocking would depend on the type, number and size of fish stocked. It is recommended that the cost of a fisheries rehabilitation program be borne by the Meadow Lake Farms Civic Association if they so desire. It is further recommended that no action be taken on fish manipulation until a lake management program has been implemented.

IX. PROPOSED ASSESSMENT CRITERIA

It is proposed that the special assessment district around Meadow Lake include all lots in the Meadow Lake Farms Subdivision.

As previously discussed, a 4:2:1 assessment breakdown is being recommended. Under this plan, a "unit" assessment would be levied against lots with a mean lot width of 150 feet or less. For lots greater than 150 feet, unit numbers will be determined at 50 foot increments with .33 units added for each additional 50 feet. Lake front property owners would pay twice the second tier unit assessment, and back lot owners would pay one-half the second tier unit assessment (see Table V). Table VI shows how the recommended assessments can be utilized to finance the various lake improvements.

Table V

Assessment Criteria

Type and Size of Lot	# of Units	Total Units per Lot Type
Front Lot:		
200' or less	1	
201' to 250'	1.33	
251' to 300'	1.66	
301' to 350'	2	
351' to 400'	2.33	
401' to 450'	2.66	
451' to 500'	3	
501' to 550'	3.33	36.31
2nd Tier Lot:		
200' or less	1	
201' to 250'	1.33	
251' to 300'	1.66	
301' to 350'	2	
351' to 400'	2.33	
401' to 450'	2.66	
451' to 500'	3	
501' to 550'	3.33	22.98
Back Lot:		
200' or less	1	
201' to 250'	1.33	
251' to 300'	1.66	
301' to 350'	2	
351' to 400'	2.33	
401' to 450'	2.66	
451' to 500'	3	
501' to 550'	3.33	98.62

Table VI

Proposed Assessment Spread and Cost Breakdown Information

Recommended Improvement	Cost	Total Units Per Lot Type*	Unit Cost Breakdown		Revenue Generated
Contract Aquatic Plant Harvesting	$ 5,000/yr.	36.31	69.00	Lake Front	$ 2,505.00
		22.98	34.50	Second Tier	795.00
		98.62	17.25	Back Lots	1,700.00
					$ 5,000.00
Dilution/Flushing (Construction)	$12,000	36.31	165.63	Lake Front	$ 6,015.00
		22.98	82.82	Second Tier	1,905.00
		98.62	41.41	Back Lots	4,085.00
					$12,000.00
Dilution/Flushing (Operation and Maintenance)	$ 1,500	36.31	20.70	Lake Front	$ 750.00
		22.98	10.35	Second Tier	240.00
		98.62	5.18	Back Lots	510.00
					$ 1,500.00
Water Quality Monitoring	$ 3,000/yr.	36.31	41.41	Lake Front	$ 1,505.00
		22.98	20.70	Second Tier	475.00
		98.62	10.35	Back Lots	1,020.00
					$ 3,000.00
Administration	$ 3,000/yr.	36.31	41.41	Lake Front	$ 1,505.00
		22.98	20.70	Second Tier	475.00
		98.62	10.35	Back Lots	1,020.00
					$ 3,000.00

* See Table V.

APPENDIX

ESTABLISHING A LAKE BOARD

(Act 345, Mich. PA-1966, as Amended)

1. Owners petition Township Board for improvements to lake
    a. Must be signed by 2/3 of property owners abutting lake.
    b. Must be for protection of the public health and safety and conservation of natural resources or to preserve property values around lake.
    c. May include improvement of adjoining swamp land.

2. Township Board within 60 days sets up Lake Board
    a. Lake Board may improve the lake or void the project

3. Membership of Lake Board
    a. A member of County Board of Commissioners, appointed by Chairman of Board of Commissioners
    b. A representative appointed by the Township Board
    c. The County Drain Commissioner
    d. A representative of the State Department of Natural Resources

4. Actions of Lake Board
    a. Elect a chairman and secretary
        1. A quorum consists of a majority of the members of the Board
    b. DNR provides necessary technical data related to project and makes recommendations on matters of conservation
    c. Requests revolving fund, if needed, from County Board of Commissioners to cover preliminary costs of improvement
        1. If granted, Lake Board assesses costs against property owners after hearing whether or not project is finally undertaken.
    d. Lake Board retains registered professional engineer to prepare and submit to the Lake Board:
        1. Engineering feasibility report
        2. Economic Study Report -- analyzing tax structure
        3. Estimate of cost, and assessments needed

5. Public Hearings
    a. Lake Board conducts, within 60 days of receipt of engineer's report, to determine practicality of recommended project
        1. Must be advertised twice in newspaper of general circulation in Township
        2. First publication must be not less than 20 days before hearing.
    b. Lake Board determines practicality of project within 10 days after hearing and issues decision
        1. Can delay decision, if additional data needed, until data obtained

