LONG LAKE WATERSHED MANAGEMENT PLAN

LONG LAKE WATERSHED

NONPOINT SOURCE POLLUTION PROJECT

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Prepared for:

The Long Lake Watershed Partnership

Prepared by:

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Traverse City, Michigan 49686

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Long Lake Township

Long Lake Association

Long Lake Foundation

Long Lake Partnership Participating Organizations

Long Lake Township
Grand Traverse County Drain Commissioner's Office
Long Lake Association
Grand Traverse Conservation District
Grand Traverse County Board of Commissioners
Conservation Resource Alliance
Grand Traverse County Road Commission
Long Lake Foundation
Grand Traverse Regional Land Conservancy
Leelanau Conservancy
MDEQ-Surface Water Quality Division (Cadillac Office)
Grand Traverse County Planning Department
Grand Traverse County Health Department
Friends of Bullhead Lake
Green Lake Township
New Designs for Growth
Leelanau County Drain Commissioner's Office
Grand Traverse County Regional Community Foundation
Long Lake Peninsula Association
Forest Lodge Association
Platte Lake Association
Traverse City Area Chamber of Commerce
Traverse City West High School
Garfield Township
Long Lake Elementary School
Pinewood Point Subdivision
Eastwood Shores Association
Grand Traverse Audubon Society

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LONG LAKE WATERSHED MANAGEMENT PLAN

1.0 INTRODUCTION

The Long Lake watershed is situated in the western portion of Grand Traverse County, located approximately seven miles southwest of Traverse City (Figure 1). The predominant feature of the watershed is Long Lake, which is almost completely situated in Long Lake Township, with the southernmost tip in Green Lake Township. Long Lake is a high quality lake. The Long Lake Watershed attracted industry (primarily logging in the mid to late 1800's) and agricultural use during the early settlement era. Because of the beauty of the lake and the surrounding region, the watershed and lake have served as a focal point of residential development during the latter part of the 1900's. Unfortunately, with increased urbanization within the watershed, there has been an increase in pollutants over time including nutrients, which have impacted the lake. Despite the increasing nutrient loads, the lake remains relatively clean and in good condition from an aesthetic, ecological and recreational perspective.

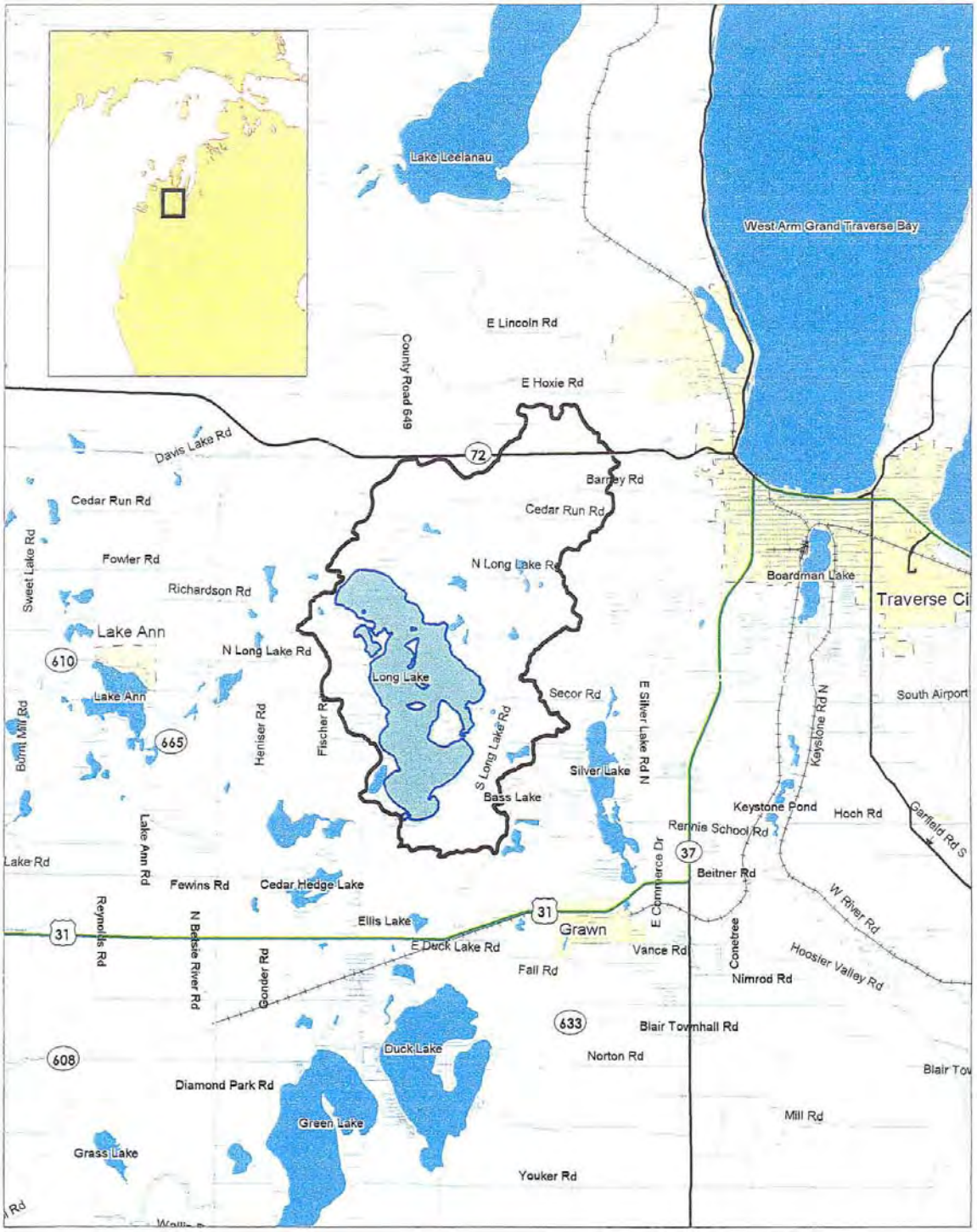
The process of eutrophication is defined as the general increase in the biological activity and content in a lake over time. Every lake, left to natural processes, will slowly change over hundreds to thousands of years from a clean, high quality lake with a low biological state to a high nutrient content, high biologically productive lake (essentially a "bog"). The purpose of lake management is to limit the rate of conversion, or at a minimum to not accelerate this process in any way. Lakes, such as Long Lake, which are very high quality with low levels of nutrients are termed "oligotrophic" while lakes which have high levels of nutrients, algae and aquatic plants are termed "eutrophic."

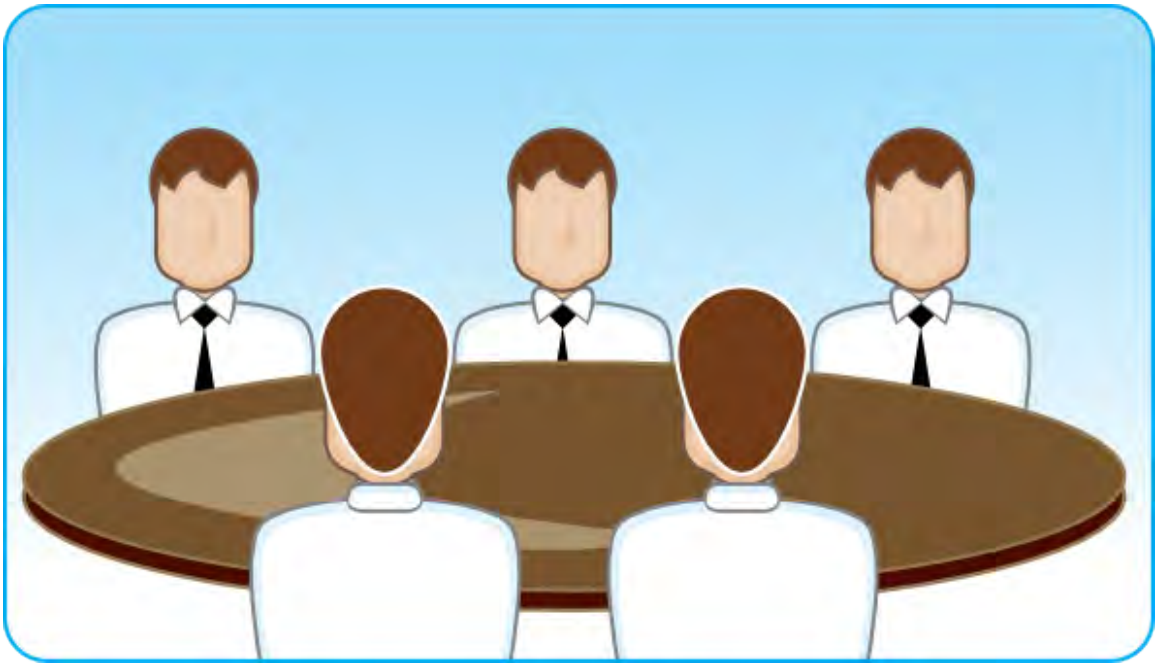
The primary difficulty associated with pollutant and nutrient input to Long Lake is that most of the sources of these compounds are *non-point* sources, i.e. sources that are not easily identified, are more general in character, and are therefore difficult to control. Because control measures are not easily implemented, it is important to utilize a watershed-wide approach to prioritize, plan and implement appropriate measures to maintain and improve water quality in Long Lake and throughout the watershed. Urbanization, recreational activities and agricultural land uses within the Long Lake watershed have the potential to impact water quality through increased nutrient and pollutant loading via storm water runoff and non-point source inputs. The protection of Long Lake's water quality is critical to maintain the current residential and recreational quality of life as well as to maintain the wildlife, wetland and integral ecological resources within the watershed.

Purpose of the Study

The development of the Long Lake Watershed Management Plan was initially a component of the larger study, the "Long Lake Watershed 319 Nonpoint Source Pollution Project," which was funded through the Michigan Department of Environmental Quality (MDEQ) in 2000. The overall objective of this program was to assess all current and potential water quality impairments within the watershed, and to provide a management framework, the Watershed Management Plan, which would address each of the identified concerns. The ultimate goal was to maintain the ecological and environmental integrity of the watershed for the future generations. The current update was also funded by the MDEQ in 2008.

Figure 1. Location of the Long Lake Watershed in Northwestern Michigan





2.0 PROJECT PLANNING/PUBLIC PARTICIPATION

The Long Lake Watershed Management Plan is an effort which exemplifies a cooperative partnership between citizen stakeholders, local organizations and public municipalities, leading to a planning effort to assess and improve the environmental conditions in the watershed.

2001 Project Planning and Implementation

The initial Long Lake Watershed Management Plan, completed in 2001, was funded in part by a grant from the Michigan Department of Environmental Quality 319 program, in conjunction with Grand Traverse County, Long Lake Township, the Long Lake Association, Long Lake Foundation and the Oleson Foundation. The project was coordinated jointly by the Grand Traverse County Drain Commissioner's Office and Long Lake Township and the Long Lake Association. In order to accomplish many of the technical monitoring aspects of the grant, Great Lakes Environmental Center (GLEC) was contracted to complete comprehensive lake monitoring, coordinate the development of a static nutrient/hydrologic model with Dr. Raymond Canale, Professor Emeritus, University of Michigan, and to draft the initial Watershed Management Plan.

In the summer of 1999, local organizations were invited to participate in the planning process, and eventually a Long Lake Partnership Agreement was drafted and signed by participants. The Conservation Resource Alliance (CRA) was contracted to coordinate and implement a partnership agreement among identified watershed stakeholders. The CRA has found that partnerships bring together the diverse interests needed to prioritize and implement long-term protection and restoration projects on a watershed basis. By its nature, a partnership facilitates open discussions, and fosters cooperation among watershed residents, users and managers. Partnerships accomplish what no single organization can achieve. The list of partnering organizations is as follows:

Long Lake Township

Grand Traverse County Drain Commissioner's Office

Long Lake Association

Grand Traverse Conservation District

Grand Traverse County Board of Commissioners

Conservation Resource Alliance

Grand Traverse County Road Commission

Long Lake Foundation

Grand Traverse Regional Land Conservancy

Leelanau Conservancy

MDEQ-Surface Water Quality Division (Cadillac Office)

Grand Traverse County Planning Department

Grand Traverse County Health Department

Friends of Bullhead Lake

Green Lake Township

New Designs for Growth

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Long Lake Peninsula Association

Forest Lodge Association

Platte Lake Association

Traverse City Area Chamber of Commerce

Traverse City West High School

Garfield Township

Long Lake Elementary School

Pinewood Point Subdivision

Eastwood Shores Association

Grand Traverse Audubon Society

The Long Lake partnership agreement has the potential for providing many benefits. It can result in efforts to improve water quality and fish and wildlife habitat in the watershed for generations to come, because it establishes a framework and forum to prioritize and establish practical, ongoing watershed-based restoration activities. The pooling of technical and financial resources capitalizes on the strengths and engages the interest of all parties, encourages cooperative projects and information sharing, helps predict unforeseen problems, leverages funding from multiple sources and more

effectively and efficiently implements strong protection/restoration projects within the community. Partnerships amplify the efforts of any single organization.

Representatives of these organizations participated in initial meetings in the spring of 2000 or were asked to provide information relevant to developing goals and objectives for the Management Plan, as well as for guiding monitoring efforts by GLEC. These planning meetings focused on educating participants on the value of developing a Watershed Management Plan, and soliciting input regarding water quality concerns, desired uses and overall management objectives. A smaller steering committee, consisting of members from the Long Lake Association, Long Lake Township and the Grand Traverse County Drain Commissioner's office, conducted meetings approximately once per month to discuss the ongoing monitoring efforts and development of the watershed plan. A number of partnering organizations, including the Grand Traverse Conservation District, the Grand Traverse Regional Land Conservancy, the Grand Traverse Health Department and Traverse City West High School participated in specific projects which provided additional assessments used in the watershed plan.

At the completion of the development of the Watershed Management Plan, the suggested monitoring, remediation and educational activities were largely coordinated by the Long Lake Association and Long Lake Township. Ongoing monitoring on Long Lake has continued since 2001 and includes a variety of assessments aimed at maintaining the water resources of Long Lake and its watershed. These assessments are included in Chapter 4, Monitoring and Source Inventories.

2009 Watershed Management Plan Update

In 2008, Long Lake Township began the process of updating the Long Lake Watershed Management Plan. Because of continued ongoing watershed and lake monitoring initiated by the Long Lake Association, and their close relationship to the development of the 2001 Watershed Management Plan, guidance for the 2009 update was provided primarily by Long Lake Township and the Long Lake Association. Meetings and planning sessions were held, as needed, during the Plan update process. The Watershed Management Plan Goals were transmitted to each of the partnering organizations from the 2001 planning process, and comments were solicited regarding revisions to the goals, their relevance to current conditions, and a prioritization of

objectives and goals for the 2008 update. Those comments received were incorporated into this revision to the Management Plan. In addition, Long Lake Township and the Township Planner provided invaluable guidance and insight for this plan update. Finally, the Michigan DEQ, Cadillac Office Technical Staff, also helped guide and correct inconsistencies in the content and format of the Management Plan Update.

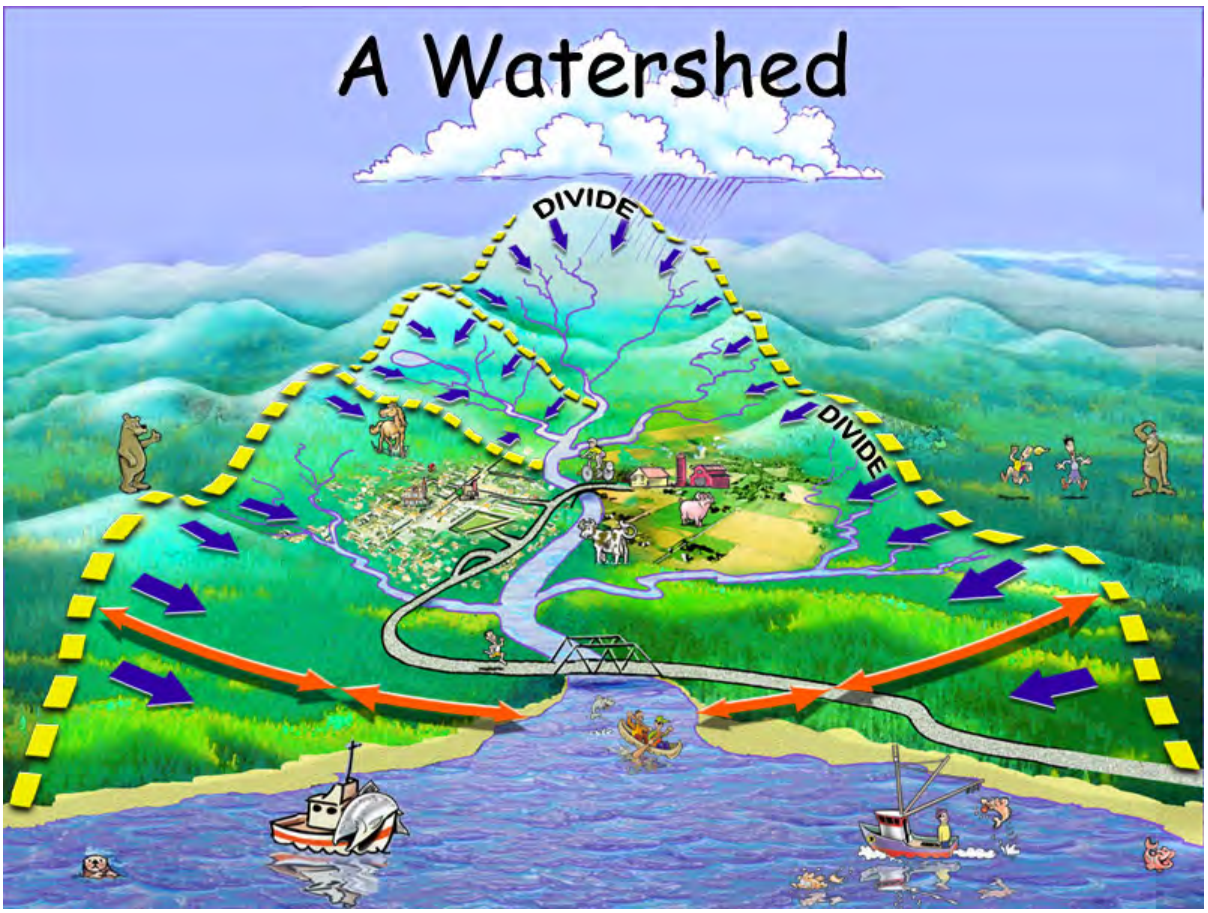


Illustration from County of San Mateo, CA Recycle Works

3.0 WATERSHED DESCRIPTION

The Long Lake Watershed consists of an area of approximately 22.6 square miles (14,435 acres) situated within Grand Traverse County and a small portion of southern Leelanau County (Figure 2). The majority of the watershed lies within Long Lake Township, and also encompasses portions of Green Lake, Garfield, Solon and Elmwood Townships. The predominant feature of the watershed is Long Lake (Figure 2), which has a surface area of approximately 3,040 acres (4.68 square miles), and has 16.7 miles of shoreline. Long Lake is primarily spring-fed with no principal inlet tributaries; there is a single outlet at the extreme southern extent of the lake. The lake is currently classified as oligotrophic, with a relatively sparse population of aquatic plants.

Topography

Long Lake watershed lies primarily within Long Lake Township, with small portions extending north into Solon and Elmwood Townships, east into Garfield Township and south into Green Lake Township (Figure 2). The watershed covers roughly 70% of Long Lake Township. The east edge of Long Lake Township lies approximately along the drainage division between Lake Michigan and the West Arm of Grand Traverse Bay. The prevailing topography varies from nearly level to very steep, with maximum slopes of 20% (Nab, 1987). Ground elevations vary from 840 to 1,115 feet above sea level, with Lake Michigan at 580+ feet. Long Lake lies at approximately 846+ feet above sea level. The highest slopes are found along the northeast and east sides of the lake which could contribute to greater surface water runoff during high volume precipitation events.

Soils

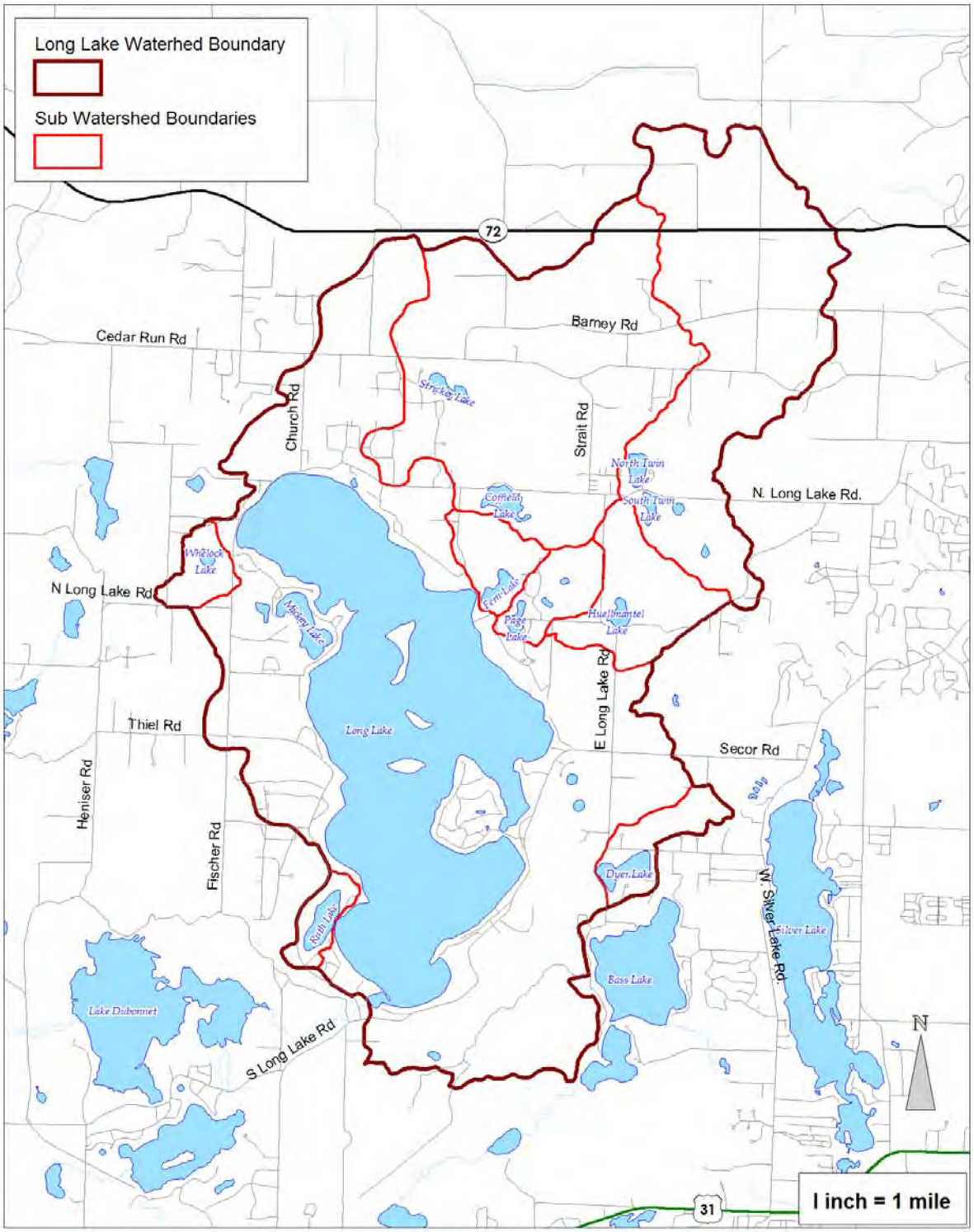
A soil survey of Grand Traverse County was analyzed by Nab in 1987 (Appendix A) and indicates that there are three principal soil types within the Long Lake watershed. They are Rubicon sand around the south end of the lake, Kalkaska sand on the west and north sides of the lake and Emmet-Kalkaska sands on the east side of the lake.

The hydrologic properties of a soil are a critical factor in determining the surface water hydrology of a watershed. Soils are classified into four major groups (Groups A-D) based on runoff potential (ordered from low to high). Nab (1987) has provided an excellent description of these soils The U.S. Natural Resource Conservation Service lists all three of the soils in the Long Lake watershed basin as Group A, which has the lowest runoff potential.

Group A – Low Runoff Potential

Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of sands or gravel; they are deep and well to excessively drained. These soils have a high rate of water transmission.

Figure 2. Detailed local view of the Long Lake Watershed



Surface and Ground Water Hydrology

The Grand Traverse area, including Long Lake, receives an average of 31 inches of precipitation per year (Cummings et.al., 1990). Approximately 16 inches of this precipitation is returned to the atmosphere via evaporation and evapotranspiration by plants. The remainder is direct runoff, or infiltration to groundwater.

In a previous hydrologic analysis, Nab (1987) provided an excellent overview of the surface water hydrology of the Long Lake Watershed. The watershed primarily drains to Long Lake, and ultimately to the west to Lake Michigan via Lake DuBonnet and the Platte River. The outlet of Long Lake is at the extreme south end of the lake, which flows to Lake DuBonnet, which is a distance of 5,800 lineal feet from Long Lake and approximately 8 feet lower in elevation. The water level in Lake DuBonnet is controlled by a dam at the west end of the lake.

The area and shape of the watershed are important in determining the amount and rate of runoff (Nab, 1987). The larger the drainage basin, the more land area that is available to develop runoff. However, the shape of the basin also plays an extremely critical role in defining peak runoff rates and the timing of runoff. The largest portion of the Long Lake watershed is located along the northeast side of Long Lake (Figure 2). The remaining portions of the watershed boundary along the east, southwest and northwest sides of Long Lake are fairly uniform in terms of distance from the lake. Steepness and length of slope are also important in determining runoff rates. The steepest slopes (> 10%) are found along the northeast and east sides of the lake which is where the highest elevations in the watershed occur (Nab, 1987), while the areas along the south and west sides of the lake are generally lower elevations with flat slopes (< 10%).

The extent and types of land cover also influence the impact of runoff from precipitation. Cover can be vegetative or impervious surfaces, but the Long Lake drainage basin is typically vegetative with good cover. Therefore, the runoff coefficient (amount of runoff for different conditions) is relatively low, resulting in low impact for a given storm. In general, most of the Long Lake watershed (about 62%) is either woodland, rangeland or agricultural in nature. In woodland systems, about 75% of the precipitation is held back and does not enter the system immediately, while about 40% of the total precipitation is retained by farmland/rangeland type cover.

Finally, the watershed storage capacity is also critical in determining potential runoff. Water that is stored in ponds, potholes and wetlands does not directly enter the drainage system, and therefore does not contribute immediately to surface water runoff. Nab (1987) assessed the storage capabilities of the watershed, and determined that nearly all of the surface water runoff from the entire basin, except for a small portion on the west side and a small area on the north side of Long Lake, drains into natural storage areas around the drainage basin. This results in little, if any, storm water runoff entering Long Lake. Nab notes, however, that some portion of this stored water will eventually find its way into Long Lake through the ground water system, but this transport may take months or years, depending on the travel distance. Based on the storage capacity of the watershed, Nab concluded that the amount of runoff from a given storm that enters Long Lake as a direct result of storms is more or less limited to the amount of precipitation that falls on the lake surface itself, but that some of this storage water will eventually impact the lake through the groundwater system. It is important to note that as the near shore areas become more developed and the percentage of impervious surface increases, there is likely to be less near shore storage capacity and retention, resulting in greater potential surface water impacts to Long Lake than Nab concluded in his 1987 report. Further analysis by Nab (personal communication) noted that the size of the near shore drainage areas relative to the area of Long Lake itself is insignificant. Given the majority of the water impacting the lake is atmospheric (see Nutrient/Hydrologic Model, Section 4.0 below and Appendix C), Nab suggested that implementation of lot setbacks and vegetative buffers may provide an effective control for near shore surface water discharge.

The groundwater hydrology of the Grand Traverse region has been described in the USGS publication, “Hydrology and Land Use in Grand Traverse County, Michigan,” (USGS, 1990). In general, most of the groundwater in Grand Traverse County is contained, and flows in the glacial deposits that overlie bedrock. Groundwater generally flows towards Grand Traverse Bay, or to tributaries to the Bay, with the exception of the southern part of the county (USGS, 1990). A groundwater contour map (Figure 3) demonstrates that flow within the general Long Lake watershed flows from east to west, and that there are likely groundwater contributions to the lake on its eastern shore. However, north and west of Long Lake, the general groundwater flow is away from the lake. A cross section of the region (Figure 4) shows general land elevations and the approximate location of the water table, again demonstrating flow away from Long Lake along the western side of the watershed.

Hydrologic, Physical and Biological Characteristics of Long Lake

Long Lake is the principal water body within the Long Lake Watershed. Long Lake is natural soft water kettle lake with approximately 3,040 acres of area and 88,272 feet of shoreline, including the shorelines of the islands. The lake has six islands: 9.3-acre Fox Island, 29.3-acre Long Island, 2.1-acre Picnic Island, 1.1-acre Brush Island, 16.2-acre South Island, and an unnamed island of about one acre. Hence the water surface area of the lake is 2,980 acres, including 25-acre Mickey Lake. The lake has a maximum depth of 90 feet, a water volume of 73,822 acre-feet, and an average depth of 24.8 feet. A depth contour map (Figure 5) shows that there are several deep basins, and that the lake monitoring sampling stations used several of these basins for ongoing assessments. The hypsographic (depth-area) graph (Figure 6) shows about 25 percent of the lake is 10 feet deep or less. The graph also shows Long Lake, although it has a maximum depth of 90 feet, is essentially a 60-foot deep lake. The elevation of the lake is 846 feet above sea level.

Long Lake has no inlets and is primarily spring fed. The only outlet, Sucker Creek, is at the southwest end of the lake. The outflow is largely a wetland area, with a well defined drainage area only at its end as it crosses under West Long Lake Road. The outflow fluctuates seasonally. During extend periods of low precipitation, Sucker Creek may not exhibit significantly flow over multiple seasons. The wetland nature of the outlet allows for much of the outflow to be recharged into groundwater, but results in very little “exchange” in the water of Long Lake. Flow measurements have not been done on Sucker Creek and are thus are not available to estimate nutrients efflux from Long Lake.

Figure 3. Groundwater elevation contours in Grand Traverse County near Long Lake

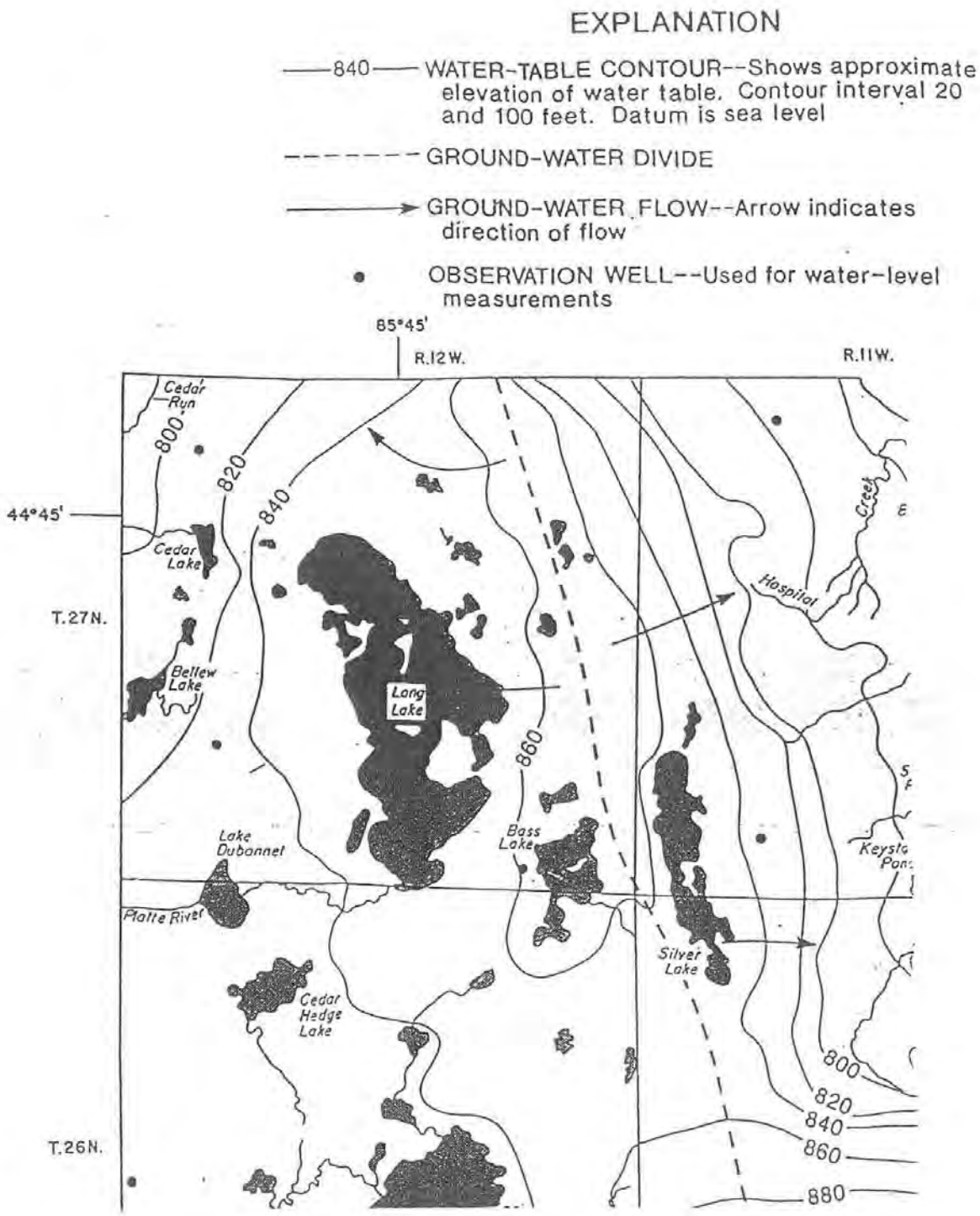


Figure 4. Cross-sectional area demonstrating water table elevation near Long Lake

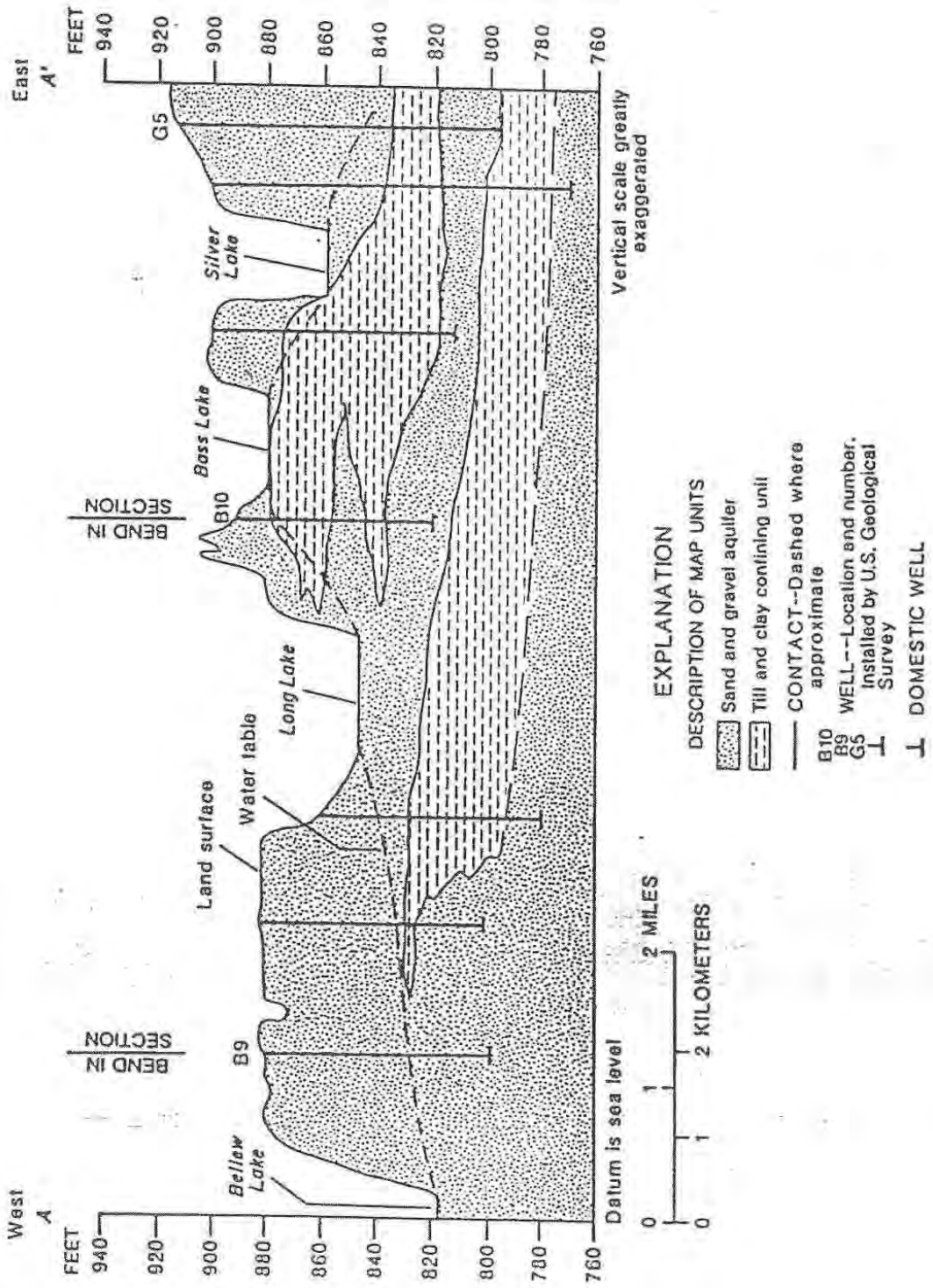


Figure 5. Depth contour map of Long Lake
Water quality sampling sites (#1, 2 and 3) are shown.

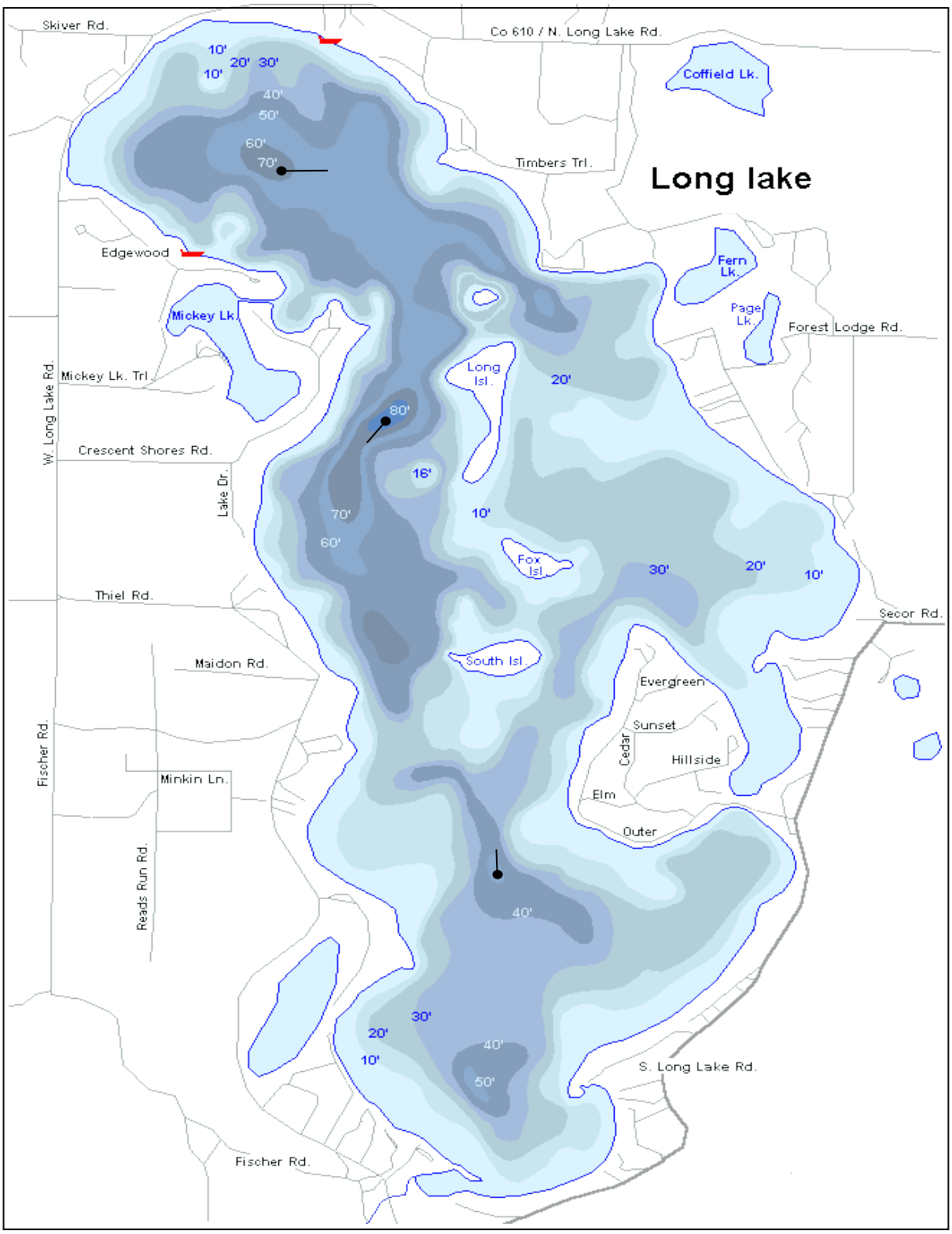
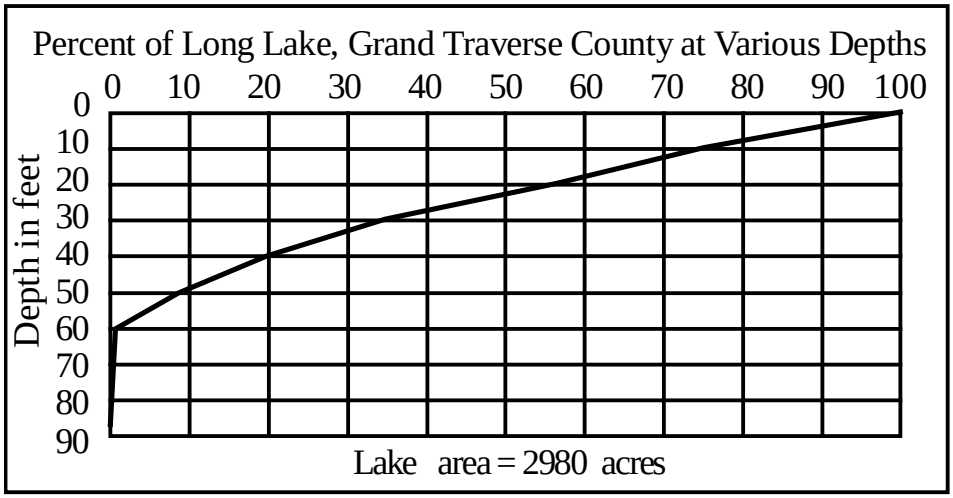


Figure 6. Hypsographic (depth-area) evaluation of Long Lake



(Hypsographic data from Wallace E. Fusilier, Water Quality Investigators, 2005)

Long Lake is considered to have a Warmwater Fishery designated use. Records indicate that Long Lake has historically exhibited a diverse and plentiful population of fish. A Michigan Department of Natural Resources (MDNR) trap net sampling survey conducted in the summer of 1997 (Resig and Stone, 1999) indicated that the perch population is one of the best of any lake in the area. An abundance of bluegill, rock bass, walleye and smallmouth bass were also noted in the lake. Species which were present in lower numbers included largemouth bass, northern pike, brown bullhead, pumpkinseed, common shiner and white suckers. All species were reproducing naturally at healthy rates. The perch population is supplemented in the lake by planting fingerlings on a regular basis.