6. Procedure with Project
    a. By resolution, Lake Board may determine project feasible and proceed by:
        1. Approving plans and cost estimates of project as submitted

or amended

2. Concluding the petitions are sufficient for the improvement
3. Publishing the resolution once in local paper
4. Proceed, barring court action, within 30 days after publication

b. Upon determination to proceed, Lake Board prepares a special assessment tax roll based on relative benefits to be derived by each property owner
   1. Local assessor joins in assessing process by naming and describing property and its owners, certifying roll, notifying Lake Board, filing roll with Township Clerk
   2. Lake Board holds hearing and review on special assessment roll following notice of hearing and filing is advertised twice in local paper, with first publication at least 10 days prior to hearing
      a. Objections must be filed in writing to chairman of Lake Board prior to close of hearing unless otherwise specified by Lake Board
      b. Lake Board returns assessment roll, after revision or amendment, to Township Clerk for confirmation

c. Lake Board after confirmation of roll, specifies payment in from 1 to 30 annual payments and includes in tax bills
   1. Assessment subject to payments on specified date with interest at 6% on overdue payments
   2. Assessment becomes lien on land
   3. Full or partial prepayment may be made by owner, with accrued interest to due date of next regular installment

d. If special assessment sums prove inadequate, Lake Board may add pro rata assessments, but only to maximum value of benefits received from the project improvement

e. Lake Board may issue bonds and Township may pledge full faith and credit on payment of interest and principal under certain conditions

f. Lake Board may accept special grants in aid and gifts for carrying out projects

g. Bids for work done shall be advertised and contracts placed with lowest bidder giving adequate security
   1. Contracts without bids may be placed with local, unincorporated non-profit homeowners association providing performance security is provided.
      a. Work may be done as a work relief project

h. Lake Board within 10 days of contract letting must assemble all project costs including inspections, work done, notices, potential court and appeal costs, bond interest for first year, fees and compensation and 10 to 15% contingency expenses and present as total project cost to be assessed and recovered.

NUTRIENT BUDGET CALCULATIONS

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 dry-fall alone may account for 70-90% of the total load (Heany & Sullivan, 1971; Chapin & Uttormark, 1973).

The atmospheric fallout loading estimate for Meadow Lake was derived from lakes of similar geography and climate.

Data Used to Estimate the Atomospheric Input of Phosphorus

Atmospheric Loading (kg/ha/yr)	Geographic Location	Reference
.390	Lobdell Lake Genesee Co., MI	Rodiek, 1979
.332	Gull Lake Kalamazoo Co., MI	Tague, 1977
.310	Houghton Lake Roscommon Co., MI	Richardson & Merva, 1976
Mean = .34 kg/ha/yr		

Septic Phosphorus Loading

Soils*

Soil Type	Number of Residents per Soil Type**
Oshtemo/Boyer	12
Spinks	3
Aquents	19
	34 Total

* Source: Soil Survey of Oakland County (Soil Conservation Service, 1980).

**Only residences directly abutting the lake were counted in this analysis.

Soil Efficiency Rating for Immobilizing Phosphorus From Septic Systems*

Drainage	Phosphorus Adsorption Capacity ($kg \times m^{-3}$)	Retention Coefficient (R.C.)	Fraction of Phosphorus not Retained by Drainfield Soil (1 - R.C.)
Good	High - Very High $1.76 \times 10^{-1} - 2.40 \times 10^{-1}$	0.75	0.25
Good	Medium $1.40 \times 10^{-1} - 1.76 \times 10^{-1}$	0.55	0.45
Good	Low - Very Low $1.20 \times 10^{-1} - 1.40 \times 10^{-1}$	0.35	0.65
Poor	High - Very High $1.76 \times 10^{-1} - 2.40- \times 10^{-1}$	0.65	0.35
Poor	Medium $1.40 \times 10^{-1} - 1.76 \times 10^{-1}$	0.45	0.55
Poor	Low - Very Low $1.20 \times 10^{-1} - 1.40 \times 10^{-1}$	0.25	0.75

*Schneider & Erickson, 1972; Ellis & Childs, 1973.

Phosphorus Loads for Household Wastewater Discharged to Septic Systems (kg/capita/yr)

Total Phosphorus	Reference
1.49	Ligman et al., 1974
1.43	Laak, 1975
.74	Chan et al., 1978
1.59	Ellis & Childs, 1973
1.49	Siegrist et al., 1976
3.00	Bernhard, 1975
.80	Otis et al., 1975
1.28	EPA-NES, 1974

Mean = 1.4775
Standard Deviation = ±0.694

The steps involved in calculating the phosphorus load from septic systems to Meadow Lake are as follows:

Step 1 - Estimate annual per capita phosphorus input to septic systems.

The mean discharge of phosphorus to septic systems was equal to 1.4775 kg/capita/yr (±0.694). It is estimated that detergent-based phosphorus accounts for approximately 50% of the total phosphorus in domestic wastewater (Sawyer, 1962; Rodiek, 1979). Using this data, the per capita phosphorus input to septic systems was estimated to be:

.50 x 1.4775 = 0.74 kg/capita/yr

Step 2 - Estimate annual phosphorus loading per residence.

.74 kg/capita/yr x 3.0 capita/residence x .60 occupancy = 1.3 kg/residence/yr

Step 3 - Calculate annual septic phosphorus contribution to Meadow Lake.

Soil Series	Drainage	P-Adsorp*	(1-RC)**	Residences/ Soil Type	Load to Septic	P-Load Soil Type
Oshtemo/Boyer	Good	Low	.65	12	1.3	10.14
Spinks	Good	Medium	.45	3	1.3	1.75
Aquents	--	--	.50***	19	1.3	12.35
TOTAL						24.27

* Schneider & Erickson, 1972.
** Fraction of phosphorus not retained by drainfiled soil.
*** Assumed Values.

LAKEFRONT LAWN CARE

Excessive lawn fertilization has been identified as a major source of nutrient loading to Meadow Lake. The plant nutrients found in most commercial fertilizers are nitrogen, phosphorus and potash. Phosphorus is the nutrient of primary concern since phosphorus is the nutrient which most often stimulates unwanted aquatic plant growth in lakes. Generally, most soils contain sufficient phosphorus to maintain a good grass cover and applying additional phosphorus saturates the soil allowing phosphorus to wash into the lake.

Many fertilizer distributors and commercial applicators market fertilizer mixtures which contain no phosphorus. Lakefront property owners should pay special attention to the type of fertilizer used and avoid mixtures which contain excess phosphorus.

Lakefront property owners can have their soil tested to determine which nutrients the soil may need. Contact you local Michigan State University Cooperative Extension Service office for instruction on how to package and mail your soil sample.

The following practices will help reduce nutrient losses from lakefront lawns:

1. If you are establishing a lawn, plant fescue rather than bluegrass. Fescue grass requires much less fertilizer.

2. Do not use fertilizer containing phosphorus or potash unless a soil test specifically indicates a need for these nutrients.

3. Use the smallest amount of fertilizer necessary to maintain a good grass cover. Fertilize in the spring or early summer using a small amount of a soluble form of nitrogen (urea, ammonium nitrate or ammonium sulfate). The principal is to fertilize while the lawn is actively growing and can utilize the fertilizer. This will reduce the amount of undissolved fertilizer washing into the lake.

4. Water sparingly to avoid washing or leaching nutrients into the lake.

5. On lightly fertilized lawns, thatch probably will not need to be removed. It will decompose and provide part of the nutrients needed by the lawn.

6. In the fall, rake and dispose of leaves away from the lake (compost if possible). Do not burn leaves near shore. Nutrients concentrate in the ash and are easily washed into the lake.

7. Do not cut lawn too close. Cutting height should be 2 to 2-1/2 inches so adequate green area remains on turf. Do no allow grass clipping to enter the lake.

8. Avoid using herbicides near the lake (many are toxic to aquatic life).

GREENBELT LANDSCAPING

Greenbelt landscaping involves planting or preserving a zone of natural vegetation around the lake's edge. This vegetation acts as a buffer trapping runoff and absorbing nutrients (through vegetative uptake) before they can enter the lake.

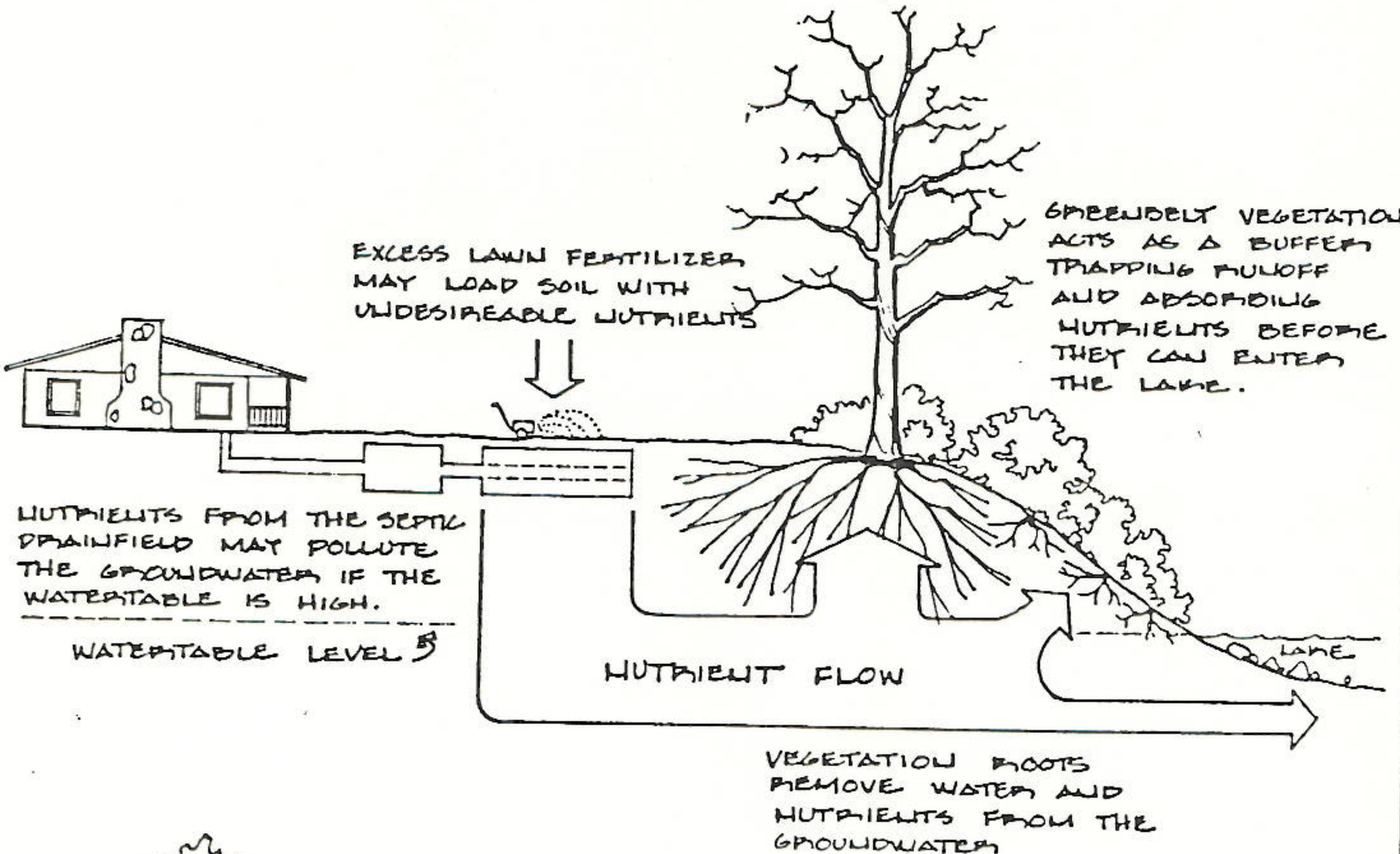
The lakefront should be landscaped so as to allow full recreational use of the lake and still provide protection. Lawns alone do not make good greenbelts. Plant varieties should be selected which are attractive, easily maintained, and effective buffers.