Community Profile

According to the most recent available census, Grand Traverse County's population increased 12.1% from 1990 to 1996. Future projections indicate a 55% increase in growth between 1996 and the year 2020. Long Lake Township's population increased by 277% from 1970 to 1990 (Resig and Stone, 1999), with approximately 8,000 people currently residing in Long Lake Township. That number is expected to rise by 75% in the next 15 years because people are attracted to the pristine water quality and quality of life provided by

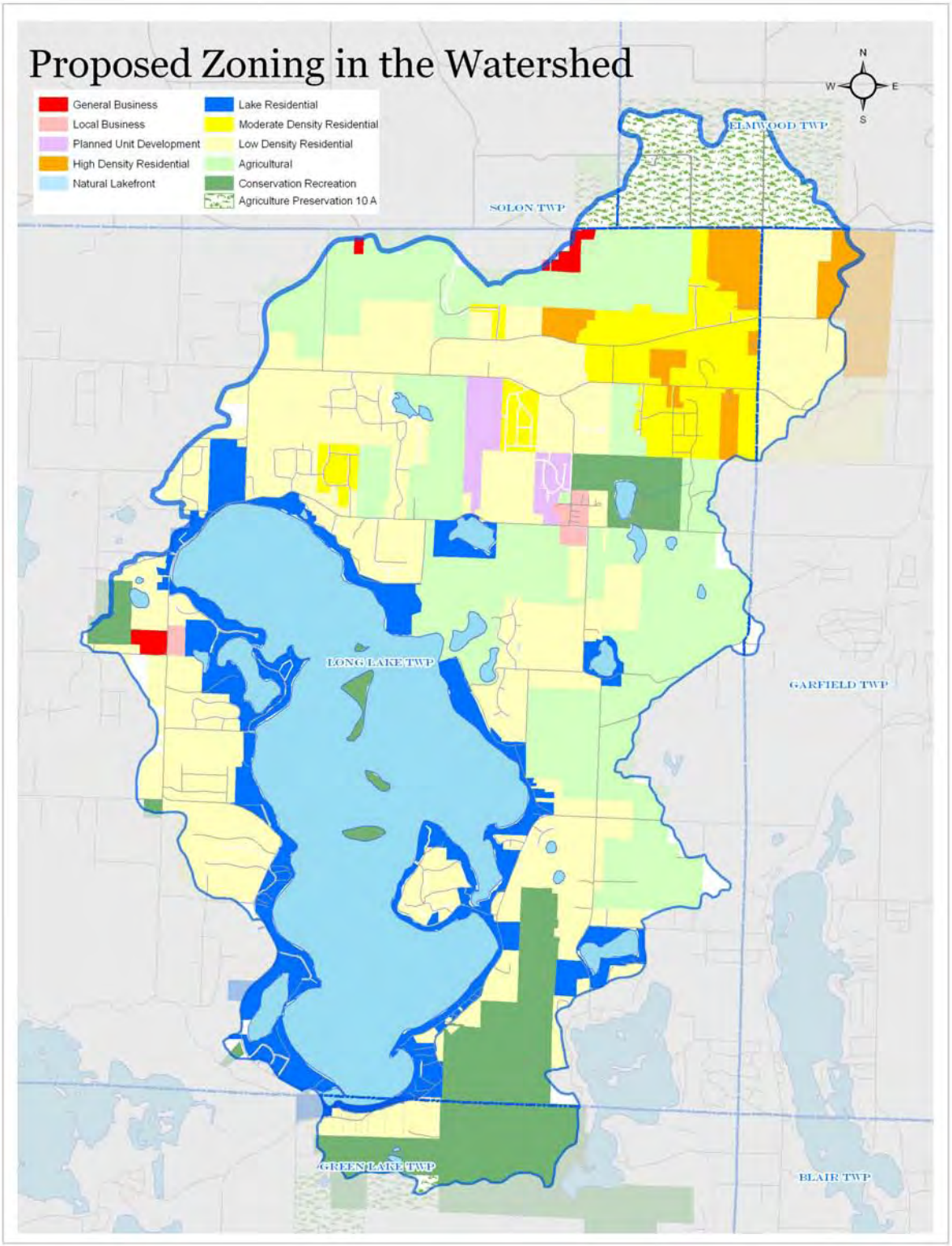
Long Lake and the surrounding lakes. These increases in population and development have the potential to impact the lake through nonpoint source pollutants, increased stormwater runoff, loss of wetlands, land fragmentation and loss of desired land use (e.g., forest land).

Currently there are a number of organizations which are actively working in the Long Lake watershed to maintain the high water quality and general quality of life. These organizations include the Long Lake Township, the Long Lake Association, the Long Lake Foundation, the Oleson Foundation, the Michigan DEQ and the Grand Traverse County Drain Commissioner's Office. For example, the Long Lake Association has been in existence since approximately 1921, and has continued to be proactive in protecting the natural resources of Long Lake, including performing volunteer monitoring for water clarity and indicators of water quality as well as utilizing professional water quality monitoring to determine long range trends in water quality. Other local and regional organizations actively collaborate in monitoring projects and land protection activities, as well.

Zoning Description

As described previously, the Long Lake Watershed encompasses portions of Long Lake, Green Lake and Garfield Townships in Grand Traverse County, and small portions of Elmwood and Solon Townships in Leelanau County. A thematic map exhibiting the distribution of zoning within the watershed is shown in (Figure 7), and is presented in categories in Table 1.

Figure 7. Proposed zoning distribution within the Long Lake Watershed (2009)



Agricultural zoning and unzoned areas occupied by lakes constitute the major percentage of land use in the watershed (57.9%). Zoned residential areas are the next highest land use category (approximately 41%), with a small area (0.8%) defined as commercial space (Table 1).

Currently, Long Lake Township (which comprises the majority of the watershed) is working on a complete revision to its Zoning Ordinance. Many of the updates show preference for the general preservation and protection of the natural environment. This is in part due to the recent adoption by the Township of a full Natural Features Inventory. This Inventory identifies locations of priority natural features, ranks them in relative importance, and recommends means of protecting them. The proposed zoning ordinance requires that approval of any development on these identified high priority properties including protection of these features.

Under the current Long Lake Township zoning ordinance, all lakefront properties are zoned Lake Residential. Lake Residential District standards include the following: 1 acre minimum lot area, 150 feet of lot width at the road and 100 feet at the waterside, setbacks from the water's edge for all structures is 50 feet. Land uses are limited primarily to single family residential and related uses.

Identified natural lakes (Cedar, Bellows, and under the proposed update to the ordinance, South Twin Lake) are in an overlay zoning district with additional standards. The only one of these lakes within the Long Lake watershed is South Twin Lake. These additional standards include: 100 foot setback from the water's edge for all structures, 200 feet of lot width at the waterside, and minimum 2 acres of lot area. The overlay district also limits the construction of artificial beaches above the ordinary high water mark; and restricts removal of natural vegetation and land grading within 50 feet of the waters edge.

Other zoning ordinance standards relating to groundwater, stormwater, wetland and surface water quality include the following:

- The Township allows shared private driveways in some circumstances, limiting impervious surface area.
- Under the proposed zoning ordinance there are several options for clustered residential development with a preference for perpetual preservation of high priority

natural features as identified in the Natural Features Inventory including wetlands, high quality forested areas, scenic vistas, and wildlife corridors.

- ☞ Private roads are permitted in all residential developments. Although there is room for improvement, the private road standards allow for less impervious surface area than the public road standards enforced by the Grand Traverse County Road Commission.

- ☞ There are two non-residential and non-agricultural areas of the Township within the Long Lake Watershed. One of these areas is zoned General Business, its roughly 36 acres in total. (The remaining 130 acres +/- of land zoned General Commercial is located outside of the Watershed.) Some heavy commercial uses are permitted in this district, although most of these uses are permitted only with a conditional land use review with high performance standards that must be met for any such use.

- ☞ There is approximately 25 acres zoned Local Business. This area may be developed with a commercial uses of a limited scale and intensity. Similar site development standards apply in this district, designed to generally protect against potential negative impacts of these uses.

Current Land Use

The Long Lake Watershed land use map (Figure 8) was Long Lake Township, Grand Traverse County, and is an approximate representation of the current distribution of landuse within the watershed in the year 2000. The watershed is not densely populated, and consists of a range of mixed uses. Currently, the watershed uses are as follows: 12.5 % urban [primarily residential plus commercial and industrial}land use (1806 acres), 25.2 % forest (3633 acres), 28.4 % agricultural (4098 acres), 10.1 % rangeland (1450 acres), 22.2 % water (3197 acres) and 1.7 % wetlands (251 acres). Note that the actual land use percentages can differ significantly from the *zoned* land use areas. For example, zone “residential” accounts for approximately 41% of the watershed, but current actual land use amounts to only approximately 12%. This is due to areas of the watershed which have yet to be fully developed according to the zoning specifications.

Future Land Use

In order to determine potential future land use scenarios, it was necessary to determine the relative trends in specific land use categories over time. The most definitive data available for this study area come from the Long Lake Township Comprehensive Plan (Long Lake Township, 2005). In this report, land use and development patterns were detailed for the years 1990 and 2000 for Long Lake Township. Because approximately 87% of the Long Lake Watershed lies within Long Lake Township, the township can serve as a surrogate to estimate future land use in the watershed. For each category (e.g., residential, agricultural, forest, etc.) a percentage change was calculated in Long Lake Township for the ten year period 1990-2000. For a rough estimate of the land use in the year 2020, the 10-year change percentages were projected to predict land use in 2010, and then applied again on these 2010 data to generate land use estimates for 2020. There are, of course, inherent errors in this approach, but using these conservative estimates allows for the development of a potential land use scenario, and enables future estimates of runoff, sediment, and nutrient loading to be developed (see Section 5.0). Table 2 shows the current Year 2000 land use, and the approximated Year 2020 land use scenario. Numbers for estimated commercial land use area in 2020 were taken from the Long Lake Comprehensive Plan estimates for the year 2025, reflecting two "town centers" anticipated to be built within the watershed. Similarly, the anticipated industrial land use area in 2020 was also taken from the Long Lake Comprehensive Plan.

In summary, the Year 2020 land use scenario projects that the largest shift in land use will be from forested areas (-36%, -1,305 acres) to developed areas which includes residential (+78%, +1,389 acres), commercial (+855%, +188 acres) and industrial (+1,767%, +159 acres). The "town centers" will be clustered developments and may spark nearby residential development. Because lake residential property is currently mostly developed, this increase in developed land (primarily residential) will be farther from Long Lake, and will enable Long Lake Township to enact appropriate zoning to limit stormwater runoff, impervious surfaces and provide greenbelt buffers to mitigate the loss of undeveloped land.

Figure 8. Land use distribution within the Long Lake Watershed

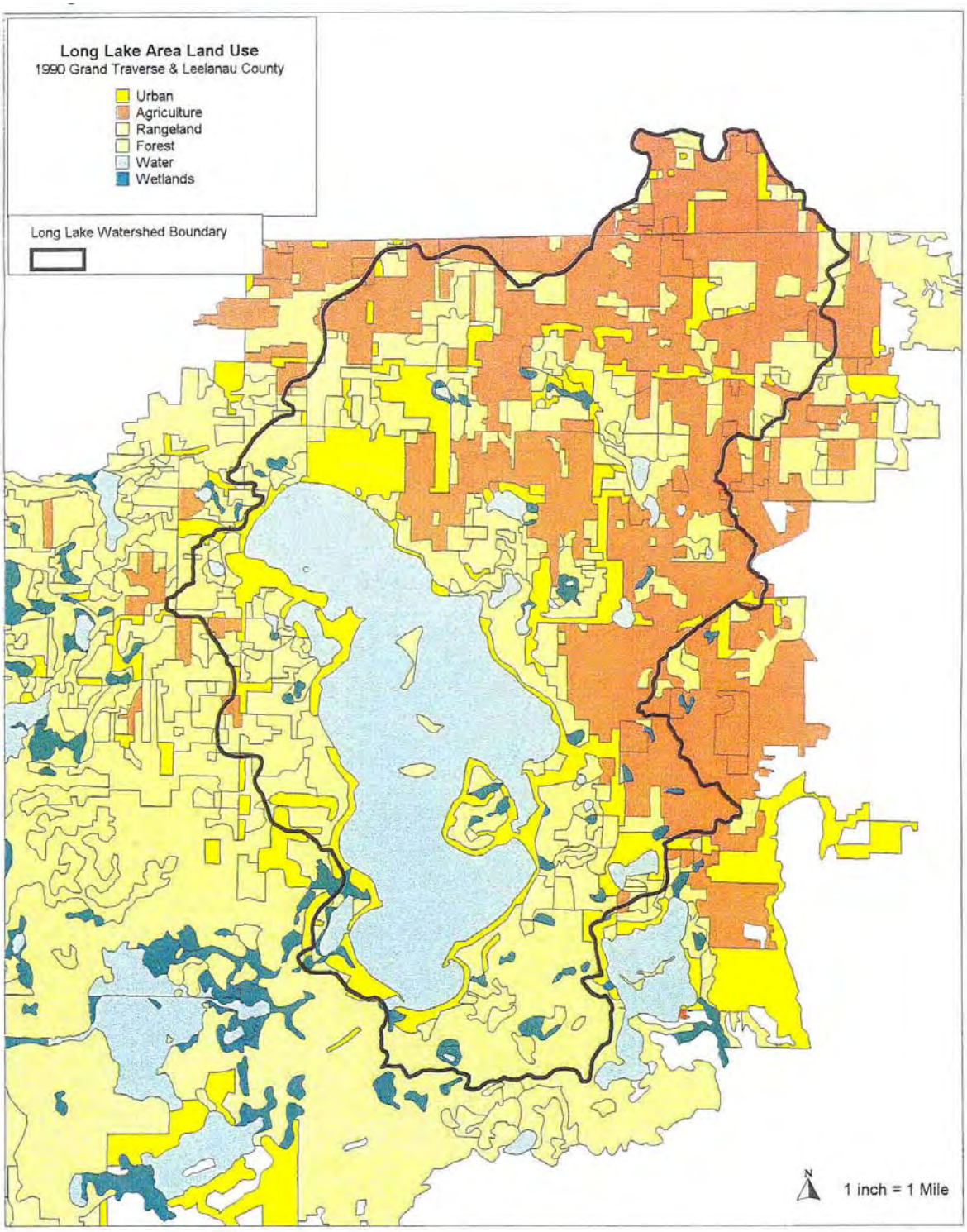


Table 1. Zoning Allotment by Township in the Long Lake Watershed

Political Entity	Land Use	Approximate Area (acres)	Percent of Total
Long Lake Township	Agricultural	3,231	25.7
	Non Lake Residential	3,084	24.5
	Lake Residential	2,621	20.8
	Conservation/Recreation	544	4.3
	None (Lakes)	3,109	24.7
		12,589	100.0
Green Lake Township	Residential	141	23.3
	Forest/Agriculture	464	76.7
		605	100.0
Garfield Township	Agricultural	516	100.0
Elmwood Township	Agricultural	578	100.0
Solon Township	Agricultural/Residential	36	100.0

Designated Uses

An important criterion for evaluating water quality is whether the waterbody meets designated uses (MDEQ, 2000). Designated uses are recognized uses of nation's waterbodies, established by state and federal water quality programs. In Michigan, the objective is for all waters of the state meet all eight designated uses as defined by the state (MDEQ, 2000) and listed in Table 3.

Table 2. Current year 2000 and projected year 2020 land use in the Long Lake watershed

Land Use Category	Year 2000 (acres)	Year 2020 (acres)	Change
Residential	1,775	3.164	+ 78%
Commercial	22	210	+ 885%
Industrial	9	168	+ 1,767%
Agricultural	4,098	3,792	-7.5%
Forest	3.633	2,328	-36%
Rangeland	1,450	1,325	-8.6%
Water	3,197	3,197	0.0%
Wetland	251	251	0.0%
Total	**14,435**	**14,435**	**0.0%**

It should be noted that groundwater is also protected under Michigan law. Groundwater discharges must meet a nondegradation standard to protect existing or potential uses such as domestic water supply, irrigation, livestock watering, etc. In order to determine if any waterbodies within the Long Lake Watershed have been designated with specific use impairments, the document, "Water Quality and Pollution Control In Michigan, 2008,

Sections 303(d), 305(b), and 314 Integrated Report" (MDEQ, 2008) (http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-12711--,00.html) was consulted. Currently, no water bodies in the Long Lake Watershed are listed as impaired. The water quality standards which apply to the stated designated uses for Michigan waters are presented in Table 4. The objective of this Watershed Management Plan is to provide an approach which will allow the Watershed to continue to meet these standards in the future, despite changes to the watershed.

Table 3. Designated Uses for Surface Water in the State of Michigan

All surface waters of the state of Michigan are designated for and shall be protected for all of the following uses:
1. Agriculture
2. Navigation
3. Industrial water supply
4. Warm water fishery
5. Other indigenous aquatic life and wildlife
6. Partial body contact recreation
7. Fish consumption
8. Total body contact recreation between May 1 and October 31

Citation: Rule 100; R323.1100 (1) Part 4, part 31 of PA 451, 1994, revised 4/2/99

Table 4. Water Quality Standards for Michigan Inland Waters.

Water Quality Parameter	Water Quality Standards (MDEQ, 2006)
Physical Characteristics	The surface waters of the state shall not have any of the following physical properties in unnatural quantities which are or may become injurious to any designated use: (a) Turbidity. (c) Oil films (e) Foams. (g) Suspended solids (b) Color (d) Floating solids. (f) Settleable solids. (h) Deposits
Dissolved Solids	The addition of any dissolved solids shall not exceed concentrations which are or may become injurious to any designated use.
Hydrogen Ion Concentraion (pH)	The hydrogen ion concentration expressed as pH shall be maintained within the range of 6.5 to 9.0 S.U. in all surface waters of the state, except for those waters where the background pH lies outside the range of 6.5 to 9.0 S.U.
Taste- or odor-producing substances.	The surface waters of the state shall contain no taste-producing or odor-producing substances in concentrations which impair or may impair their use for a public, industrial, or agricultural water supply source or which impair the palatability of fish as measured by test procedures approved by the department.

Water Quality Parameter	Water Quality Standards (MDEQ, 2006)
Toxic Substances	Toxic substances shall not be present in the surface waters of the state at levels that are or may become injurious to the public health, safety, or welfare, plant and animal life, or the designated uses of the waters.
Plant Nutrients	Nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the surface waters of the state.
Microorganisms	(Partial Body Contact Recreation): 1,000 or less *E. coli** per 100 mL sample, based on geometric mean of 3 samples (Total Body Contact Recreation): 130 or less *E. coli* per 100 mL sample (30-day geometric mean) or 300 or less *E. coli* per 100 mL for any single sample event, based on a geometric mean of 3 samples. **E. coli* = *Escherichia coli*, and indicator organism for fecal contamination
Dissolved Oxygen -Inland Lakes	Dissolved Oxygen (D.O.) not less than 5.0 mg/L during summer stratification in the epilimnion (uppermost layer of the lake). Not less than 5.0 mg/L for the rest of the year for entire lake area

Water Quality Parameter	Water Quality Standards (MDEQ, 2006)
Temperature	Inland lakes shall not receive a heat load which would: (a) Increase the temperature of the thermocline or hypolimnion or decrease the volume thereof. (b) Increase the temperature of the receiving waters at the edge of the mixing zone more than 3 degrees Fahrenheit above the existing natural water temperature. (c) Increase the temperature of the receiving waters at the edge of the mixing zone to temperatures greater than the following monthly maximum temperatures: J F M A M J J A S 0 N D 45 45 50 60 70 75 80 85 80 70 60 50
Antidegradation	For all waters, the level of water quality necessary to protect existing uses shall be maintained and protected. Where designated uses of the water body are not attained, there shall be no lowering of the water quality with respect to the pollutant or pollutants that are causing the nonattainment. Where, for individual pollutants, the quality of the waters is better than the water quality standards prescribed by these rules, that water shall be considered high quality and that quality shall be maintained and protected unless allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. For high quality waters, no action resulting in the lowering of water quality shall occur unless the provisions of this rule have been complied with.

Desired Uses

In addition to the designated uses associated with water quality, it is important to identify desired uses for the watershed. Desired uses can be defined as the ways in which people use the watershed and think should be protected and/or preserved for future generations. They may be very general or very specific, or somewhere in between.

These desired uses may include protecting areas for their intrinsic value, developing new uses that would enhance the quality of life within the watershed (such as development of a recreational trail), or they may be linked to protecting wildlife and endangered aquatic habitats. Desired uses are important because they can become a focal point for community activities, and can help to foster stakeholder involvement in watershed protection. Several general desired use categories were identified for the Long Lake watershed (Table 5). These include:

1) Landscape Views

2) Maintain ecological diversity.

3) Protect cultural and rural heritage

4) Enhance recreational opportunities

These desired uses are difficult to define, but address inherent quality of life issues which attract people to live in Northern Michigan, and specifically to live on or near high quality lakes like Long Lake. In essence, the enjoyment of being outdoors in a area of natural beauty is a high priority to residents of the watershed, as well as to the visiting public. For some individuals, the simple enjoyment of the area's natural beauty may be more important than opportunities for high quality fishing or boating

Table 5. Desired uses not explicitly protected under Water Quality Regulations, location, purpose, and additional protections considered to help preserve these uses.

Desired Use Category	Location	Purpose	Applicable laws/regulations/programs	Potential additional protections
Landscape Views	View corridors, riparian open space near Long Lake, selected areas and in agricultural areas	Provide landscape views for residents and visitors of the area; Minimize Urbanization and preserve open space	Private land conservancies, local parks and recreation programs, scenic turnouts and rest areas, State and local zoning ordinances	Acquisition of conservation easements, local ordinance to guide new development, tourism/education; promotion of locally grown agricultural products.
Ecological Diversity	Selected areas; other areas as identified in Long Lake Natural Features Inventory	Maintain and provide habitat for endangered, rare or threatened species Preserve Wetlands and Wildlife corridors	State/federal endangered and threatened species laws; state/local property tax exemption status for specific properties; land conservancy acquisitions/easements	Acquisition of conservation easements; education of owners and general public; new ordinances related to new development.

Desired Use Category	Location	Purpose	Applicable laws/regulations/programs	Potential additional protections
Cultural and rural heritage	Selected areas or zones	Continue land preservation efforts; Maintain agricultural heritage of the area for educational enrichment of residents and visitors	Land conservancy programs, Farmland Preservation Act; Centennial Farm Recognition program; accommodation of local zoning requirements.	Promotion of natural areas protected for public use and enjoyment.
Recreational Opportunities	Selected areas or zones	Maintain high quality areas in the watershed for recreation such as fishing, canoeing, boating, hiking, and birding.	Local parks and recreation programs, State recreational programs	Promotion of local awareness of recreational opportunities

Photo from the Minnesota Dept. of Transportation

4.0 MONITORING AND SOURCE INVENTORIES

In order to identify sources of pollutants, environmental stressors and specific areas of watershed concern, a review of available monitoring and assessment studies is required. These studies included 1) water quality monitoring of Long Lake, 2) a comprehensive survey of aquatic plants in Long and Mickey Lakes, 3) development of a steady-state hydrologic and nutrient budget model to determine the relative contributions of individual sources of nutrients, 4) an assessment of soil erosion sites within the watershed possibly contributing sediments, 5) a shoreline survey of Long and Mickey Lakes to look for additional areas of erosion, sedimentation, possible nutrient enrichment and potential leaking septic systems, 6) a preliminary analysis of the extent of impervious surface within the watershed, 7) comprehensive sediment sampling in nearshore areas of Long and Mickey Lakes, and 8) bacterial monitoring in Long/Mickey Lakes (based on findings from the shoreline survey). The results of each of these studies are presented in

their entirety in the appendices of this report, and are briefly summarized below. The synthesis of these individual studies allowed for a comprehensive overall picture of the contribution of individual pollutants and their sources.