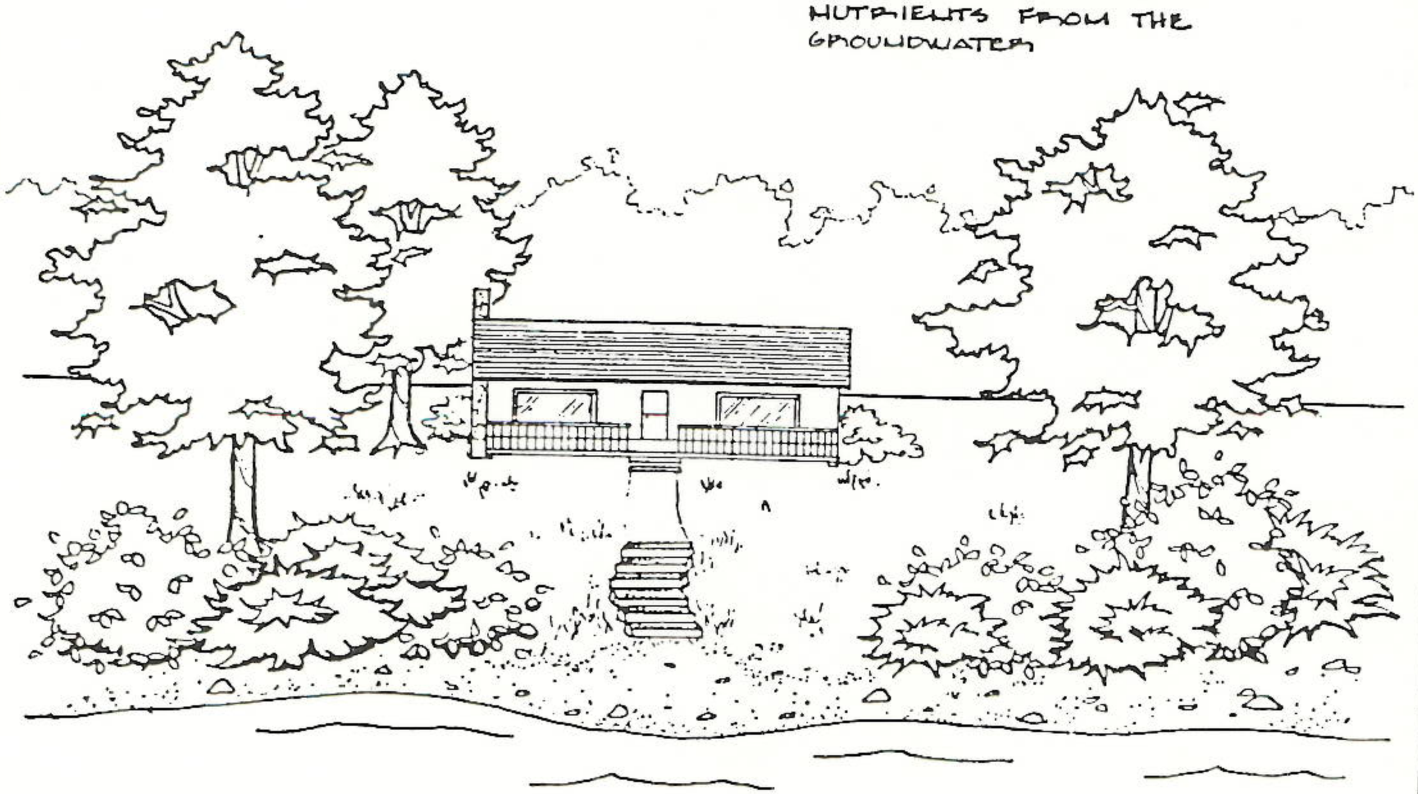
Some greenbelt varieties native to the area include:

Groundcovers	Periwinkle or Myrtle	
	Snow-on-the-Mountain	
	Pachysandra	
	Crown Vetch	
Trees and Shrubs	Honeysuckle	Red Oak
	Autumn Olive	White Oak
	Mock Orange	Birch
	Crabapple	Beech
	Viburnum	Tamarack
	Forsythia	Cedars
	Serviceberry	Quacking Aspen
	Lilacs	American Sycamore
	Wild Rose	Basswood
	Ninebark	Red Maple
	Autumn Olive	Sugar Maple
	Rosebud	Silver Maple
	Rose of Sharon	Ash
	Common Privet	Red Pine
	Gray Dogwood	White Pine
	Junipers	Balsam Poplar
	Cottoneaster	Black Locust

In order to minimize the amount of leaves falling into the water, deciduous trees and shrubs should only be used on the leeward side of the lake (the side opposite the direction of the prevailing winds). Evergreens can be established on the windward side of the lake.

GREENBELT LANDSCAPING





THE LAKEFRONT SHOULD BE LANDSCAPED SO AS TO ALLOW FULL RECREATIONAL USE OF THE LAKE AND STILL PROVIDE PROTECTION. PLANT VARIETIES SHOULD BE SELECTED WHICH ARE ATTRACTIVE, EASILY MAINTAINED AND EFFECTIVE BUFFERS.

SEPTIC SYSTEM MAINTENANCE

A typical septic system consists of two working parts: the septic tank and soil adsorption field (most commonly a drainfield). Wastes from the home flow into the septic tank where the settling of solids occurs. The liquid effluent from the septic tank, carrying bacteriological and nutrient pollutants, is discharged into the soil adsorption system. Here the wastewater is further purified by soil filtration and biological decomposition.

Many factors influence the efficiency at which a lakeside septic system accepts and treats incoming wastewater. These include soil type, depth of water table, age of system, type of system, number of people using system and proximity of the system to the lake. The following practices may help prolong the life and efficiency of your septic system.

- Know the location of your septic tank and drainfield.
- Avoid putting harmful materials such as bleach, drain cleaners, strong cleaning agents, chemicals, paint, oils, solvents, coffee grounds, etc., into your septic system. These materials can kill beneficial micro-organisms and cause the system to back up or fail.
- Do not put materials into system which are not easily broken down and decomposed (cigarette butts, kleenex, band aids, paper towels, hair, grease, fat, etc.)
- Do not put water softener waste brine into septic system.
- Do not use kitchen garbage disposal unit, ground up garbage burdens septic tank.

- Avoid use of chemical additives. Many additives allow organic material from your tank to flow into your drainfield increasing the potential for failure.
- Check sludge level in tank every two years. Have it pumped out if sludge level exceeds 1/3 of tank volume or is within 18 inches of outlet pipe. This will prevent solids from entering and clogging drainfield.

Drainfields function best when the surrounding soil is porous. Practices which compact or saturate the soil around the drainfield should be avoided.

- Do not allow downspouts to drain onto or into your drainfield.
- Do not cement or build (driveways, patios, etc.) over a drainfield.
- Do not fertilize the soil above the drainfield.
- Keep automobiles and heavy vehicles away from drainfield.
- Do not stockpile soil or snow over drainfield.
- Water lawn sparingly and avoid saturating drainfield.
- Avoid planting trees or shrubs whose roots may clog drain tiles.
- Grass cover and shallow rooted plants are beneficial over the drainfield.

Conserve water; the less water you use, the better your septic system will function.

- Take showers instead of baths.
- Repair dripping faucets and toilet leaks.
- Use washing machine and dishwasher only when you have a full load.
- Use water saving devices: flow control shower heads, faucet aerators, low flush toilets, toilet tank dams, sud saving or front loading washing machines, etc.

WATER QUALITY DATA

pH is a measure of alkalinity or acidity. The pH scale ranges from 0 (acidic) to 14 (alkaline) with neutrality at 7. The pH of lakes generally ranges from between 6 to 9 in calcareous hard water lakes of southern Michigan (SEMCOG 1978). The concentration of gases, such as oxygen and carbon dioxide, directly influence pH.

In the absence of oxygen, lake water tends to become slightly more acidic due, in part, to the build up of carbon dioxide from bacterial respiration. Carbon dioxide reacts with water to form carbonic acid, a weak acid, which increases the acidity of the water and lowers the pH. This phenomenon can be observed on Meadow Lake where the pH of the oxygen deficient bottom waters was lower than the surface waters.

Nitrogen exists in numerous forms in fresh water. Ammonia nitrogen and nitrate are the forms commonly utilized by aquatic plants for growth. Organic nitrogen is bound in living organisms.

Nitrogen inputs are difficult to control because of its natural abundance in the atmosphere and groundwater. As phosphorus loading to fresh waters increases and lakes become more productive, nitrogen becomes more important as a growth limiting nutrient.

Alkalinity is the measure of the buffering capacity of water in that it is the quantitative capacity of water to neutralize a strong acid to a designated pH. It is a function of the pH and a measurement of a variety of compounds such as carbonates, bicarbonates and hydroxides.

Alkalinity can give an indication of hardness for water supply and fishery purposes. Generally, lakes with low alkalinity (less than 10 mg/l $CaCO_3$) are called soft water lakes and those with a high alkalinity (greater than 100 mg/l $CaCO_3$) are called hard water lakes (SEMCOG, 1978).

The problem of acid rain or more accurately acid deposition (both wet and dryfall) and its affect on lake water quality has achieved much media attention in recent years. The sensitivity of a lake to acid deposition is governed to a large extent by the buffering capacity of the lake which, in turn, is dependent on lake alkalinity. The alkalinity of Meadow Lake is sufficiently high to protect the lake and acid deposition at present levels should not adversely impact the lake.