Long Lake Water Quality Monitoring

Integrated water quality monitoring was conducted yearly on Long Lake from 1997 to 2000 and again in 2005 and 2008 by the Long Lake Association. Three sampling sites were established (Figure 5) and have been consistently used for all water quality investigations. The sites are located in three of the deeper areas of the lake. Site 1 is in the northern part of the lake at approximately 60-70 feet depth, Site 2 is in the north central area of the lake in the deepest depth (80 feet) and Site 3 is in the southern portion of the lake at about 40-50 feet depth. Water quality parameters (dissolved oxygen, pH, temperature, oxidation-reduction potential) were measured by a Hydrolab mulitparameter probe, and water samples were collected at the surface and near bottom for total phosphorus, nitrate-nitrite nitrogen and chlorophyll a (an indicator of algal growth). Data were collected once in the early summer (June to July) and in the fall (early October). Nutrient and water quality parameters can change depending on time of year, so it is necessary to collect multiple samples to provide a better indication of overall lake quality. In addition to these basic parameters, the secchi depth (measure of water clarity) was measured. Finally, sediment phosphorus concentrations were determined in 2000 and 2005 at these sampling sites to provide some indication of whether a pool of phosphorus is contained in the bottom sediments.

Average phosphorus, nitrogen and chlorophyll a concentrations for all samples collected are presented in Table 6. The data show that total phosphorus concentrations in summer surface samples averaged approximately 9.5 ug.L for Sites 1 and 2, and 4.5 ug/L for Site 3. Bottom phosphorus concentrations were higher, ranging from9.1-12.5 ug/L at the three sites. In the fall, the surface concentrations ranged from 7.4 to 10.4 ug/L, and bottom concentrations 14.5 – 15.9 ug/L. Nitrogen levels were not elevated with respect to other northern Michigan lakes (Leelanau Conservancy, personal communication). Chlorophyll a levels were 1.6- 1.6 ug/L in early summer, and ranged at the three sampling sites from 2.0-2.7 ug/L in the fall. The observed surface total phosphorus concentrations are indicative of oligotrophic (high quality lakes), generally less than 10 ug/L (Chapra, 1997). In addition, chlorophyll a levels less than 4 mg/L are also

considered in the oligotrophic range. All secchi depth measurements, for all years, were in the oligotrophic range (> 13 feet) at both summer and fall sampling events.

Table 6. Total phosphorus, chlorophyll aconcentrations and secchi depth at the three Long Lake sampling sites, average from 1998-2005.

Sampling Site #1

Sampling Season	Total Phosphorus (ug/L)		Chlorphyll a	Secchi Depth
	Surface	Near Bottom	(ug/L)	(ft)
June/July	9.5	9.1	1.46	28.5
October	7.4	14.5	2.01	18.5

Sampling Site #2

Sampling Season	Total Phosphorus (ug/L)		Chlorphyll a	Secchi Depth
	Surface	Near Bottom	(ug/L)	(ft)
June/July	9.5	12.45	1.6	27.0
October	9.2	14.5	2.25	18.5

Sampling Site #3

Sampling Season	Total Phosphorus (ug/L)		Chlorphyll a	Secchi Depth
	Surface	Near Bottom	(ug/L)	(ft)
June/July	4.5	12.5	1.5	28.5
October	10.4	15.9	2.7	18.5

Near bottom phosphorus levels were somewhat higher the surface concentrations, ranging from 9.1 – 15.9 ug/L, depending on sample date and sampling site (Table 6). Measurement of sediment concentrations at the three sampling sites are significantly higher than other area lakes and may be an area of concern, particularly with surface inputs of phosphorus from near shore areas and precipitation.

Measurement of dissolved oxygen concentrations demonstrated that Long Lake consistently meets the standard of 5 mg/L in the epilimniom (upper lake levels) but concentrations are near zero in the deepest portions of the lake, a normal occurrence for deep lakes. However, this anoxic (lack of oxygen) condition may lead to the release of phosphorus from the bottom sediments, and possibly fueling algal blooms in the late summer.

These data demonstrated that although Long Lake is considered a high quality, oligotrophic waterbody, there were a number of warning signs which indicated that Long Lake water quality could be vulnerable to degradation if long-term nutrient input is not limited. In particular, lake bottom sediments were determined to have concentrations of total phosphorus two to three times higher than 10 other oligotrophic lakes in the area which have had long-term monitoring programs. In addition, bottom oxygen levels were shown to decline to nearly zero each summer at the deepest sampling points, and near bottom water total phosphorus concentrations were consistently greater in the fall. These

high values are likely due to the release of bound phosphorus from sediments under anoxic conditions. The flushing rate (water replacement time) for the lake is roughly 9 years, and the lake has suffered from extremely low water levels over the past number of years, which has eliminated most outflow. The result of this situation is that most of the nutrients and sediments which enter Long Lake through the watershed and precipitation remain in the lake, and therefore continue to accumulate. These data, coupled with anecdotal observations of increased shoreline algal blooms and evidence of increasing incidence of aquatic plants, indicate that there is a significant pool of phosphorus contained within the lake which may supply nutrient resources to sustain algal and excessive plant macrophyte growth.

Long Lake Macrophyte Study

A lake macrophyte survey can be particularly valuable in watershed management efforts because lake fertility (nutrient concentration) is an important factor affecting aquatic plant growth, and because the distribution of aquatic plants can be a reflection of the characteristics of the surrounding watershed. A survey of the rooted aquatic plants in Long and Mickey Lakes was conducted by GLEC in the summer of 2000 and updated in 2005 (Appendix D and D1). The objective of this survey was to map the major macrophyte growth areas in the lakes, and to characterize the vegetation in Long and Mickey Lakes. This survey established macrophyte baseline data, which will be an important resource to be used for future comparative monitoring efforts by the Long Lake Association. Plant species composition, average lakewide density, and the distribution of macrophyte growth areas was determined from transect data, and from direct observation of the lake bottom during the peak growing periods during the summer of 2000 and 2005.

The methods used to conduct the surveys were based on methods described in "A Citizen's Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes" (Michigan State University, 2000. Transects established during the 2000 survey were sampled again, and some new transects were added, for a total of 35 transects surveyed (full description and results in Appendix D1). The results of the most recent survey are as follows and are presented in Figure 9.

2005 Transect Sampling Results (Long Lake). During the macrophyte sampling survey, nineteen different aquatic plants were found in Long Lake. Of 35 transect sites, Eurasian

water milfoil was found at 22 of the sites. Eurasian milfoil is the only non-native species identified during this survey, as was the case during the survey in 2000.

2005 Transect Sampling Results (Mickey Lake). During the macrophyte sampling survey, 10 different aquatic plants were found in the samples from two transects in Mickey Lake. Eurasian water milfoil was found at only one of the two transect sites, but was prevalent on the northern side of the lake.

Macrophyte Growth Trends. The macrophyte growth areas identified in 2000 were resurveyed and compared as to larger or smaller than sited in 2000. Three new growth areas were observed and added to the macrophyte map Figure 9 . Of the macrophyte visual survey sites, 32 sites out of 46 had at least some amount of Eurasian water milfoil (varying from one stem to dense patches). Comparison with data from the 2000 survey showed that in 16 sites, Eurasian water milfoil either increased in density or was sited in an area where it was not sited before. At five macrophyte areas, Eurasian water milfoil decreased in density. General macrophyte growth, in area amount, increased at five sites and decreased at two sites.

Overall Aquatic Macrophyte Acreage. The total acreage of macrophyte growth in the lake was calculated. Because Eurasian water milfoil is of such concern, the relative abundance of milfoil as a percentage of lake area was also calucalted. In the year 2000 survey, aquatic macrophytes consisted in approximately 1.6% of the total lake area. This increased to 1.7% in 2005. The total Eurasian Milfoil Area was not calculated in the year 2000 survey, but was a total of 7.1 acres in 2005, approximately 14% of the total macrophyte area and only 0.2% of total lake area. These numbers may be small, but should considered in the context that in general, macrophyte growing areas are primarily limited to areas of less than 20 feet which is about 40% of the total lake area. Therefore these numbers should be adjusted to reflect probable macrophyte growing area (2000 adjusted macrophyte area: 4%; 2005 adjusted area: 4.3%).

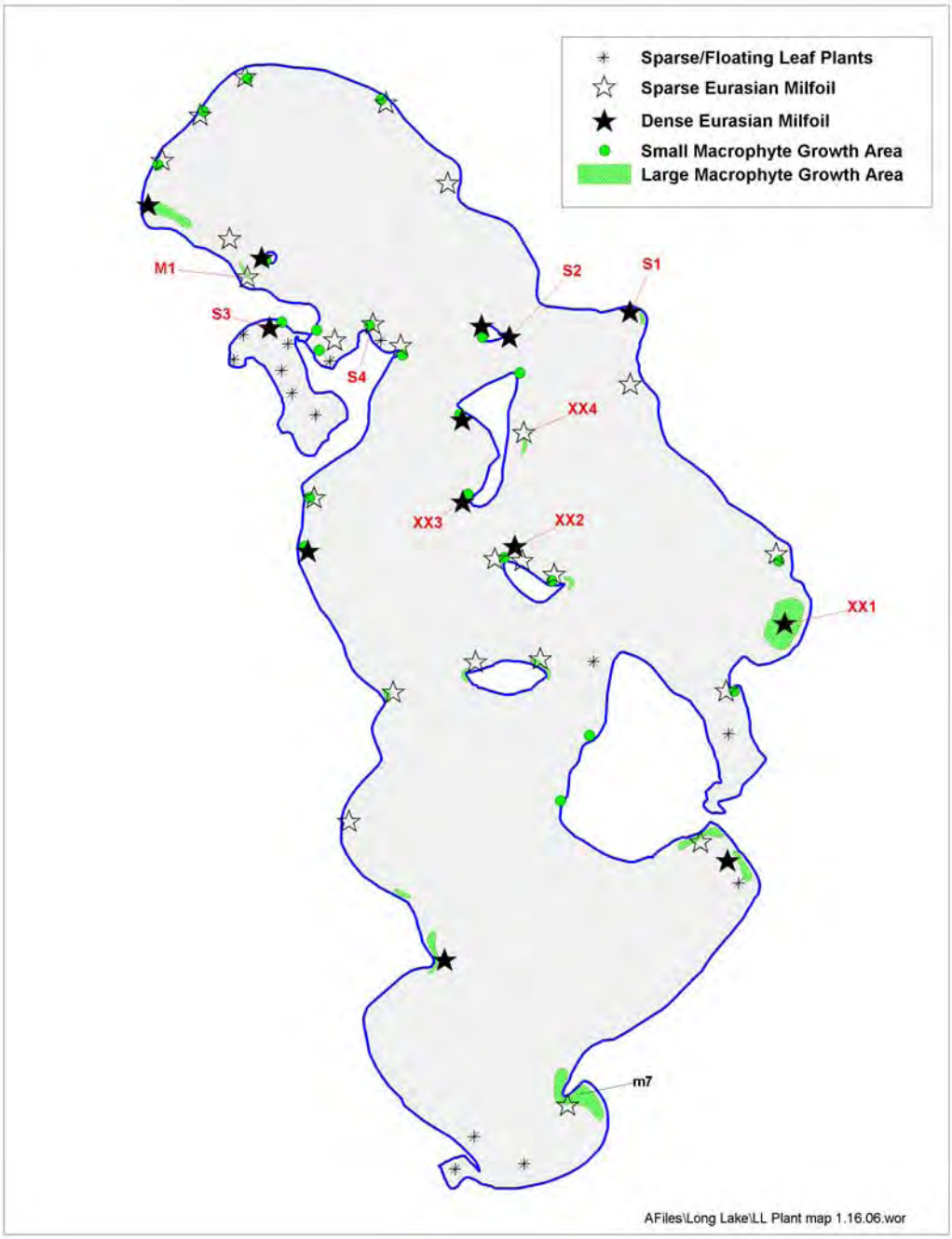
The vegetation observed during this survey in Long Lake is indicative of a well balanced aquatic plant community, with a low overall abundance of plant growth, which is typical of oligotrophic lakes like Long Lake. Eurasian milfoil control efforts are reducing the abundance of this species, as well as the abundance of native species. Milfoil will continue to be a major concern in the Long Lake Watershed.

Nutrient/Hydrological Model

The objective of developing a nutrient/hydrological model was to develop a screening tool that gives a preliminary estimate of the affects of groundwater, surface runoff, sediment release, and aquatic macrophytes on the water quality of Long Lake. This model was for lake-wide total phosphorus and did not include dissolved oxygen, algal productivity or water transparency. The model was intended to describe steady-state conditions during the summer and did not include dynamic mechanisms such as lake turnover or algal blooms. The model assumed the lake is stratified into two well-mixed layers and did not include near-shore impacts of watershed activities. Furthermore, although the model calculated the impact of the sediments on water quality, it did not simulate the long-term accumulation of organic materials in the sediments. Additional research and analysis would be required to enable the model to dynamically predict long-term nutrient accumulations in the sediments. Details of the model equations are provide in Appendix C. A summary of the relevant features of the model are presented here.

The primary parameters used to calibrate the model were the macrophyte decay rate, the vertical exchange rate, and the upper (epilimnion) and lower (hypolimnion) water settling velocities for nutrients. The macrophyte decay and the vertical exchange rates were typical values from Chapra (1997). The model used measurements of rainfall phosphorus collected on Long Lake as a part of the model development process. The model was tested by adjusting any of five different input Management Parameters (days dissolved oxygen <2 mg/L, Rainfall, macrophyte area, surface runoff total phosphorus and groundwater total phosphorus).

Figure 9. Areas of macrophyte growth on Long Lake, 2005.



Examining the rainfall parameter, rainfall can be varied to simulate wet or dry conditions. The model suggested that water quality in the lake declined as rainfall increased, like due to direct input of total phosphorus from rain itself. Increasing or decreasing the surface runoff parameter has much less effect on water quality (as measured by water total phosphorus) than increased rainfall. Increasing the parameter for area of the macrophytes resulted in a significant increase in the total phosphorus concentration in water. Surface and groundwater total phosphorus concentrations can be varied to reflect different levels of watershed development.

In general, the phosphorus input from precipitation and internal loading from sediments, both uncontrolled sources, were the biggest factors in the static model determining lake water phosphorus content. These factors exhibited a much more predominant effect than other management factors which would be easier to manipulate through the use of BMPs. This does not suggest, however, that using management practices in the watershed will result inconsequential changes with respect to maintaining water quality, but simply states that some sources are not necessarily controllable.

Soil Erosion Inventory

As is typical of many Northern Michigan Lakes, Long Lake is a mixture of past "cabin" developments and more recent, large-home residential development. Development was initially on properties which easily accommodated a dwelling. However, as lake front property became more scarce and more valuable, the steeper, more erosion-prone properties were developed. It follows that these less suitable sites, if developed improperly, may contribute significant amounts of sediment and nutrients to Long Lake through overland runoff, resulting in more rapid eutrophication and negative impacts on fish habitat and overall lake quality. In 1999, the Grand Traverse County Soil Conservation District conducted a soil erosion inventory within the watershed, emphasizing the shoreline of Long Lake. The purpose of the inventory was to document the sources of erosion around Long Lake, and to suggest Best Management Practices (BMPs) to stabilize these areas.

Although sixteen of shoreline erosion sites were documented on Long Lake, the 13 of these sites were given a severity rating of minor, and could be adequately addressed with direct input of the shoreline property owner, or with an educational program. These

sites were located around the perimeter of the lake and on the islands (map is unavailable, see Table 7; aerial photos documented in Appendix E). Three erosion sites (#31-E, #32-E and #33-E) werenoted on the three islands (South, Fox and Long, respectively), which demonstrated specific sites of moderate to severe erosion, possibly due to recreational use. South Island is maintained by the Grand Traverse Regional Land Conservancy and Fox and Long Islands are maintained as public parks. These erosion sites have been remediated as of this Watershed Plan update, and are no longer considered severe problems. However, continued recreational use puts pressure on maintaining erosion control programs on these islands.

The stabilization of the 13 remaining erosions sites identified in the survey, as well as any other sites which are identified as a result of physical observation by riparian stakeholders will be a priority for this watershed plan update. In general, over the years, homeowners have effectively stabilized the shoreline using a variety of methods, including broken concrete, breakwalls, rocks, and similar materials. In addition, homeowners have constructed access steps, decks and docks to facilitate the use of their property without continued disturbance of the shoreline. Although it was beyond the scope of the inventory, past and present removal of fallen trees (woody debris) from the water was observed in many places. The removal of woody debris is a common occurrence on many developing inland lakes around Northern Michigan. However, the practice is not ecologically sound because fallen trees provide critical fish and shorebird habitat. Thus removal of these fallen trees and standing dead trees from the shoreline by landowners “improving” their property has greatly reduced the amount of near-shore fish and shorebird habitat over the years.

Though shoreline erosion/sedimentation does not appear to be a major problem on Long Lake at this point in time, landowners should be informed of BMPs which will help reduce the amount of sediment and nutrients entering the lake. The complete results from the erosion/sedimentation inventory are presented in Appendix E, including costs for implementation of appropriate BMPs where necessary.

Table 7. Soil Erosion Inventory, 1999. Site numbers are located around the shoreline of Long Lake. Assessment completed by the Grand Traverse County Soil Consersvation District.

LONG LAKE WATERSHED

NON-POINT SOURCE POLLUTION
INVENTORY
Summer 1999

E = Erosion
PE = Potential Erosion
PCE = Potential Conservation Easement
0 = Other

Site #	Description/Severity	BMP
1-E	Sheet Erosion/Minor	Plantings
2-E	Beach Erosion/Minor	Education/BMP Handbook
3-E	New Construction/Minor	Education/BMP Handbook
4-E	Point Erosion/Minor	Rock rip-rap, Plantings, Handbook
5-PE	Cement Blocks/Minor	Replace Cement Blocks w/rip-rap, Handbook
6-PE	Broken Cement/Minor	Replace Broken Cement w/rip-rap, Plantings
7-E	High Bank Erosion/Moderate	Replace Access Steps, Rip-rap, Top soil, Plantings , Bulkhead, Handbook
8-E	Sheet Erosion/Minor	Plantings
9-E	High Bank Erosion/Minor	Rock Rip-Rap, Top Soil, Plantings
10-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
11-PE	High Bank/Minor	Plantings
12-PE	High Bank/Minor	Plantings
13-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
14-PCE	Large Undeveloped Parcel on Point	Work w/ G.T. Regional Land Conservancy
15-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
16-0	Landowner used Coco Fiber Rolls in an attempt to protect/reclaim point	Education/Handbook

Table 7 (Continued). Soil Erosion Inventory, 1999. Site numbers are located around the shoreline of Long Lake. Assessment completed by the Grand Traverse County Soil Consersvation District.

Long Lake Watershed Erosion Inventory (Cont.)
Page - 2 -

17-PE	Piles of sand near water/Minor	Education/Handbook
18-E	Sheet Erosion/Minor	Ground Cover/Handbook
19-PE	High Bank/Minor	Plantings
20-PE	New Construction/Minor	Education/Handbook
21-E	Sheet Erosion/Minor	Ground Cover/Handbook
22-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
23-E	High Bank Erosion/Moderate	Rock Rip-Rap, Plantings, Eductaion/ Handbook
24-E	High Bank Erosion/Minor	Rock Rip-Rap, Plantings,
25-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
26-E	Toe & High Bank/Moderate	Rock Rip-Rap, Plantings, Handbook
27-PE	Failing Bulkhead/Minor	Replace/Repair Bulkhead
28-E	High Bank Erosion/Minor	Plantings
30-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
31-E	Bank Erosion/Severe	Rock Rip-Rap (10 yds^3), Top Soil (15 yds^3), Plantings (2000 ft^2) Est. Material Cost: $1,500
32-E	Bank Erosion/Severe	Rock Rip-Rap (20 yds^3), Access Steps (30 ft.), Top Soil (25 yds^3), Plantings (3,000 ft^2), Est. Material Cost: $3,000
33-E	Upper Bank Erosion/Severe	Rock Rip-Rap (20 yds^3), Top Soil (20 yds^3), Log Cribbing (75 ft.), Plantings (3000 ft^2); Est. Material Cost: $2,500

Impervious Surface Analysis

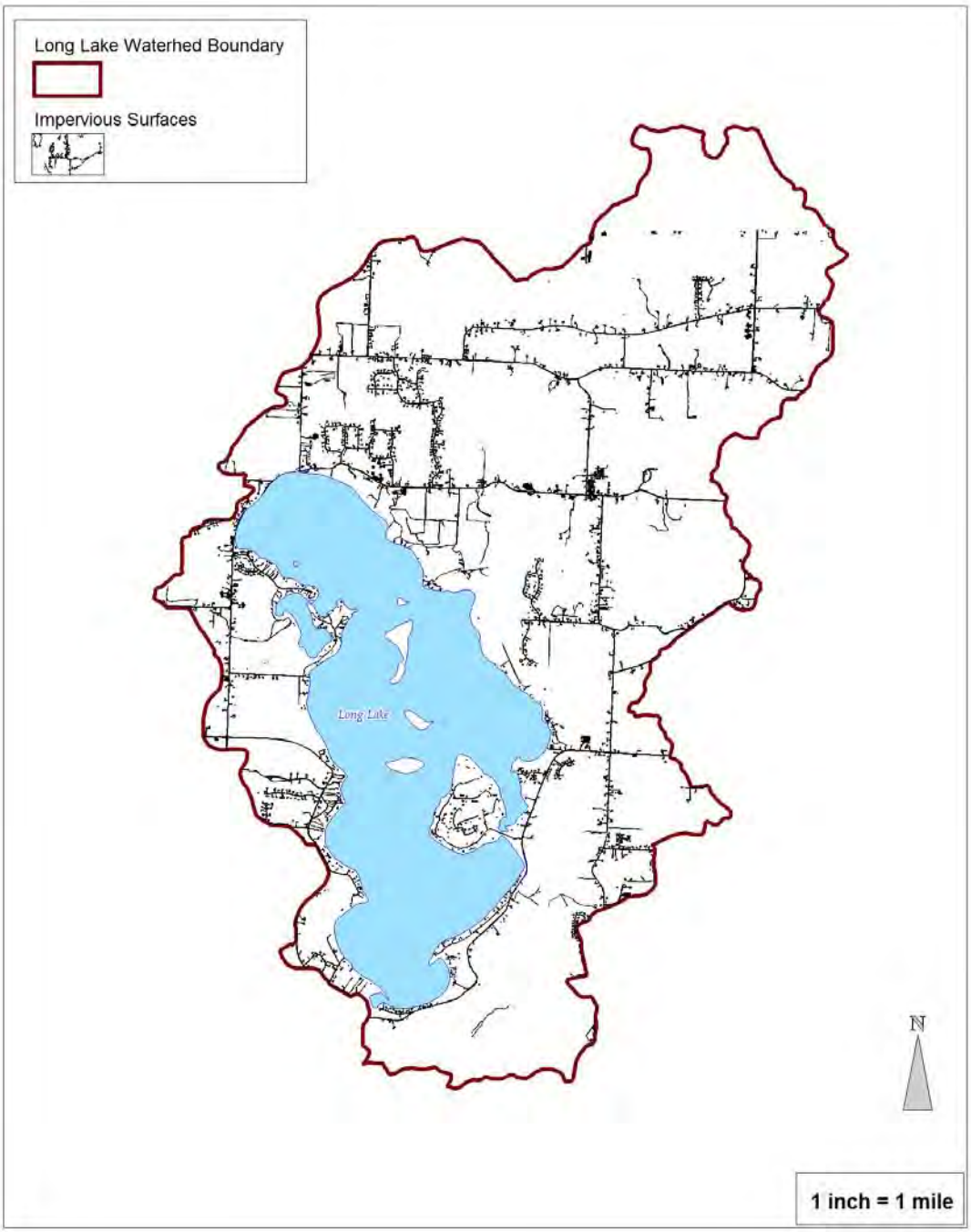
Impervious surface mapping was initiated to determine overall watershed imperviousness and to help define the specific areas within the watershed which contribute to the accumulation and delivery of stormwater and pollutants to aquatic systems, primarily Long Lake. Impervious areas, if not managed appropriately, can alter the natural hydrology of the watershed by disrupting the natural conveyance and storage of water. In addition to changing the patterns of water runoff, improperly managed impervious cover also contribute to declining water quality by delivering pollutants (salt, asphalt constituents) to sensitive aquatic habitats. In cases where the impervious surface area is high, there may be serious consequences for community water supplies because of the potential reduction or loss of groundwater recharge (Harbor, 1994).

The impervious surface map layer was produced from 1995 aerial photographs (1:2000 scale, black and white negative) of Grand Traverse County taken at 12,500 feet. The photographs were were digitized, using a tracing approach, to create the impervious surface layer. Features deemed impervious were recorded as shape files using Arc\Info Geographical Information Systems (GIS) software. Impervious areas were categorized as buildings (rooftops) and transportation (paved and unpaved roads and road shoulders, driveways and parking lots). The shape files were utilized by a GIS system to compute percent impervious surface for the entire watershed (Figure 10). The digitizing effort was a collaboration between the Grand Traverse County Drain Commissioner's Office and a group of Environmental Science students from Traverse City West Senior High School. This collaborative approach was an integral part of the Public Outreach/Education component of the Long Lake Watershed Nonpoint Source Pollutant 319 grant.

Examination of the impervious surface map demonstrates that the watershed as a whole has a very low percentage of impervious cover (Figure 10). This is to be expected due to large areas of agricultural and open space (see land use map, Figure 8), and the relatively concentrated development around the lakeshore and in several major subdivisions. Of the 14,435 acres in the watershed, 432.2 acres were identified as impervious surface, constituting a total of 3 percent of the total watershed area. Several sources of inaccuracy may be inherent in this calculation: 1) The small portion of the watershed which resides in Leelanau County (the northeast tip of the watershed) was not digitized due to lack of available aerial photographs. This area is relatively sparsely

populated, and probably does not contribute significantly to additional impervious area. 2) The digitizing process was performed, in large part, by volunteer high school students with limited training. The students were required to practice digitizing a selected area and to compare results from repeated measurements in order to improve their consistency. 3) As mentioned previously, the inherent tree cover surrounding Long Lake likely reduced the digitizing accuracy by obscuring visible structures. Given the range of this variability, it is probable that the percent impervious surface for the Long Lake watershed is in the range of 3 to 5 percent. This amount of impervious surface is considered good. However, as the population density increases over the next 20 years, it is entirely possible that there will be distinct areas within the watershed which may exceed levels of impervious cover considered necessary to limit surface water runoff and maintain the integrity of surface and groundwater resources.

Figure 10. Impervious surface analysis of the Long Lake Watershed.



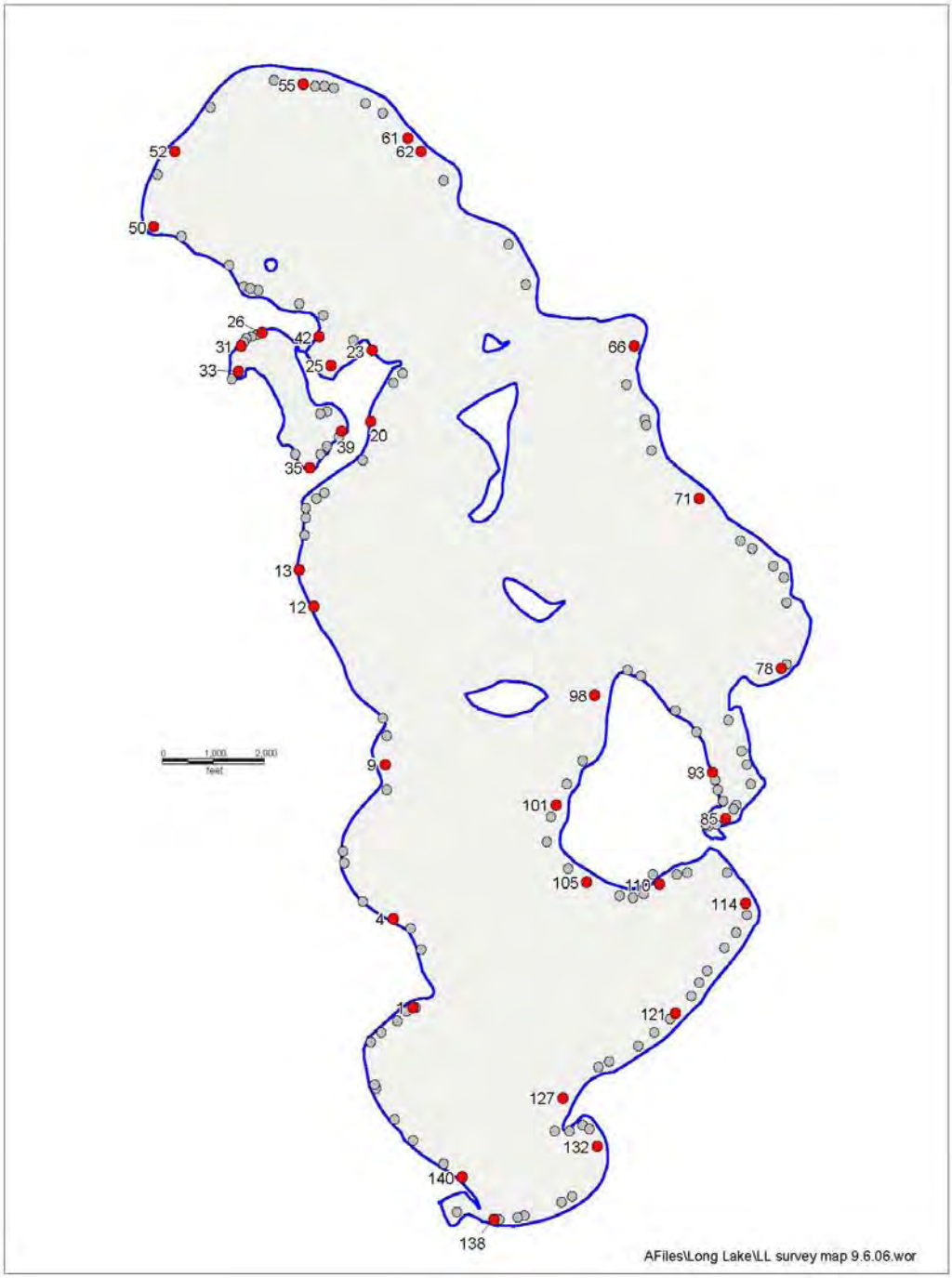
Shoreline Survey of Long Lake

In addition to water quality monitoring of Long Lake, a visual observation of the lake nearshore areas was completed to determine instances of erosion, sedimentation, possible nutrient enrichment and well as observation of lakeside residences which might have outdated septic systems contributing nutrients or bacterial contamination to the lake (full report attached in Appendix E1). A summary is provided here.

The shoreline survey was conducted by Great Lakes Environmental Center (GLEC) along with members of the Long Lake Association over several days in August, 2006. The survey was completed using a pontoon boat which was able to move close to shore to enhance the visual observations. Global Positioning System (GPS) readings were taken at designated sites (Figure 11) and relevant observations regarding shoreline characteristics (aquatic vegetation, erosion, homeowner landscaping, age of structures) was recorded for each site. These observations were used as a basis for determining sediment sampling sites, bacterial monitoring sites which were conducted later in the summer by GLEC.

Examination of the data collected by GLEC and the Long Lake Association in the shoreline survey did not show any new significant areas of concern that were not already documented by the soil erosion survey or identified previously by members of the Long Lase Association. A number of older residential structures were noted as possible sources of leaking septic systems. This information was used by Long Lake Township during the proposed implementation of a Time of Sale or Transfer (TOST) septic inspection program (see **Figure**). The occurrence of high aquatic plant density in various spots on Long and Mickey Lakes was observed. In addition, lakeside residences with landscaping to the waters edge (e.g., lawn) or sites without a buffer area of native vegetation were noted. Continuing education of riparians is necessary, in the absence of specific zoning, to address the lack of buffer areas and to elucidate the importance of vegetation buffers in maintaining lake water quality. Overall, Long and Mickey Lake shorelines appeared to be stable with no significant problem areas. The relatively high lakeside population continues to pose a challenge in terms of nutrient runoff from landscaping. Although a few erosion sites were noted, these sites did not seem problematic. The relatively high lakeside population continues to pose a challenge in terms of nutrient runoff from landscaping.

Figure 11. Shoreline survey sites on Long Lake, 2006. Sites in red are sediment sampling sites.



Sediment Sampling of Long and Mickey Lakes

Comprehensive sediment sampling of nearshore areas can be useful in relating observed characteristics of the Lake, such as sparse or dense areas of aquatic vegetation, with sites of likely nutrient enrichment from groundwater runoff. By examining the sediment reservoir of one of the primary plant nutrients, total phosphorus, it was hoped that some insight could be gained to explain the distribution of aquatic plants, as well as identify problem areas which should be addressed through the Long Lake Watershed Management Plan or through an aquatic plant management plan.

Sampling sites for sediment sampling were determined by examining the data from the Shoreline Survey.. Sites were chosen based on visual observation notes (possible areas of concern) and were also chosen to provide a geographical balance by distributing the sites around the lake. Sites chosen for sediment sampling are shown in Figure 11. (full description in Table 1, Appendix E2). Sediment was obtained nearshore by a the use of a dredge and samples were analyzed for total phosphorus and percent solids. The value for percent solids is an indication of the organic content of the sample. The higher the percent solids (e.g., sand), the less organic matter in the sample. As the proportion of organic matter in the sample increases (lower % solids), the greater the ability of the sediment to capture phosphorus. Results are shown in Table 8.

In general, sediment phosphorus levels were low, usually less than 30 mg/kg dry weight. This may be due in part to a lower organic content in many of the samples.

Ten sampling sites which had concentrations greater than 40 mg/kg dry weight were identified (Table 8, Appendix E2), and checked against the observations in the shoreline survey. In many cases, Eurasian milfoil was present near the site, particularly in the northern extent of the lake, as well as the southeast corner below the peninsula, and in some areas near Mickey Lake. In a majority of the cases, there were also suspected septic problems, erosion noted, or closely spaced cabins near the water. Five of these ten sites (#'s 25,33,29,61 and 85) had phosphorus concentrations in excess of 100 mg/kg dry weight, and should be watched to see if they become problem areas for aquatic vegetation or algal blooms. For reference, two randomly selected sites which were deemed "Clear sites", with no aquatic vegetation and no observed algal problems, exhibited phosphorus concentrations of 27 and 11 mg/kg dry weight. Additionally, the sediment phosphorus concentrations determined in the deep sampling spots in Long Lake (see Water Quality

Monitoring), phosphorus appears to be accumulating in these deeper areas as opposed to the shallow nearshore areas.

Table 8. Total Phosphorus (kg/mg dry weight) and Percent Solids of Nearshore Sediment

Sampling Site #	Total Phosphorus (mg/kg dry wt)	Percent Solids
1	21.49	63.16
4	15.48	73.91
9	7.37	70.81
12	11.79	63.39
13	**44.31**	66.87
20	14.33	72.38
23	20.67	72.22
25	**101.9**	71.58
26	25.86	61.86
31	22.04	35.41
31 (duplicate)	23.15	36.46
33	**168.4**	3.84
35	**80.6**	2.61
39	**189.5**	3.7
42	14.2	59.44
50	10.96	69.08

Sampling Site #	Total Phosphorus (mg/kg dry wt)	Percent Solids
52	**52.15**	54.57
55	**58.87**	68.75
61	**179.8**	64.99
62	29.08	67.08
66	16.83	65.29
66 (duplicate)	15.4	37.01
71	10.52	69.68
71 (duplicate)	10.99	67.15
78	17.57	64.94
85	**278.7**	5.25
85 (duplicate)	**272.1**	5.09
93	3.65	74.61
98	7..95	70.19
101	**47.21**	57.42
105	26.04	69.2
110	15.58	74.34
114	237	22.01
121	13.54	61.25
127	8.23	75.83

Sampling Site #	Total Phosphorus (mg/kg dry wt)	Percent Solids
132	12.18	73.65
138	12.95	70.64
140	7.64	73.99
Random Clear 1	27.26	64.82
Random Clear 2	11.29	73.49
Samples in Boldface exceed 40 mg/kg dry weight		

Bacterial Monitoring of Long and Mickey Lakes

Bacterial monitoring on Long and Mickey Lakes was completed in conjunction with the 2006 shoreline survey. Samples were chosen based on observations from the shoreline survey completed earlier in the summer. Shoreline survey sites which identified older structures with probable original septic systems, older structures with little lakeside setback, and closely spaced groups of cabins or cottages were chosen as some of the bacterial monitoring sites. Twelve sites, geographically spread around Long and Mickey Lakes, were chosen for monitoring (Figure 11, site numbers listed in Table 9). Samples were all analyzed for *E. coli* using EPA Method 1603. An indicator organism, such as *E. coli*, is used to determine fecal contamination. The presence of *E. coli*, a normally non-pathogenic intestinal organism of warm-blooded animals, is easy to test for and is relatively more abundant than the human enteric pathogens, thus leaving a safety margin for the detection of disease-causing organisms. *E. coli* is considered a more specific indicator of fecal contamination than fecal coliforms since the more general

test for fecal coliforms also detects non-fecal coliform bacteria. Currently, the State of Michigan single day standard for *E. coli* is 300 CFU (colony forming unit) per 100 mL sample, based on triplicate samples. It was decided that bacterial monitoring on Long Lake would preliminarily use single samples (rather than triplicates) in order to find any potential "hot" spots. These hot spots could then be resampled, as necessary, in triplicate to determine whether or not they exceed the State of Michigan standards.

The results of the bacterial testing did not indicate high numbers of *E. coli*, suggesting that fecal contamination in Long Lake at these suspected sites was not a problem. The data (Table 9) show that only two sites of the twelve monitored had bacterial counts greater than 1 CFU per 100 mL sample, and these sites had counts of 4 and 6 CFU/100 mL. These concentrations are extremely low. It should be noted that bacterial concentrations can be quite transient, and therefore any sample collection may miss a potential septic discharge if it isn't collected within 48 – 72 hours of a discharge. In addition, the dilution effect of the lake water can also reduce concentrations. However, the consistently low bacterial concentrations observed in Long Lake do not suggest that this is would be an ongoing concern. Periodic reexamination of *E. coli* concentrations at those sites identified as possible contamination spots would be easy and cost effective.

Table 9. Levels of *E. coli* bacteria at selected nearshore monitoring sites on Long and Mickey Lakes, August, 2006. Sampling site numbers correspond to locations shown in Figure 11.

Sampling Site	Concentration (CFU/100 mL)*
1	**0****
13	**1**
20	**0**
26	**1**
35	**6**
61	**0**
66	**4**
78	**1**
114	**1**
121	**1**
138	**1**
140	**1**
*CFU = Colony forming Unit	
** State Standard for singe event sample	
(based on geometric mean of 3 replicates) = **300 CFU/100 mL**	

Analysis of Possible Septic System Failures

In 2008, Long Lake Township contracted with William & Works, consulting engineers to investigate the extent of the problem of failing septic systems. This work was utilized to develop a detailed analysis of the technical basis and justification for a Time of Sale or Transfer Inspection Program (TOSTIP) for on-site wastewater disposal systems.

According to William & Works, industry reports indicate that septic systems, if properly installed and maintained under optimal conditions, will have a lifespan of twenty to thirty years. Factors that could shorten the lifespan of the septic system include water logging the system by doing multiple loads of laundry within a short period of time, increased usage from more people living within a home, disposing of items not intended to be in the septic system such as cooking grease, and damage from driving vehicles across the drain field and crushing the pipe network.

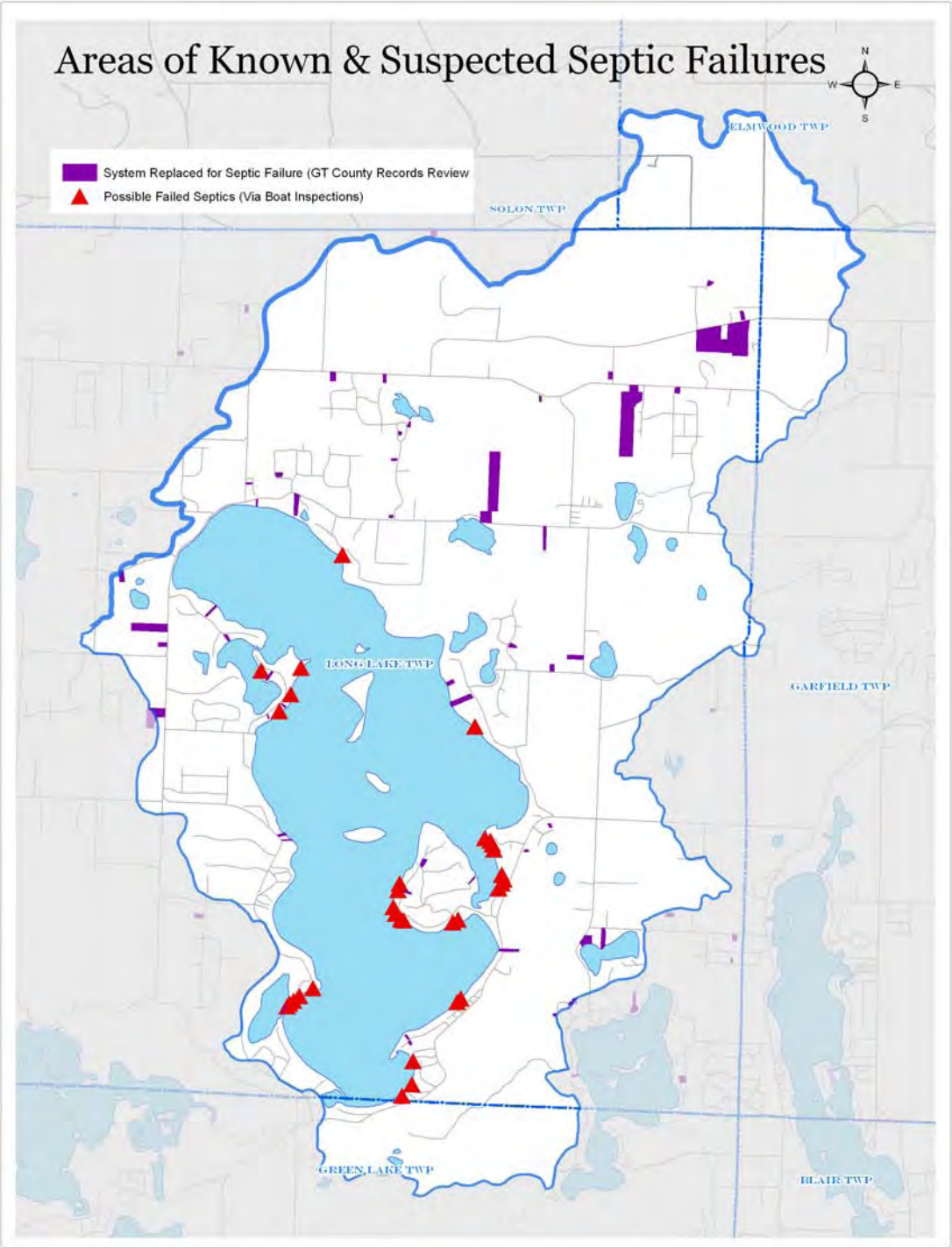
The on-site conditions in which a septic system is installed can affect its longevity. Septic systems that are located in areas with sandy soils and higher water tables, or in areas with poor drainage will not be able to operate as efficiently as systems that are installed in optimal conditions.

Forty percent of the homes were constructed before 1980. Based on typical system longevity of twenty to thirty years, those that have not been replaced may have failed or may be on the verge of failing soon. In fact, since 1990, only six percent of the existing septic systems in the Township have been replaced. This is about one third to one quarter of what would be expected, and it may indicate either extraordinary system longevity or failed (or failing) systems still in service.

In lake shore neighborhoods, the septic systems are often placed in sandy soils where the water tables are higher, potentially at nearly the same elevation as the surface water. Thus there is often less filtration of the effluent and a direct hydraulic connection to the lake. As effluent leaks out of the system and into the lake, the higher nutrient levels can result in unnatural algae blooms which may be an indicator of possible water contamination harmful to aquatic life. Beyond algae blooms, the high nutrient levels caused by failing septic systems start a chain of environmental consequences that accelerate the eutrophication of the lake. The Long Lake Association has already noted approximately thirty-seven sites along Long Lake that show indications of possible septic

system failure and leakage into the surface water. Figure 12 shows locations of possible failed septics established during the shoreline survey in 2006, and also the locations of failed/replaced septic systems in Long Lake Township. Based on these numbers, failing septic systems have become a concern for Long Long Township which has led to the adoption of a “time of sale or transfer” (TOST) inspection program, which is anticipated to identify a number of these failed systems annually.