Specific conductance is a measure of dissolved ions in water. Sewage and chloride loading can increase lake conductivity. Eutrophic and mesotrophic lakes will often have a greater concentration of dissolved substances in the oxygen deficient bottom waters during periods of thermal stratification and thus will exhibit increased conductivity. This can be clearly seen in Meadow Lake where the conductance of the surface waters measured 600 umhos/cm and the conductivity of the bottom waters was 680 umhos/cm.

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES
WILDLIFE DIVISION
LANSING, MICHIGAN 48909

Information Circular No. 185
April 16, 1979

NUISANCE CANADA GEESE

by
Marvin K. Johnson

Flocks of nesting Giant Canada geese (Branta Canadensis maxima) occur throughout Michigan. The largest flocks are found in southern Michigan (Region III) in the populated urban areas. Some flocks are also found in the Upper Peninsula (Region I) and in the northern Lower Peninsula (Region II) near urban centers or lakeshore developments. As local goose populations have grown, and as more people have moved into the areas frequented by the birds, problems and conflicts have resulted. Geese often come in conflict with people because they leave droppings when they feed on lawns and golf courses and loaf on docks, swimming rafts and beaches. Some of the problems are intensified when goose populations reach artificially high levels due to hunting closures and because artificial feeding programs are engaged in by well-meaning local people.

The Department of Natural Resources will assist property owners in alleviating some of the problems caused by concentrations of nuisance Canada geese. The following procedures have been established to facilitate the orderly handling of goose complaints.

1. All complaints involving resident Canada geese are to be referred to the appropriate district wildlife biologist.

   Region III - District 9, Grand Rapids (616-456-5071)
   District 11, Imlay City (313-724-2014)
   District 12, Plainwell (616-685-6851)
   District 13, Jackson (517-784-3188)
   District 14, Pontiac (313-666-1500)

   The nearest conservation officer or DNR field office can also assist you in making this contact in Region III or in Regions I and II. The district wildlife biologist or his designated representative will make an on-site field inspection to determine the cause and extent of the problem.

2. If artificial feeding is determined to be the cause of the problem, the district wildlife biologist will request in writing that all feeding cease before any further action is taken by the DNR.

3. If the problem continues after artificial feeding has ceased or if the problem is caused by factors other than artificial feeding, control techniques such as scaring may be employed. District wildlife personnel will coordinate the use of scare tactics if this alternative is deemed necessary.

4. If cessation of feeding and use of scare techniques fail to solve the problem, geese may be trapped and removed subject to the following conditions: (Contact the district wildlife biologist as soon as possible with your intent in order to help in planning as late application may have to wait for another year.)

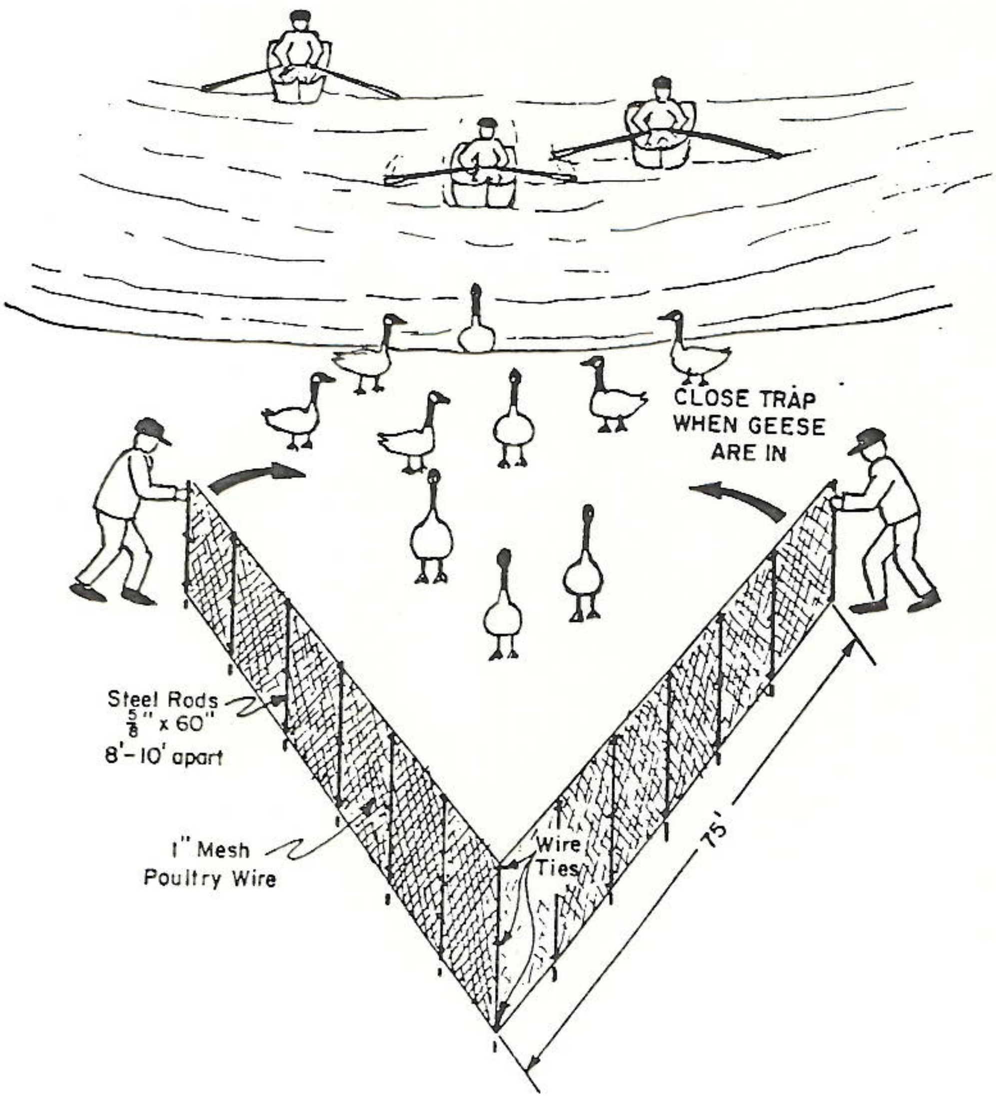
   a. Seventy (70) percent of the property owners surrounding the body of water or wetland or a local unit of government may, by petition, ask the DNR to remove the geese. This petition is to be submitted to the district wildlife biologist.