Figure 12. Location of failed/replace septics in Long Lake Townsip and potential failed septics in riparian areas surrounding Long Lake.



5.0 THREATS/ SOURCES/ CAUSES

Threats to Designated Uses

In many watershed plans there is a focus on restoring protected use impairments due to water pollution sources, as indicated by non-attainment of water quality standards in the 303(d) list. In the Long Lake watershed, water quality standards are being met based upon the currently available information Therefore, the overall intent of this watershed plan is to protect the existing high water quality of the lake and associated protected uses by carefully monitoring priority threats, and addressing sources of detected problems *before* they cause designated use impairments.

Based on the Source Inventories presented in Chapter 4, comprehensive analyses of the Long Lake Watershed have demonstrated that although all the state designated uses are currently supported, there are several uses which can be considered threatened in localized areas. These designated uses, watershed concerns, and potential sources are listed in Table 10 and discussed below.

Table 10. Pollutants or Stressors potentially affecting Designated Uses in the Long Lake Watershed.

Pollutant or Environmental Stressor	Designated Uses Potentially Affected
Sediment	Warmwater Fishery Other Indigenous Aquatic Life Navigation (**Not impacted for Long Lake**)
Nutrients	Warmwater Fishery Other Indigenous Aquatic Life Total Body Contact
Thermal Pollution	Warmwater Fishery (**Not impacted for Long Lake**) Other Indigenous Aquatic Life (**Not impacted for Long Lake**)
Toxins **(Pesticides, Herbicides, Oils, Gas, Grease, Salt/Chlorides)**	Warmwater Fishery Other Indigenous Aquatic Life
Invasive Species	Warmwater Fishery Other Indigenous Aquatic Life

Pollutant or Environmental Stressor	Designated Uses Potentially Affected
	Navigation Total Body Contact Recreational
Pathogens **(*E. Coli* and Fecal Coliform indicators)**	Total Body Contact Recreational
Loss of Habitat	Warmwater Fishery Other Indigenous Aquatic Life

Pollutants & Stressors/Suspected Sources

The pollutants and environmental stressors listed in Table 10 may come from a variety of sources and may be caused by different processes. Table 11 summarizes the known, suspected or potential sources and causes of these listed pollutants/stressors. It should be clarified that thermal pollution is listed as one of the known stressors which impacts many watersheds in Michigan. However, the Long Lake Watershed, particularly Long Lake, does not have any contributing stream inputs and is primarily spring fed. Much of the surface water runoff in lakeside property is intercepted by vegetation or stormwater management practices. Therefore, there is little expected thermal impact on Long Lake, and no impact is indicated in Table 11.

Table 11. Pollutants/Stressors, Sources and Causes of Potential Water Quality Degradation in the Long Lake Watershed.

Environmental Stressor or Pollutant	Threatened Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
Sediment	Warmwater Fishery Other Indigenous Aquatic Life	Bank/Shoreline Erosion (k)	Removal of riparian vegetation (k) Boat traffic/wakes (k) Recreational activities (k) Sandy soils (k)
		Construction (k)	Poor soil erosion practices (p)
		Urban/Agricultural/ Rural Storm Water (k)	Poor storm water management practices Wetland Filling (s) (k)
		Poor storm water management practices (k)	Non-compliance with permits (k) Development (k)
Nutrients	Warmwater Fishery	Residential or Commercial Fertilizer Use (k)	Improper application (amount, timing, frequency, location, method, P content) (k)
		Septic Systems (s)	Poorly designed, sited, and

Environmental Stressor or Pollutant	Threatened Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
	Other Indigenous Aquatic Life		maintained (s) High density/age of system (s)
		Urban/Agricultural/ Rural Storm Water (k)	Poor storm water management practices (k) Development (k)
	Total Body Contact, Recreation	Lack of Riparian Buffer (k)	Development (k) Clearing by landowner (k) Lack of adequate shoreline setbacks (p)
		Agriculture (s) (fertilizer, manure, & livestock)	Improper application (amt., timing, freq., location, method, P content) (s) Improper storage/handling/application (p)
		Animal Waste (k)	Wild/domestic animals along shore & beach areas (k)

Table 11. Pollutants/Stressors, Sources and Causes of Water Quality Degradation in the Long Lake Watershed.

Environmental Stressor or Pollutant	Threatened Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
Toxins **(Pesticides, Herbicides, Oils, Gas, Grease, Salts/Chlorides, Etc.)**	Warmwater Fishery Other Indigenous Aquatic Life	Urban/Agricultural/ Rural Storm Water (k)	Poor storm water management practices (k)
		Motor Boats (k)	Inefficient (2-cycle) or poorly maintained watercraft motors (k) Fuel spills (p)
		Improper Chemical Use/Disposal (s)	Poor public knowledge of consequences (s) Lack of disposal facilities and/or limited hours of operation (s)
		Illegal Dumping (p)	Lack of restrictions and enforcement (p)
		Road Salt in Winter (k)	Runoff from roads (k)
Invasive Species	Warmwater Fishery Other Indigenous Aquatic Life	Boat Hulls and Bilges (k)	Lack of restrictions on boat travel (k) Lack of public knowledge on impact (k)
		Other Biota (i.e. birds, frogs) (k)	'Hitching' a ride (k)

Environmental Stressor or Pollutant	Threatened Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
	Navigation Total Body Contact, Recreation	Accidental Human Intro (k)	Lack of public knowledge on impact (k)
Pathogens **(*E. Coli* and Fecal Coliform indicators)**	Total Body Contact, Recreation	Urban/Agricultural/ Rural Storm Water (k)	Poor storm water management practices (k)
		Animal Waste (k)	Geese/ducks along shore & beach areas (k) Other wild/domestic animals (k)
		Illegal Discharges from Boats (p)	Lack of enforcement (p) Lack of public knowledge on impact (k)
		Septic Systems (s)	Improperly designed and maintained septic systems (s)

Table 11. Pollutants/Stressors, Sources and Causes of Water Quality Degradation in the Long Lake Watershed.

Environmental Stressor or Pollutant	Threatened Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
Loss of Habitat	Warmwater Fishery Other Indigenous Aquatic Life	Development (including 're-development') (k)	Poor development and design practices (k) Lack of knowledge on impact (k) New construction (p) Inadequate laws or regulations (p) Lack of adequate enforcement (p) Habitat fragmentation (k) Wetland loss (k)
		Shoreline Erosion & Stabilization (k)	Wave/ice action (k) Improperly designed/sited sea walls (k) Removal or lack of riparian vegetation (k)
Thermal Pollution	**Long Lake not impacted by Thermal Pollution**	**Long Lake not impacted by Thermal Pollution**	**Long Lake not impacted by Thermal Pollution**

A brief discussion of some of the pollutant/stressors follows to provide background for the development of the Watershed Management Plan.

Sediment

Sedimentation occurs naturally in all lake and stream systems. Sedimenation is the depositon of fine soil and sand particles and can result in the degradation of riparian systems. Excessive sediment can impact the amount of suitable habitat needed to support healthy communities of fish and other aquatic organisms. Significant sources of sediment to streams and lakes include activities that cause bank erosion such as road/stream crossings, boat traffic, removing bank vegetation, users entering and exiting the water Other sources are clearing land for agriculture, development, or other purposes. This also creates a host of other erosion related problems including flooding, polluted runoff, loss of topsoil from surface runoff, and a reduction in fisheries and channel depth. Any kind of excavation, earth moving, drainage, bridging, tunneling, or other activity in which soil is disturbed can result in sediment transport to nearby water systems. Although soil erosion was not noted as a sizeable problem in the Long Lake Watershed, residential and urban development, agriculture and surface water runoff may be sufficient to warrant this pollutant as a concern in the watershed.

Nutrients

Nutrients speed up the natural aging process of lakes and ponds. This process is called eutrophication. The signs of an aging water body are deeper bottom sediments and heavy weed growth. This aging process is very slow, but is quickened by the added sediments, fertilizers, and other organic wastes supplied by runoff from a developed watershed. Nutrients are essential for the growth of living organisms, and phosphorus and nitrogen in particular are important nutrients in aquatic systems. When levels of phosphorus increase in a lake ecosystem, there can be an increase in the presence of rooted aquatic plants, and result in algal blooms. These blooms can reduce the amount of available oxygen in the water, and possibly impact other aquatic life. Comprehensive monitoring on Long Lake has shown that the lake phosphorus level has remained in the

oligotrophic range, but is on the edge of the mesotrophic scale. Management strategies which will limit nutrients, including phosphorus, will maintain the current water quality of the lake and the watershed.

Toxins

Toxic substances such as pesticides, herbicides, oils, gas, grease, and metals often enter waterways unnoticed via stormwater runoff. These types of toxins are perhaps the most threatening of all the watershed pollutants because of their potential to affect human and aquatic health. It is highly probably that at any given moment, somewhere in the watershed there is a leaking automobile radiator, a landowner applying herbicides or pesticides to their lawns, or someone spilling gasoline while filling up their car. Every time it rains, these toxic pollutants are washed from the roads, parking lots, driveways, and lawns into the nearest storm drain or road ditch, eventually reaching nearby lakes and streams. Each winter, hundreds of tons of road salt and sand are spread over area roadways; when spring rolls around, it all gets washed into the nearest waterway. Additionally, farms, businesses, and homes throughout the watershed are potential sites of groundwater contamination from improperly disposed and stored pesticides, solvents, oils, and chemicals.

Invasive Species

Invasive species are organisms that are introduced into areas where they are not native. While many exotic species are introduced accidentally, others are intentionally released, often to enhance recreational opportunities such as sport fishing. Not all invasive species are considered detrimental, particularly if they do not impact the native ecosystem. Species are considered a nuisance when they disrupt native species populations and threaten the ecology of an ecosystem as well as causing damage to local industry and commerce. Without pressure from the competitors, parasites, and pathogens that normally keep their numbers in check, invasive species, may undergo large population increases. In the Long Lake Watershed, the invasive aquatic plant Euarsian Water Milfoil, (EWM) has become established in Long Lake. In other lakes in Michigan, EWM has become a significant problem, choking out most native vegetation, impairing navigation and swimming activities. Currently, Long Lake has a stable but small

population of EWM. The Long Lake Association is aggressively monitoring and managing this invasive species.

Pathogens

Pathogens are organisms that cause disease and include a variety of bacteria, viruses, protozoa and small worms. These pathogens can be present in water and may pose a hazard to human health. The US Environmental Protection Agency (EPA) recommends that freshwater recreational water quality be measured by the abundance of *Escherichia coli* (*E. coli*) or by a group of bacteria called *Enterococci*. Michigan has adopted the EPA's *E. coli* water quality standards.

With respect to Long Lake, surveys conducted in the 1970's demonstrated that elevated levels of total coliform, fecal coliform and fecal streptococcus bacteria were found at several locations on the lakeshore, presumably from leaking or poorly maintained septic systems. However, since that time, improvements have been made at some of the identified "hot spots" (e.g., the Girl Scout Camp on the northeastern shore). A bacterial analysis of likely high nutrient, near shore areas (as determined by a 2006 shoreline survey) did not identify high levels *of E. coli*. It is also important to recognize that the presence of fecal coliform bacteria or *E.* coli (a specific fecal coliform bacterium) is not definitive evidence of septic leakage, because many warm blooded birds and mammals also excrete these organisms. Therefore, although there is a general public concern about leaking or nonfunctional septic systems contributing bacteria and nutrients to the lake, there are no recent supporting data to determine whether or not designated uses are threatened from this source. A general information and education program for septic system maintenance would be a good strategy within the context of lake management, and development of an effective approach for assessing the presence of any current bacterial contamination should be initiated.

Loss of Habitat

Habitat loss is a function of degradation and fragmentation. Habitat degradation is the diminishment of habitat quality and its ability to support biological communities. It stems from the adverse effects of urban development, such as increases in impervious

surfaces within watersheds. Its adverse effects can be immediate or cumulative. Habitat loss is the outright destruction of habitat, such as filling a wetland or channelizing a section of stream. Its impacts upon biological communities are immediate and catastrophic. Habitat fragmentation is the piecemeal disassembly of terrestrial habitats into discontinuous, oftentimes isolated, patches as a consequence of development. Its adverse effects are cumulative and not immediately noticeable. Habitat fragmentation stems from habitat loss. In the Long Lake Watershed, as residential, commercial and urban development continues, there is the potential for habitat losses in both aquatic and terrestrial systems.

Thermal Pollution

Not normally thought of as a pollutant, heated stormwater runoff and elevated stream temperatures are a concern in developing watersheds like Long Lake. When water temperature increases, its ability to hold dissolved oxygen decreases, thereby reducing the available amount of oxygen in the water to fish and other aquatic life. As stated previously, The Long Lake Watershed does not consider thermal pollution to be a problem, as there are no direct stream or stormwater inputs to Long Lake. Therefore, this pollutant will not be addressed.

Pollutant Priority Ranking

The pollutants listed above were ranked and prioritized based on their potential or actual impact on the watershed's threatened designated uses (Table 11, above). Overall, nutrients were given the highest high priority the Long Lake Watershed, followed by invasive species and sediment (Table 12). The Long Lake Association has placed a priority on monitoring for nutrients and invasive species, which they feel impact the water quality of the Lake to the greatest degree. Sediment is a high priority pollutant in the surrounding watershed. Maintaining the high quality, oligotrophic status for Long Lake requires minimizing the amount of nutrient pollution that enters the lake from all possible sources that are controllable. Pathogens have also been identified as in important priority, as there is a concern that there may be a significant number of aging, nonfunctional septic systems in the watershed as a whole, and particularly in the near shore area of Long Lake.

Table 12. Pollutant Priority Rankings for the Long Lake Watershed

Pollutant	Priority Ranking
Nutrients	**1**
Invasive Species	**2**
Sediment	**3**
Pathogens (E. coli)	**4**
Loss of Habitat	**5**
Toxins	**6**

Runoff and Pollutant Loading Estimates - Current and Future Scenario

In order to help identify critical areas within the watershed and priority areas for protection, an overall watershed runoff analysis was completed using the Long-Term Hydrologic Impact Assessment (L-THIA) model developed by Purdue University in cooperation from the US EPA(see http://www.ecn.purdue.edu/runoff/lthia/lthia_index.htm). This model utilizes inputs of land use type and area, as well as hydrologic soil group to provide estimates expected runoff and nonpoint source pollutant loading within a watershed.

For the Long Lake Watershed, the most current land use figures were used (Grand Traverse County, MI) as well as projected land use in 2020 (Chapter 3, Current and Future Land Use, presented above). These land use values were utilized by the L-THIA model to generate runoff and pollutant loading values. Runoff, phosphorus and suspended solids loading rates are shown in Table 13. Full L-THIA model results are presented in Appendix C1.

The average total annual runoff (acre-ft) would be expected to increase by 57%, based on the projected land use changes in 2020 (Table 13). The largest contributors would be commercial and residential land use. Of great concern is input of phosphorus and sediment into waterbodies in the watershed. Estimated total yearly increases of phosphorus and sediment in the watershed are 15% and 29%, respectively (Table 13) by the year 2020. The anticipated increase in urbanization (conversion of non urban lands to residential and commercial/industrial use) would likely be responsible for these nonpoint source pollutants.

Septic systems are also a concern within the watershed, particularly those sited on or near surface water bodies such as Long and Mickey Lakes. As septic systems age, they may function poorly, leak or fail all together leading to additional introductions of nutrients to surface and groundwater, as well as contribute sources of bacterial and pathogen contamination.. The impact of these systems is influenced by system age and design, soil type, use of the system and the relative proximity to surface and groundwater sources. The Long Lake Township has prioritized septic systems in current ordinances, developing and passing a “Time of Sale or Transfer” septic inspection program. What is missing, however, is methodology for estimating loading from poorly functioning or failed septics. This is anticipated to be a priority area in the coming years for the Township and the Watershed.

Table 13. Current (Year 2000) and projected (Year 2020) runoff volume, phosphorus and suspended solids for the Long Lake Watershed.

	Current (Year 2000)			*Projected (Year 2020)*		
Land use	***Runoff (acre-ft)***	***Phosphorus (lbs)***	***Suspended Solids (lbs)***	***Runoff (acre-ft)***	***Phosphorus (lbs)***	***Suspended Solids (lbs)***
Industrial	***1.87***	***1***	***309***	***34.99***	***26***	***5769***
Commercial	***9.95***	***8***	***1504***	***94.99***	***82***	***14364***
Residential (Low Density)	***26.51***	***41***	***2962***	***47.27***	***73***	***5280***
Agricultural	***180.27***	***638***	***52555***	***166.81***	***590***	***48631***
Forest	***0***	***0***	***0***	***0***	***0***	***0***
Rangeland	***2.40***	***0.065***	***6***	***2.19***	***0.059***	***5***
Water/Wetlands	***0***	***0***	***0***	***0***	***0***	***0***
Total (Annual)	***221.02***	***688.065***	***57,336***	***346.27***	***771.059***	***74,049***

Current and projected loading estimated using the Long-Term Hydrologic Impact Assessment (L-THIA) model

Defined Critical Areas

In order to best define and control non-point source pollutants, critical areas contributing to non-point source pollution should be determined within the watershed. Critical areas are areas of the watershed which contribute the majority of pollutants to the waterbodies, or are of specific concern demonstrating a significant likelihood of impacting designated uses. By focusing on critical areas, it is easier to prioritize specific concerns, identify pollutants and design appropriate implementation strategies to reduce these pollutants.

The critical areas were identified by analyzing the Pollutant/Sources/Causes table (Table 11) and identifying the major areas where most of the threats to water pollution exist. Other resources used to identify the priority areas include stakeholder recommendations, DEQ water quality reports, Long Lake shoreline survey, and monitoring data accumulated during the course of this project.

The critical areas for the Long Lake Watershed include the following areas (Table 14**,** Figure 13):

Riparian Corridors: Areas within 1,000 feet of bodies of water (Long Lake, various pothole lakes)

Wetlands: All wetlands and areas within 1,000 feet of wetlands identified in the Watershed

Agricultural Areas – Areas defined as active agricultural use

City and Village Centers: Urban areas that may contribute stormwater runoff to waterbodies or to groundwater recharge sites. This is broken down into the following: Planned high density village area, General business zoning and local business zoning.

Septic: Areas immediately surrounding suspected failed septics

Figure 13. Critical areas in the Long Lake Watershed.

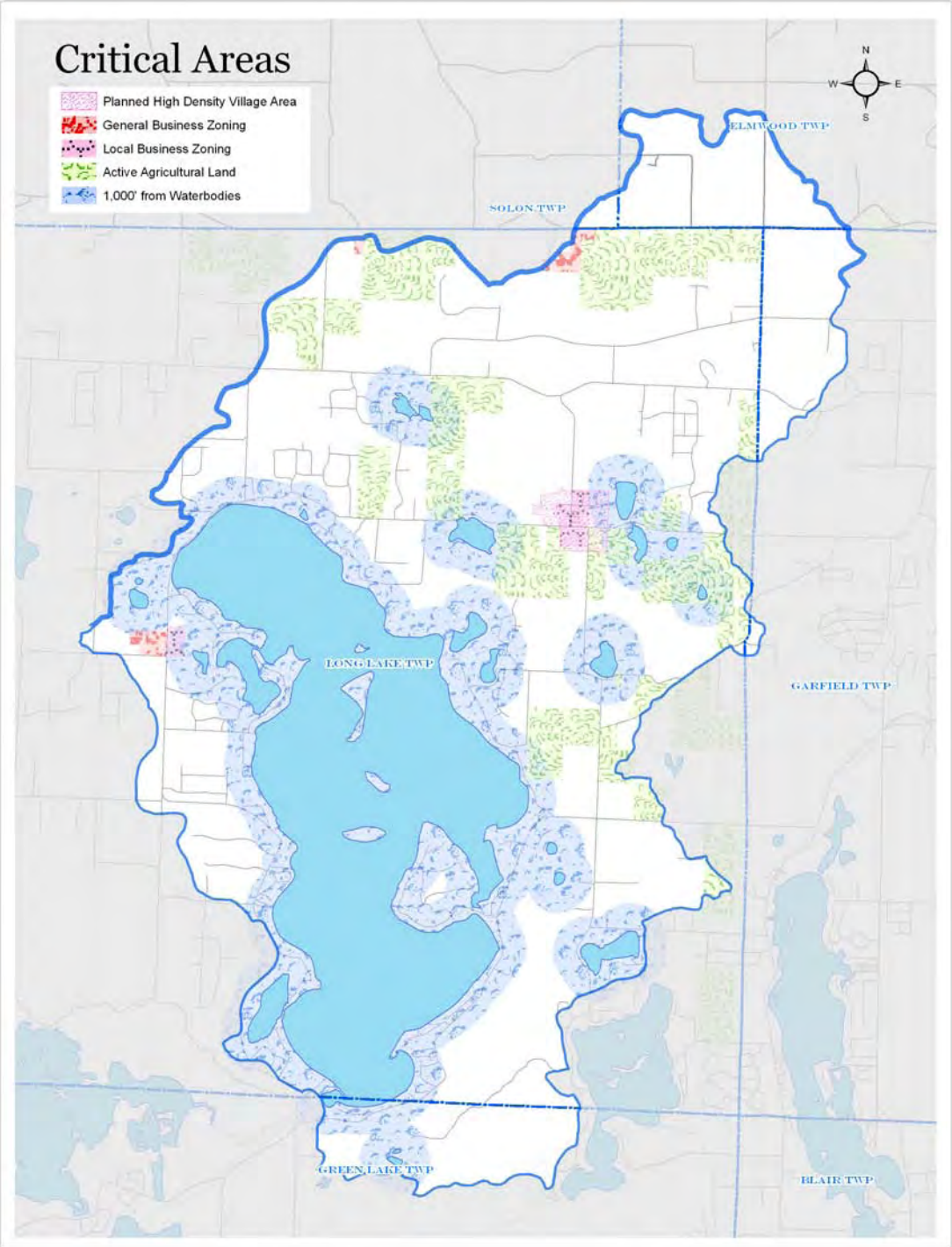


Table 14. Critical areas for the Long Lake Watershed.