   b. Property owners, through a designated spokesperson or lake association or unit of government, must agree to construct and locate a trap that meets DNR specifications. This is to be submitted in writing along with the petition to the district wildlife biologist. It will be up to the lake association or governmental unit to supply all trap materials, boats, motors and enough personnel to set up the trap and carry out the round-up operation. Department personnel will provide advisory assistance on trap site selection, trap set up and personnel to catch and crate birds for transport <u>after</u> they have been trapped.

A trapping program will usually occur in late June or early July at a time when the geese are flightless, adults having moulted their wing feathers and young goslings not yet having developed these flight feathers. Geese that are captured in this program will be transported by DNR personnel and equipment to other sites. Birds will be used for restocking purposes in Michigan and other states in the Mississippi Flyway. Small numbers of the geese will have been previously marked with leg bands or colored neck collars as part of biological studies. These may be released back on site immediately to avoid disruption of these study programs. Geese to be removed will have their new growing flight feathers pulled at the time of trapping to render them flightless for a longer period of time in their new home. These flight feathers will be renewed by each bird before fall and will allow the goose to fly away in the fall migration.

The actual trapping of these resident flocks is usually quite simple and very successful on the <u>first</u> attempt. Detailed instructions will be furnished by the visiting biologist including a description of of the trap needed (see attached illustration). Loafing sites on the lake shore such as lawns or beaches make good trap sites. A trap is constructed from materials such as steel rods, chicken wire or snow fence. The trap is placed on dry land. Leads to the water are extended from the trap and the birds are then herded into it. The ends of the leads are closed on the geese and the job is done. Materials needed for one trap include: one roll (150 feet) of 1" heavy duty poultry mesh wire or snow fence (36"-48") high, 15-18 steel reinforcing rods, 5/8" in diameter and 60" long and sharpened on one end, a sledge hammer for driving stakes into the ground and some light baling or mechanic's wire for fence repair and closing the trap.

A reminder: The maximum time available to complete the trapping is short (four weeks) so all planning, petitions, trap construction, etc. must be done well in advance of June 20. Schedule for removal of the geese will be made by the order of completed applications and preparations.



TYPICAL GOOSE TRAP

PLACEMENT AND DRIVE

D. Armstrong, 4/79
Wildlife Div.

Meadow Lake Fish Survey

At the request of Progressive Engineering, I conducted a survey of the Meadow Lake fish population during October 12-13, 1985. The survey consisted of two nights of netting with three experimental gill nets and seining the shoreline with a 30 foot minnow sein. The gill nets were 125 feet long with five 25 foot sections each of a different mesh size. These nets are designed to collect a sample of various species and sizes of fish. The sein collects mostly minnows and young-of-the-year fish inhabiting the shoreline.

I found a very limited species distribution of fish in Meadow Lake. Most Michigan lakes support 15 to 20 species of fish. I collected only two species of sunfish (pumpkinseed and green sunfish), largemouth bass, and goldfish. It is possible that other species do reside in the lake since some are not readily caught in gill nets. However, it is doubtful that any other species are abundant. I would expect to take minnows with the sein if any were present.

A few scales were taken from each fish caught in the nets. We can determine the age of fish from growth rings on the scales similar to reading the age of a tree. The following table shows the average size of Meadow Lake fish compared with the average sizes of fish throughout Michigan.

Species	Ages and size(inches)						
Pumpkinseed sunfish	0	1	2	3	4	5	6
Meadow Lake		-	-	4.4	5.4	6.5	6.9
State average		-	-	5.2	5.9	6.4	6.9
Green sunfish							
Meadow Lake		-	-	4.5			
State average				4.7			
Largemouth bass							
Meadow Lake	6.1						
State average	3.6						

The sunfish are mostly growing close to the state average, and the young-of-the-year largemouth bass are growing much faster than state average. The fish present in the lake are thus growing at a satisfactory rate. However, the lake does not have a satisfactory fish population for sport fishing. The sunfish species present are not satisfactory and bass reproduction seems very limited. I only caught young-of-the-year bass, and I should have expected to catch two or three year classes.

Bluegill would be a more satisfactory panfish than the species present. They could be introduced into the lake with the existing population, but would maintain a more desirable growth rate if they were the only sunfish species present.

There are several possible causes of the limited largemouth bass reproduction. An overabundant sunfish population can inhibit bass reproduction by eating eggs and fry. The dense mat of Chara covering almost the entire lake bottom could also be a factor by limiting areas for spawning. Goldfish also eat eggs however I don't feel that they are abundant.

My recommendations for managing the fish population of Meadow Lake are as follows.

1. If there is sufficient interest among the residents in attempting to develop a fishable population, I feel that we should eliminate the entire population and restock the lake with largemouth bass and bluegills. We have developed a technique of poisoning fish under the ice during winter that eliminates most of the undesirable attributes of fish poisoning. No fish pick-up is necessary since they disappear under the ice before spring. There would be no damage to the lake from allowing the fish to decay away. Many fish die from natural causes in all lakes every year.

2. If the population is not eliminated we should stock bluegill and attempt to enhance the bass population. All bass fishing should be eliminated for two years and then bass larger than 14 inches should voluntarily be returned to the lake. These large bass will promote reproduction and also control numbers of bluegills and sunfish. Smaller bass are not efficient predators.

3. Periodically a few tiger musky or walleye could be stocked in the lake. Neither of these would reproduce , but survival of just a few could produce exciting fishing and help control numbers of panfish.

4. The lake is seriously over-enriched by geese frequenting the lake and lawns. This enrichment is the cause of excessive plant and algae growth which is smothering fish habitat.

I would be willing to assist with any of the above management programs. I will need your calculations of lake volume in order to determine the cost of fish removal. I really believe that Meadow Lake could produce a satisfactory sport fishery. Fishing pressure would probably never be excessive, and thus we should be able to manage the fish population.

James W. Merna

REFERENCES

Bernard, A.P. 1975. Return of Effluent Nutrients to the Natural Cycle Through Evapotranspiration and Subsoil-Infiltration of Domestic Wastewater; In: Proc. National Home Sewage Symposium, ASE, p. 175-181.

Bureau of Census Data. 1980. Summary Characteristics for Governmental Units and Standard Metropolitan Statistical Areas for Michigan.

Chan, H.T. 1978. Contamination of the Great Lake by Private Wastes; PLUARG Technical Report Series, p. 269.

Chapin, J.D. and Uttormark, P.D. 1973. Atmospheric Contributions of Nitrogen and Phosphorus; University of Wisconsin Water Resources Lab., Madison, Wisconsin, p. 35.

Chapra, S.C. and Reckhow, K.H. 1979. Expressing the Phosphorus Loading Concept in Probabilistic Terms. J. Fish. Res. Board of Canada. 36(2):225-229.

Dillon, P.J. and Rigler, F.H. 1975. A Simple Method for Predicting the Capacity of a Lake for Development Based on Lake Trophic Status. J. Fish Res. Board of Canada. 32(9):1519-1531.

Ellis, B., and Childs, K. 1973 Nutrient Movement from Septic Tanks and Lawn Fertilization; Tech. Bull. 73-5 Department of Natural Resources, Lansing, Michigan.

Heany, J.P., and Sullivan, R.H. 1971. Source Control of Urban Water Pollution; J. Water Poll. Contr. Fed. 43(4), p. 571-578.

Laak, R. 1975. Relative Pollution Strengths of Undiluted Waste Materials Discharged in Households and the Dilution Waters Used for Each; Manual of Grey Water Treatment Practice - Part II, Monogram Industries Inc., Santa Monica, California.

Ligman, K., Hutzler, N., and Boyle, W.C. 1974. Household Wastewater Characterization. J. Env. Div., ASCE, 150(EEI), p. 201-213.

Michigan Department of Natural Resources. 1983. Inland Lake Self-Help Program.

National Academy of Science and National Academy of Engineering, 1972. Water Quality Criteria. A report of the Committee on Water Quality Criteria, Washington, D.C.

National Biocentric, Inc. 1978. Southwest Michigan Inland Lake Watershed Study; SMRPC, St. Joseph, Michigan.

Otis, R. J. Boyle, W.C., and Suer, D.K. 1975. The Performance of Household Wastewater Treatment Units Under Field Conditions. Proc. National Home Sewage Disposal Symposium, ASAE, p. 191-201.

Reckhow, K.H., Beaulac, M.N., and Simpson, J.T. 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients; EPA 440/5-80-011.

Rodiek, R.K. 1978. Some Water Analysis Tools for Lake Management; In: Lake Restoration; EPA 440/5-79-001.

Sawyer, C.N. 1965. Problems of Phosphorus in Water Supplies; J. AWWA, 57:1431.

Schneider, I.F., and Erickson, A.E. 1972. Soil Limitations for Disposal of Municipal Waste Waters; Research Report 195., Michigan State University, East Lansing, Michigan.

Siegrist, R.L. 1977. Waste Segregation to Facilitate Onsite Wastewater Disposal Alternatives. Proceedings of the Second National Home Sewage Treatment Symposium, Chicago, December 12-13.

Soil Conservation Service. 1980. Soil Survey of Oakland County, Michigan. USDA-SCS.

Southeast Michigan Council of Governments. 1978. Water Quality in Southeast Michigan: Inland Lakes.

Tague, 1977. The Hydrological and Total Phosphorus Budgets of Gull Lake, Michigan; An unpublished thesis from Michigan State University.

Wetzel, R.G. 1983. Limnology, 2nd Edition. Saunders College Publishing, Philadelphia.