Critical Area	Highest Priority Contributing Pollutants	Priority Causes
Riparian Corridors	Nutrients, Sediment, Pathogens	*Sediment*: Road crossings, Bank erosion, Stormwater, Wetland filling *Nutrients*: Fertilizer, Stormwater, Lack of buffers *Pathogens:* Septic Systems
Wetlands	Sediment , Nutrients	*Sediment*: Wetland filling *Nutrients*: Reduction of wetlands
Agricultural Areas	Sediment , Nutrients, Toxins	*Sediment*: Erosion control Stormwater, *Nutrients*: *Nutrients:* Fertilizer, *Toxins:* Pesitide applications
City and Village Centers	Sediment , Nutrients	Stormwater
Septic Fields	Nutrients, Pathogens	Failing septic systems

Defining various critical areas allows for a better determination of which appropriate Best Management Practices (BMPs) should be utilized. BMPs are any structural, vegetative, or managerial practices used to protect and improve surface water and groundwater. For Best Management Practices to be effective, the correct method, installation, and maintenance need to be considered for each site. Addressing each of these factors will result in a conservation practice that can prevent or reduce nonpoint source pollution. Table 15 lists potential

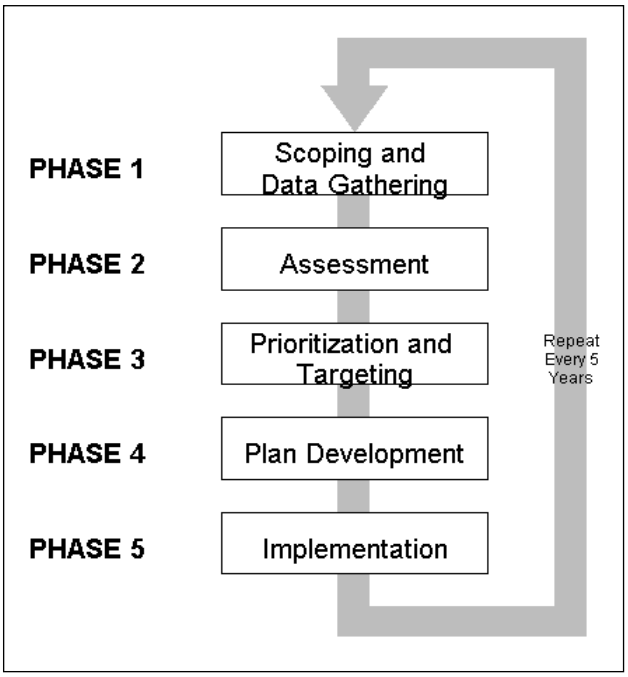
systems of commonly used Best Management Practices (BMPs) that deal with various types of pollutant sources, as well as where to find more information about each type of BMP.

Table 15. BMP Examples by source and type.

Source	Potential System of BMPs (not inclusive)	BMP Manual
Animal Waste	Watercourse crossings Riparian buffers	Michigan Ag BMP Manual Guidebook of BMPs for Michigan Watersheds
Bank/Shoreline Erosion	Stream bank stabilization	Guidebook of BMPs for Michigan Watersheds
Construction	Construction barriers Staging and scheduling	Guidebook of BMPs for Michigan Watersheds
Development Along Shoreline and Wetlands	Workshops, Brochures, Flyers, Videos, Etc.	Public Information and Education Strategy
Lack of Streamside Canopy and Riparian Buffer	Riparian buffers	Guidebook of BMPs for Michigan Watersheds Natural Resources Protection Strategy for Michigan Golf Courses
Purposeful & Accidental Human Intro of Exotic Spp	Workshops, Brochures, Flyers, Videos, Etc.	Public Information and Education Strategy
Reduction of Groundwater Recharge	Infiltration basins	Guidebook of BMPs for Michigan Watersheds

Source	Potential System of BMPs (not inclusive)	BMP Manual
	Grassed waterways	Stormwater Management Guidebook
Residential/Commercial Fertilizer Use	Workshops, Brochures, Flyers, Videos, Etc.	Public Information and Education Strategy
Septic Systems	Workshops, Brochures, Flyers, Videos, Etc.	Public Information and Education Strategy
Stormwater and Impervious Surfaces	Check dams Grassed waterways Stormwater conveyance outlets Infiltration basins Porous asphalt pavement	Stormwater Management Guidebook Guidebook of BMPs for Michigan Watersheds Public Information and Education Strategy

Adapted from the Grand Traverse Bay Watershed Protection Plan, 2003



6.0 WATERSHED MANAGEMENT GOALS AND OBJECTIVES

The Long Lake watershed is a high quality area which currently features a major oligotrophic lake, and currently meets all designated use guidelines as set forth by the State of Michigan. Based on stakeholder and Long Lake Partnership input, monitoring and source inventories, and identification of specific areas of concern, a set of comprehensive goals and objectives have been developed to help maintain or improve the water quality in the Watershed and continue to meet specific designated use requirements.

Watershed Management Goals

The following goals and objectives have been developed for the Long Lake Watershed:

Table 16. Long Lake Watershed management goals, designated/desired uses addressed and specific pollutants addressed.

GOAL	Designated or Desired Use Addressed	Pollutant/Stressor Addressed
1. Protect and improve the quality of the water resources in the Long Lake Watershed	Warm water fisheries Partial/Total body contact OtherAquatic Life Navigation	Nutrients Sediment Invasive Species Toxins Pathogens
2. Protect aquatic and terrestrial ecosystems within the watershed	Warm water fisheries Other aquatic life Desired Use: Ecological Diversity	Nutrients Sediment Toxins Invasive species
3. Establish long-term effective strategies for monitoring and managing aquatic and terrestrial watershed resources	Warm water fisheries Other Aquatic life wildlife	Nutrients Sediment Invasive Species
4. Protect groundwater quality and natural hydrology within the watershed	Other Aquatic Life	Nutrients Toxins
5. Establish comprehensive land-use strategies to conserve and protect natural resources in the watershed	Warm water fisheries Partial/Total body contact Desired Use: Recreation	Sediment Nutrients
6. Develop and promote information and educational programs that support stewardship, and support goals, and objectives of the watershed plan	Agriculture Warm Water Fisheries Partial/Total Body Contact Navigation Other Aquatic Life Fish Consumption	Nutrients Sediment Invasive Species Toxins Pathogens

Objectives and Tasks

Individual project objectives and tasks have been developed to achieve the watershed management goals. For each objective, specific tasks are enumerated, as well as projected costs and timeline for completion.

Table 17. Long Lake Watershed Management Goals, Objective, relevant tasks, organizational responsibilites and timeline.

GOAL 1. Protect and improve the quality of the water resources in the Long Lake Watershed.

Objective	Task	Responsible Organization (Priority Level; Lead or Support)	Completion Timeline
1.A Maintain or reduce nutrient and sediment loading to all water bodies in the Watershed	1.A.1 Continue comprehensive monitoring of potential sources of nutrients and sediment in Long Lake and associated waterbodies	Long Lake Association (Lead) Grand Traverse Conservation District, All Townships (Support)	3 years (repeated)
	1.A.2 Calculate/refine nutrient and sediment loading estimates via measurements (if possible) or by refining land-use base modeling estimates	GT County Conservation Dist. / Long Lake Township/All Townhips (Lead) Long Lake Associateion/MDEQ/ (Support)	3 years
	1.A.3 Inventory watershed areas to determine critical locations requiring storm water and/or soil erosion control measures, such as retention basins or vegetated buffer strips.	Grand Traverse County Conservation Dist. /All Townships (Lead); Long Lake Association/ MDEQ/ MSU Extension/Property Owner (Support)	2 years
	1.A.4 Implement establishment of storm water/soil erosion control measures at inventoried critical locations.	GT County Drain Commissioner (Lead) Long lake Association/ Long Lake Township/All Townhips (Support)	8 years

Objective	Task	Responsible Organization (Priority Level; Lead or Support)	Completion Timeline
1.B. Reduce the potential for pathogen contamination in all waterbodies	**1.B.1 Continue investigation and comprehensive monitoring of potential sources and causes of elevated bacteria (*E. coli)* in Watershed waterbodies**	**Long Lake Association; MDEQ All Townships; MSU Extension Grand Traverse County Health Dept. ; Long Lake Association**	**1 year (repeated every 4 years)**
	1.B.2 Develop education programs concerning septic system upgrades and maintenance and provide information to Watershed residents.	**All Townships/ MSU Extension/ Grand Traverse County Health Dept (Lead)**	**3**
1.C. Reduce the potential for misuse or accidental release of toxins in the Watershed.	**1.C.1 Conduct targeted outreach program to increase awareness and education of proper commercial and residential use and storage of pestsicides and other chemical contaminants which may affect the Watershed**	**MSU Extension, All Townships (Lead)**	**7 years**

Table 17. Long Lake Watershed Management Goals, Objective, relevant tasks, organizational responsibilites and timeline.

GOAL 2. Protect aquatic and terrestrial ecosystems within the watershed

Objective	Task	Responsible Organization (Priority Level; Lead or Support)	Completion Timeline
2.A Protect shoreline habitats	2.A.1 Establish riparian shoreline buffer demonstration projects	Grand Traverse Conservation District (Lead) Long Lake Association; Property Owners (Support)	5 years
	2.A.2. Identify and develop a prioritized list of desirable aquatic and terrestrial habitat areas in need of restoration	Grand Traverse Regional Land Conservancy / MDEQ/ MSU (Lead); Long Lake Association/ Extension/Property Owner (Support)	2 years
	2.A.3 Restore or stabilize aquatic and/or terrestrial habitat at prioritized sites.	Grand Traverse Conservation District (Lead) All Townships; MDEQ (Support)	8 years
	2.A.4 Stabilize soil erosion sites on Long Lake previously identified.	Long Lake Township/ GT County Conservation Dist. /All Townhips (Lead) Long Lake Associateion/MDEQ/ (Support)	6 years

Table 17. Long Lake Watershed Management Goals, Objective, relevant tasks, organizational responsibilites and timeline.

GOAL 3. Develop long-term effective strategies for monitoring and managing aquatic and terrestrial watershed resources

Objective	Task	Responsible Organization (Priority Level; Lead or Support)	Completion Timeline
3.A. Establish long-term objectives for managing aquatic macrophytes	3.A.1 Continue comprehensive monitoring for native and invasive plant species in the Long Lake Watershed	Long Lake Association (Lead) All Townships; MDEQ; MSU Extension Professional Environmental Analyst (Support)	1 year (repeated every 5 years)
	3.A.2 Develop and draft a long-term, comprehensive Aquatic Plant Management Plan	Long Lake Association (Lead) All Townships; MDEQ; MSU Extension Professional Environmental Analyst	2 years
	3.A.3 Coordinate and implement targeted outreach activities to increase awareness of invasive species, their spread and control.	Long Lake Township (Lead) Grand Traverse Conservation District; Long Lake Association; MDEQ All Townships; MSU Extension Property Owner (Support)	3 years

Objective	Task	Responsible Organization (Priority Level; Lead or Support)	Completion Timeline
3.B. Establish land management practices which conserve natural resources and protect water quality throughout the Watershed	**3.B.1 Coordinate and implement outreach and educational activities to increase awareness of Best Management Practices which help to conserve Watershed natural resources**	**Long Lake Township (Lead) Grand Traverse Conservation District; Long Lake Association; MDEQ All Townships; MSU Extension (Support)**	**4 years**
	3.B.2 Initiate a review and update the Natural Features Inventory for Long Lake Township to reassess priorities of stakeholders and municipalities	**Long Lake Township (Lead) Grand Traverse Conservation District; Long Lake Association; MDEQ All Townships (Support)**	**1 year**

Table 17. Long Lake Watershed Management Goals, Objective, relevant tasks, organizational responsibilites and timeline.

GOAL 4. Protect groundwater quality and natural hydrology within the watershed

Objective	Task	Responsible Organization (Priority Level; Lead or Support)	Completion Timeline
4.A. Establish and Promote Best Management Practices which limit or modify fertilizer and pesticide applications in agriculture, golf course operations and residential developments to protect groundwater resources	4.A.1 Inventory potential sources of groundwater contamination in the Watershed and related to identified critical areas established in this Watershed Plan	Grand Traverse Conservation District/ Long Lake Association (Lead) All Townships; MSU Extension MDEQ (Support)	2 years
	4.A.2 Work with agricultural and recreational facility managers to implement BMPs to reduce loading of toxins in the Watershed	MDEQ/All Townships/ MSU Extension (Lead) Grand Traverse Conservation District/ Long Lake Township Long Lake Association/ (Support)	4 years
	4.A.3 Work with municipalities to establish retention basins and vegetative buffer strips in inventoried areas which are shown to be subject to potential ground water contamination	Grand Traverse Conservation District (Lead) Long Lake Association; MDEQ All Townships; MSU Extension Property Owner (Support)	10 years

Objective	Task	Responsible Organization (Priority Level; Lead or Support)	Completion Timeline
4.B. Maintain and protect wetlands, small lakes and other groundwater recharge areas in the Watershed	**4.B.1 Promote and enforce restrictions for reduced development on or near wetlands in accordance with DEQ and local zoning**	**Grand Traverse Conservation District/ Long Lake Township (Lead) Long Lake Association/MDEQ All Townships/ MSU Extension (Support**	**10 years**
	4.B.2 Encourage septic system upgrades and maintenance through comprehensive education outreach programs	**Long Lake Township (Lead) Long Lake Association; MDEQ All Townships; MSU Extension (Support)**	**10 years**
	4.B.3 Coordinate and implement outreach and educational activities to increase awareness of BMPs to limit hydrological impacts	**All Townships; MSU Extension (Lead) Grand Traverse County Health Dept (Support)**	**4 years**

Table 17. Long Lake Watershed Management Goals, Objective, relevant tasks, organizational responsibilites and timeline.

GOAL 5. Develop comprehensive land-use strategies to conserve and protect natural resources in the watershed

Objective	Task	Responsible Organization (Priority Level; Lead or Support)	Completion Timeline
5.A. Review all current zoning and master plan documents which impact the Watershed	5.A.1 Create a targeted program in local government units which evaluates current and proposed zoning and evaluates how it impacts natural resources and future development	Long Lake Township (Lead) All Townships Grand Traverse County (Support)	1 year
	5.A.2Coordinate activities with local Conservancies to protect vulnerable land and natural resources within the Watershed	Grand Traverse Regional Land Conservancy (Lead) Long Lake Association; All Townships; (Support)	10 years (ongoing)
5.B. Develop local programs for wetland protection with Watershed stakeholders and local organizations.	5.B.1 Coordinate and implement outreach and educational activities to increase awareness of Best Management Practices and impacts of stakeholder activities on watershed quality and wetlands	Grand Traverse Conservation District (Lead) Long Lake Association; MDEQ All Townships; MSU Extension Property Owner (Support)	3 years

Objective	Task	Responsible Organization (Priority Level; Lead or Support)	Completion Timeline
5.C. Utilize comprehensive land use planning programs to maintain open space	**5.C.1 Coordinate activities with local Conservancies, County and Township officials to develop coordinated planning to protect vulnerable land and natural resources within the Watershed**	**Grand Traverse County/ All Townships (Lead) Grand Traverse Regional Land Conservancy (Support)**	**10 years**
	5.C.2 Work with local governments to develop and promote initiatives and zoning which preserves open space, natural areas and recreational opportunities	**Grand Traverse County/ All Townships (Lead) Grand Traverse Regional Land Conservancy (Support)**	**10 years**

Table 17. Long Lake Watershed Management Goals, Objective, relevant tasks, organizational responsibilites and timeline.

GOAL 6. Develop and promote information and educational programs that support stewardship, and support goals, and objectives of the watershed plan

Objective	Task	Responsible Organization (Priority Level; Lead or Support)	Completion Timeline
List of Objectives for this goal is presented in Chapter 9 (Information and Education Programs)	**List of Tasks for this goal is presented in Chapter 9 (Information and Education Programs)**	**Responsible parties for each task will be identified in Chapter 9 (Information and Education Programs)**	**Project Timeline is presented in Chapter 9 (Information and Education Programs)**

Implementation Timeline

The Long Lake Watershed Management Plan goals and objectives (Table 17) outlined basic costs per task, the potential lead organization and a total implementation timeframe. In order to better determine how implementation activities will proceed, a 10 year implementation timeline was developed showing activity by year from 2010 through 2019 (Table 18). Implementation milestones are also indicated, and referenced by year.

Table 18. Tasks (Goals and Objectives list, Table 17), listed in order of priority, total project costs, milestones and years of implementation.

			Implementation Year									
Task **List Prioritized, Highest Priority first** **(Goal/Objective/Task Identified)**	**Total Project Cost**	**Milestones**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
1.A.1 Continue comprehensive monitoring of potential sources of nutrients and sediment in Long Lake and associated waterbodies	$7,500	Complete monitoring each cycle and evaluate trends; ($2,500 per cycle)	X			X			X			X
3.A.1 Continue comphrensive monitoring for native and invasive plant species in the Long Lake Watershed	$4,000	Complete monitoring each cycle and evaluate trends; evaluate invasive species density ($4,000 per cycle);		X					X			
3.A.2 Develop and draft a long-term, comprehensive Aquatic Plant Management Plan	$1,200	Aquatic Plant Management Plan to be completed after completion of next plant survey		X	X							
1.A.2 Calculate/refine nutrient and sediment loading estimates via measurements (if possible) or by refining land-use base modeling estimates	$1,500	Nutrient load estimate 2012, sediment 2013, recheck both 2014;			X	X	X					

Task List Prioritized, Highest Priority first (Goal/Objective/Task Identified)	Total Project Cost	Milestones	Implementation Year									
			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
4.A.3 Work with municipalities to establish retention basins and vegetative buffer strips in inventoried areas which are shown to be subject to potential ground water contamination	$30,000	Stormwater retention/improvement- 2 projects completed/yr	X	X	X	X	X	X	X	X	X	X
1.B.1 Continue investigation and comprehensive monitoring of potential sources and causes of elevated bacteria (*E. coli)* in Watershed waterbodies	$1,200	Repeat every 4 yers; evaluate after 2010 to adjust cycle and sample sites. ($400 per cycle)	X				X				X	
1.B.2 Develop education programs concerning septic system upgrades and maintenance and provide information to Watershed residents.	$10,000	Target 5-7 systems/yr; re-evaluate after 2015	X	X	X	X	X	X	X	X	X	X
2.A.4 Stabilize soil erosion sites on Long Lake previously identified.	$18,000	16 erosion sites; 3 completed/yr; ($3000/yr)	X	X	X	X	X	X				
2.A.2. Identify and develop a prioritized list of desirable aquatic and terrestrial habitat areas in need of restoration protection and other zoning based programs.	$5,000	Prioritized list to be utilized for restoration activities to start in 2015				X	X					

Table 18. Tasks (Goals and Objectives list, Table 17), listed in order of priority, total project costs, milestones and years of implementation

			Implementation Year									
Task **List Prioritized, Highest Priority first)** **(Goal/Objective/Task Identified)**	**Total Project Cost**	**Milestones**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
2.A.3 Restore or stabilize aquatic and/or terrestrial habitat at prioritized sites.	$15,000	Complete 2 sites per year		X	X	X	X	X	X	X	X	
5.A.1 Create a targeted program in local government units which evaluates current and proposed zoning and evaluates how it impacts natural resources and future development	$2,500	Evaluate report with respect to current Township policies		X								
4.A.1 Inventory potential sources of groundwater contamination in the Watershed and related to identified critical areas established in this Watershed Plan	$2,000	Draft report after 1 year.		X	X							
1.A.3 Inventory watershed areas to determine critical locations requiring storm water and/or soil erosion control measures, such as retention basins or vegetated buffer strips.	$7,000	Draft report after 1 year.				X	X					
1.A.4 Implement establishment of storm water/soil erosion control measures at inventoried critical locations.	$20,000	Stormwater retention/improvement- 2 projects completed/yr		X	X	X	X	X	X	X	X	

			Implementation Year									
Task **List Prioritized, Highest Priority first)** **(Goal/Objective/Task Identified)**	**Total Project Cost**	**Milestones**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
2.A.1 Establish riparian shoreline buffer demonstration projects	$10,000	Develop 1 project/ year for 3 years. Last two years demonstration				X	X	X	X	X		
3.B.2 Initiate a review and update the Natural Features Inventory for Long Lake Township to reassess priorities of stakeholders and municipalities	$2,000	Draft report completed				X						
5.A.2Coordinate activities with local Conservancies to protect vulnerable land and natural resources within the Watershed	---- (ongoing)		X	X	X	X	X	X	X	X	X	X
3.A.3 Coordinate and implement targeted outreach activities to increase awareness of invasive species, their spread and control.	$4,000	Activities planned/developed after 1 yr. Last two years for distribution.			X	X	X					

Table 18. Tasks (Goals and Objectives list, Table 17), listed in order of priority, total project costs, milestones and years of implementation

			Implementation Year								
Task **List Prioritized, Highest Priority first)** **(Goal/Objective/Task Identified)**	**Total Project Cost**	**Milestones**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
3.B.1 Coordinate and implement outreach and educational activities to increase awareness of Best Management Practices which help to conserve Watershed natural resources	$10,000	Complete 2 mtgs/yr plus targeted mailings yearly						X	X	X	X
4.A.2 Work with agricultural and recreational facility managers to implement BMPs to reduce loading of toxins in the Watershed	$8,000	Visit 4 farms/yr		X	X		X	X			
4.B.3 Coordinate and implement outreach and educational activities to increase awareness of BMPs to limit hydrological impacts	$10,000	Complete 2 mtgs/yr plus targeted mailings yearly				X	X	X	X		
5.B.1 Coordinate and implement outreach and educational activities to increase awareness of Best Management Practices and impacts of stakeholder activities on watershed quality and wetlands	$2,500	Complete 2 mtgs/yr plus targeted mailings yearly				X	X	X			

Task List Prioritized, Highest Priority first) (Goal/Objective/Task Identified)	Total Project Cost	Milestones	Implementation Year								
			2010	2011	2012	2013	2014	2015	2016	2017	2018
4.B.1 Promote and enforce restrictions for reduced development on or near wetlands in accordance with DEQ and local zoning	$1,500	Ongoing as needed	X	X	X	X	X	X	X	X	X
5.C.1 Coordinate activities with local Conservancies, County and Township officials to develop coordinated planning to protect vulnerable land and natural resources within the Watershed	-----	Ongoing	X	X	X	X	X	X	X	X	X
5.C.2 Work with local governments to develop and promote initiatives and zoning which preserves open space, natural areas and recreational opportunities	-----	Ongoing	X	X	X	X	X	X	X	X	X

Watershed Goals and Objectives – Implementation Costs

As developed for the Long Lake Watershed Management Plan, there are six major goals and a total of 17 objectives. Costs for each of the objectives is based on best professional judgement if an actual cost estimate was not available from the organization identified as the Lead. In any event, estimates are very subjective and may change based on re-evaluations of project goals. The Goal/Objective Cost totals are as follows:

Goal 1 (3 objectives) - Total Estimated Costs over 10 years: $ 47,200

Goal 2 (1 objective) - Total Estimated Costs over 10 years: $ 48,000

Goal 3 (2 objectives) - Total Estimated Costs over 10 years: $ 21,200

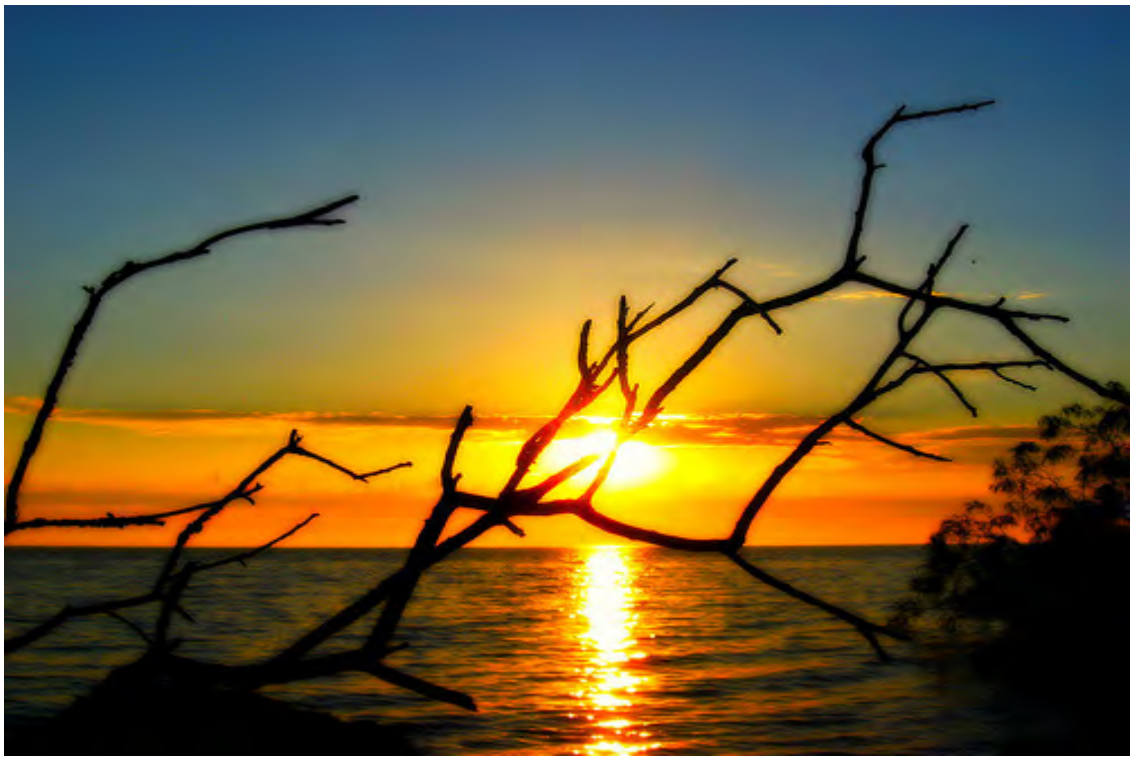
Goal 4 (2 objectives) - Total Estimated Costs over 10 years: $ 51,500

Goal 5 (3 objectives) - Total Estimated Costs over 10 years: $ 5,000

Goal 6 (1 objectives) - Total Estimated Costs over 10 years: $ 41,400

(**Goal 6 cost estimate shown in Section 8, Table 19)**

Total Estimated 10 year Implementation Cost: $ 214,300



7.0 CURRENT IMPLEMENTATION

Implementation of the Long Lake Watershed Management Plan involves a variety of strategies, and involves a range of different organizations with distinct responsibilities and objectives. Ongoing watershed projects include watershed monitoring, facilitated primarily by the Long Lake Association; Implementation of appropriate BMPs, enforcement and revisions to current zoning (Long Lake Township, Grand Traverse County); Development of specific projects which enhance watershed planning, such as the Natural Features Inventory and revisions to the township master plans (Townships); Projects which may have specific beneficial impacts to protecting water quality in the watershed, such as the septic system time of sale inspection program (Long Lake Township); Continued public education outreach (Long Lake Association, Townships); and Land conservation activities designed to enhance recreational opportunities, maintain ecological diversity and landscape views, and protect the watershed's cultural and rural heritage (Grand Traverse Regional Land Conservancy). This is

by no means and exhaustive list of organizations which participate, both formally and informally, in creating and maintaining the character of the Long Lake Watershed.

Watershed Projects Initiated Since 2001

A number of projects have been initiated and finished since the completion of the original Long Lake Watershed Management Plan, in 2001. A short summary of these projects is listed below, and a more comprehensive discussion on some of these projects can be found in Section 4.0 (Monitoring and Source Inventories).

Repair of Documented Watershed Soil Erosion Sites

The soil erosion inventory (Appendix E) identified 16 sites within the watershed which exhibited instability and evident of erosion. Three of these sites were considered severe, and one each was located on three of the islands in Long Lake (South, Fox and Long, respectively). These three sites have been remediated. The remainder of the sites were located on lakeside properties of Long Lake, and were listed as minor in severity. Their status is unclear, but some may have been remediated by riparian homeowners and the remainder should be given high priority because when they have the potential to have an immediate impact on the watershed ecosystem and water resources. The inventory accurately describes the appropriate BMPs required to stabilize the sites and approximate costs, where appropriate.

Water Quality Monitoring of Long Lake

The Long Lake Association has continued to regularly monitor water quality parameters at three designated locations in the lake, including dissolved oxygen, secchi depth (clarity), chlorophyll a concentrations, total phosphorus and nitrate/nitrite nitrogen in the water column. Sampling was completed in 2005 and 2008, and the Lake Association plans to continue to monitor every three years. These monitoring results help to categorize the lake water quality and the consistency of monitoring provides an exceptional way of detecting water quality trends, either positive or negative.

Rooted Aquatic Macrophyte Survey

Long Lake Association has prioritized monitoring aquatic macrophytes (rooted plants), primarily due to the presence of the invasive Eurasian Water Milfoil (EWM). EWM is an aggressive plant which can degrade recreational opportunities, including boating and fishing due to the density of its growth. An initial lake macrophyte survey was completed prior to the 2001 Management Plan preparation, and a subsequent survey was completed in 2005. The surveys are important as they can document the spread and location of EWM, and identify any instances or substancial changes in native vegetation poplulations, which may occur from other environmental stressors (nutrients, sediment) impacting Long Lake.

Long Lake Shoreline Survey

Based on recommendations in the 2001 Watershed Plan, the Long Lake Association completed a comprehensive shoreline survey in 2005. This survey provided insight into new areas of erosion, areas of heavy aquatic plant growth or algal growth, suspected sites of leaking septic systems and a general assessment of the overall shoreline quality.

Long Lake Sediment Sampling and Bacterial Monitoring

In addition to providing a snapshot of the Long Lake shoreline, the shoreline survey (above) also was used to identify sites to sample nearshore lake bottom sediments for nutrient concentrations, primarily phosphorus. The survey also provided an opportunity to identify sites to evaluate bacterial contamination (sites suspected of septic failures), as measured by *E. coli*.

Septic System Review/Groundwater Hydrology

Suspected sites of septic system failures surrounding Long Lake was incorportated into a larger study initiated by Long Lake Townshp. They examined records from the Grand Traverse County Health Department to establish locations of failed and repaired septic systems in the Township as well as using the well log database to determine groundwater hydrology with respect to average well depths, well characteristics and potential for impacts of leaking septic systems to contaminate wells. In addition, the Township was able to pass a

"Time of Sale or Transfer" (TOST) ordinance which mandates that the septic system be inspected during transfers of property titles.

Lake Residential Zoning Review

The Long Lake Township initiated and completed a comprehensive review of the Lakeside residential zoning ordinances, to order to evaluate whether the ordinance provides a level of protection for lake water resources. This project was suggested in the 2001 Watershed plan.

8.0 INFORMATION AND EDUCATION PLAN

The information and education (IE) plan attempts to define the communication requirements associated with implementing the Long Lake Watershed Management Plan. Increasing the awareness and understanding of how actions on the land within the watershed can impact water quality is critical to successful water quality protection. The purpose of an IE strategy is to establish and promote information and educational programs that support the implementation of the watershed planning goals and objectives and tasks.

This IE plan constitutes what is essentially **Watershed Goal #6**: Develop and promote information and educational programs that support stewardship, and support goals, and objectives of the watershed plan (Table 17). The details of this goal are discussed here, and total costs are referenced back to Section 6.0 (Goals and Objectives). Implementation tasks, timeline, milestones and total costs are presented in Table 19, in the same format as was presented in Section 6.0.

Information/Education Programs

Current and Completed Activities

A number of public information and education programs were initiated during the course of the Watershed Planning Study in 2000 and have contributed significantly to developing an understanding of the Long Lake Watershed by riparians, the general public and by local students. The following programs were completed prior to the development of the current Watershed Management Plan.

1) The development of the publication, "Long Lake Watershed: A Landowner's Handbook" (Resig and Stone, 1999) was an important step in compiling all the relevant current and historical knowledge about the watershed, as well as describing a range of BMPs and conservation tools which would help protect the watershed. This publication was distributed to all watershed residents, and additional copies are currently available through Long Lake Township and the Office of the Drain Commissioner, Grand Traverse County. This publication also provides a wealth of information and resource contacts for determining what activities (e.g., new building, changes in lot topography, septic systems, etc) are appropriate, and whether permits are required. Publications similar to this have been developed for a number of other local area lakes and watersheds and have proven to be valuable educational tools for the public.

2) In June of 1999, a student Watershed Festival was held for students of two local elementary schools. Over 500 students attended and participated in the program which featured over 30 distinct "stations," each with a specific learning objective. The students were involved in learning all aspects of watershed function, groundwater, surface water and the hydrologic cycle. The event was sponsored by MSU Extension, Long Lake Township, The Grand Traverse County Drain Commissioner's Office, the local Soil Conservation Districts, and several other partners. The event was highly successful and provided an important learning opportunity for discovering the complexities of watershed function.

3) In the summer of 2000, Long Lake Township sponsored an educational workshop which was open to the public. The workshop, "Long Lake Naturally," was an opportunity for lakeside residents and homeowners in the watershed to be informed of the water quality issues, proposed zoning changes, land conservation opportunities,

residential lakeshore management practices, impacts of urban sprawl and the impacts of these issues on maintaining the high quality nature of the watershed's water resources.

4) A critical component of protecting watershed resources involves education of our children. Developing an appreciation of how a watershed's resources are intricately interrelated will reap benefits in the future when our children become the new custodians of our land and lakes. Towards this effort, a Long Lake Watershed Student Education Project (Appendix H) was initiated, involving the participation of 75 high school students (Grades 10 and 11), as well as the integration of curriculum from four teachers. The integrated subject areas included Environmental Science, Global Studies, Language Arts, and Technology. Environmental Science focused initially on the geology of the watershed, and culminated in 3 days of water quality monitoring and data presentations. The Language Arts class developed histories of the Long Lake Watershed, and Global Studies created posters of critical watershed elements. Finally, the Technology class participated in the classification and development of the Impervious Surface Study (Section 4.0) in an effort to help determine specific areas which may contribute surface water runoff to the high quality waters present in the watershed. The education component was very successful, and hopefully will be repeated with another group of students in the future.

5) Finally, the Michigan State University Extension office provided several programs which targeted riparians in the Long Lake Watershed. A current program, Lake*A*Syst, provides written information and tools for riparians to maintain lake water quality and reduce or eliminate activities which may have a detrimental effect on designated uses for Long Lake. In addition, MSU Extension sponsored a traveling "boat" seminar on Long Lake for two days. A boat and extension agent toured the shoreline of Long Lake, and provided information about the Lake and relevant conservation/environmental activities which can benefit lake water quality. Although these programs were not funded as a part of the Watershed 319 Planning grant, it is important to recognize that there were a wide range of activities associated with the Watershed, which effectively communicate critical information to the public.

Proposed Information/Education Programs

A number of approaches for disseminating information and providing education will be valuable in the future in a continuing effort to educate residents of the watershed. The proposed activities are outlined in the IE plan (Table 19). For ease of presentation, four main information categories of IE programs are presented: 1) Monitoring Information, 2) Water Resource Protection Information, 3) Natural Resource Protection Information, and 4) Student Education/Watershed Plan Update.

Table 19. Public Information and Education (IE) Plan

Category/Task	Target Audience	Frequency	Medium	Partners*	Timeline	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total Estimated Cost
INFORMATION CATEGORY – MONITORING																
Inform stakeholders of results of water quality monitoring	**Riparian homeowners, general public, local government, tourists**	**Annual Summary**	**Website, email, newspaper, newsletter, bulletin board**	**LL Assn, LL Township, GT Health Dept**	**0-1 (continuous) As available**		**X**			**X**			**X**			**$800 + volunteer time**
Inform stakeholders of results of Long Lake Aquatic Macrophyte Study	**Riparian homeowners, general public, local government, tourists, MDEQ**	**Summary upon completion every 5 years**	**Website, email, newspaper, newsletter, bulletin board**	**LL Assn, LL Township, GT Health Dept**	**3-5**		**X**					**X**				**$800 + volunteer time**

Category/Task	Target Audience	Frequency	Medium	Partners*	Timeline	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total Estimated Cost
Inform stakeholders of results of pathogen monitoring for *E. coli*	**Riparian homeowner, general public, local government, tourists, MDEQ, Health Dept.**	**Summary upon completion every 4 years**	**Website, email, newspaper, newsletter, bulletin board**	**LL Assn, LL Township, GT Health Dept MDEQ**	**4-6**	**X**				**X**				**X**		**$800 + volunteer time**
Develop and distribute a Long Lake aquatic plant educational survey, to gauge citizen awareness of invasive species	**Riparian homeowners, general public, businesses**	**Develop and distribute every 8-10 years**	**Website, email, brochure**	**LL Assn, LL Township, MSU Extension MDEQ**	**5-8**	**X**								**X**		**$2500 + volunteer time**
Train local volunteers to participate with the Long Lake Assn in water quality monitoring, inventories and monitoring of watershed and lake conditions	**Riparian homeowners, general public, schools, local government, businesses**	**Develop, implement and repeat as necessary**	**Training packet, newsletter, workshop**	**LL Assn, LL Township MSU Extension**	**2-5**	**X**					**X**					**$5000 + volunteer time**

Table 19. Public Information and Education (IE) Plan

Category/Task	Target Audience	Frequency	Medium	Partners*	Timeline	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total Estimated Cost
INFORMATION CATEGORY – WATER RESOURCE PROTECTION																
Develop and distribute information on proper maintenance and operation of septic systems	**Riparian homeowners, general public, local government, businesses**	**(Info Developed) Annual distribution**	**Brochure, newsletter, newspaper, website, email**	**LL Assn, LL Township MSU Extension USDA-NRCS EPA**	**0-2**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**$400 + volunteer time**
Develop and distribute information limiting phosphorus loadings to surface water via modifications to fertilizer use	**Riparian homeowners, general public, businesses**	**(Info Developed) Annual distribution**	**Brochure, newsletter, newspaper, website, email**	**LL Assn, LL Township MSU Extension USDA-NRCS EPA**	**0-3**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**$400 + volunteer time**
Develop and distribute information on the important functions of wetlands	**Riparian homeowners, general public, businesses**	**(Info Developed) Annual distribution**	**Brochure, newsletter, newspaper, website, email**	**LL Assn, LL Township MSU Extension USDA-NRCS EPA**	**0-2**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**$400 + volunteer time**

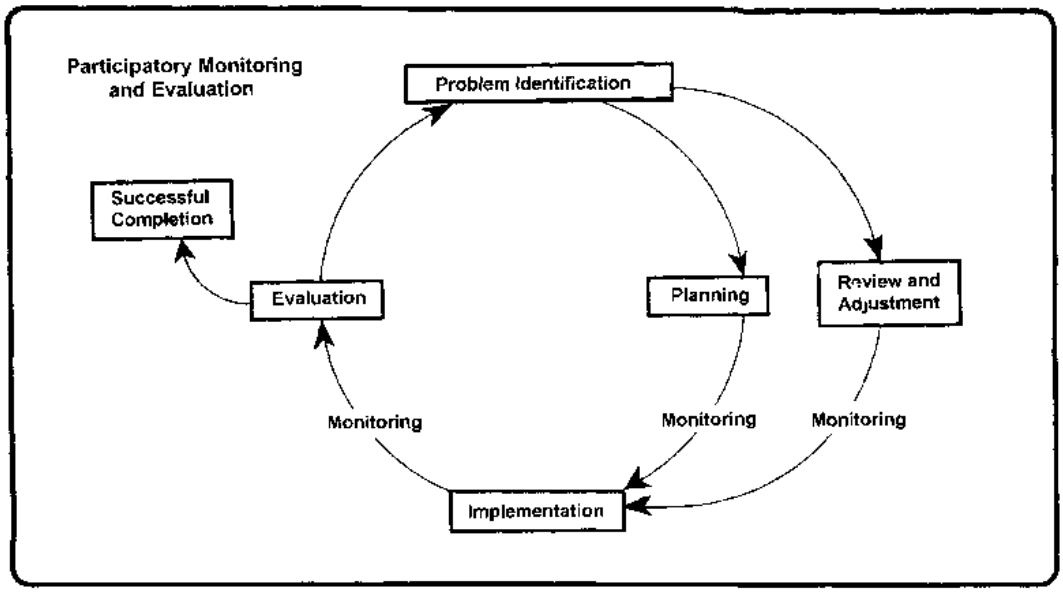
Category/Task	Target Audience	Frequency	Medium	Partners*	Timeline	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total Estimated Cost
Develop and distribute information on the importance of nearshore areas and impacts of beach grooming, shoreline hardening & lack of vegetative buffers on habitat essential to fish, wildlife and aquatic organisms.	**Riparian homeowners, general public, businesses, local government**	**(Info Developed) Annual distribution**	**Brochure, newsletter, newspaper, website, email**	**LL Assn, LL Township MSU Extension USDA-NRCS EPA**	**0-3**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**$400 + volunteer time**
Develop and distribute information regarding groundwater resources and their protection	**Riparian homeowners, general public, local government, business**	**Develop and distribute 5 years**	**Website, email, newspaper, newsletter, bulletin board**	**LL Assn, LL Township, GT Health Dept MDEQ**	**4-6**	**X**		**X**		**X**		**X**		**X**		**$800 + volunteer time**

Table 19. Public Information and Education (IE) Plan

Category/Task	Target Audience	Frequency	Medium	Partners*	Timeline	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total Estimated Cost
INFORMATION CATEGORY – NATURAL RESOURCE PROTECTION																
Inform and involve stakeholders in reviewing zoning and wetland ordinances, and encourage participation in development of new or amended ordinances	**Riparian homeowners, general public, businesses, local government**	**0-5 years as issues arise**	**Public meetings, government meetings, educational information**	**LL Assn, LL Township MDEQ EPA**	**0-5**		**X**					**X**				**Volunteer time**
Inform stakeholders of land conservation efforts and communicate the benefits of conservation easements and preserved open space	**Riparian homeowners, general public, businesses, local government**	**Annual as projects develop**	**Website, email, newspaper, newsletter**	**LL Assn, LL Township, GTRLC**	**0-1**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**$500 + volunteer time**

Category/Task	Target Audience	Frequency	Medium	Partners*	Timeline	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total Estimated Cost
Develop and distribute a stakeholder assessment survey, to assess attitudes, beliefs and behaviors of watershed residents	**Riparian homeowners, general public, businesses**	**Develop and distribute every 8-10 years**	**Website, email, brochure**	**LL Assn, LL Township, MSU Extension MDEQ**	**5-8**			**X**							**X**	**$2500 + volunteer time**
INFORMATION CATEGORY – STUDENT EDUCATION/WATERSHED PLAN UPDATE																
Watershed student educational programs	**Students, Teachers, Riparian homeowners, general public**	**Develop, implement and update as necessary**	**Information packets, Lesson plans**	**Local schools LL Assn, LL Township MSU Extension**	**0-4**		**X**					**X**				**$3000 + volunteer time**
Re-evaluate the Long Lake Watershed Management Plan and develop/distribute updates	**Riparian homeowners, general public, businesses, local government**	**Review every three years**	**Website, email, newspaper, newsletter, Public meetings,**	**Landowners LL Assn, LL Township, GT Health Dept MDEQ, EPA USDA-NRCS**	**3-4**					**X**					**X**	**$1500 + volunteer time**

Abbreviations: LL Assn (Long Lake Association); LL Township (Long Lake Township); GT Health Dept (Grand Travese Health Department); MDEQ (Michigan Department of Environmental Quality); EPA (Environmental Protection Agency); USDA-NRCS (US Department of Agriculture-Natural Resource Conservation Service); GTRLC (Grand Traverse Regional Land Conservancy)



9.0 MONITORING AND EVALUATION STRATEGIES

The overall objective of the Long Lake Watershed Management Plan is to implement activities which will monitor the current health of the watershed, and to seek to maintain or reduce all levels of pollutants, nutrients, sediments at current levels and specifically reduce nutrient and sediment loading as projected for the Year 2020 in Table 2.

Implementation of watershed plan goals and objectives for site-specific activities will require monitoring activities. Evaluation of monitoring activities will also be necessary to determine the progress and effectiveness of the proposed activities. In this section, the monitoring activities will be briefly discussed and presented with approximate frequencies.

Table 20 summarizes the key elements of the proposed monitoring plan that correspond to specific task items listed under Goals and Objectives Table 17). Monitoring of conditions in the Long Lake watershed is a key component of this watershed plan since the focus is on sustaining current conditions that support designated and other beneficial uses.

The intent of the monitoring plan is to detect changes in environmental conditions early enough to develop corrective actions before significant impairments occur.

Watershed Monitoring Programs

In order to continue to evaluate the "state of the watershed" and the efficacy of any implementation programs for watershed management, it is important to develop specific monitoring objectives which will provide the information needed to manage the watershed. Current monitoring efforts, including lake water quality, lake macrophyte density and impervious surface analysis have all provided excellent data which lead to this comprehensive watershed assessment. Monitoring should be continued in these areas and additional monitoring programs, as suggested below, are likely to be valuable for making management decisions as well.

Long Lake Water Quality Monitoring

Comprehensive lake water quality monitoring has been conducted every year from1997 to 2000 and approximately every three years since then. Overall, monitoring programs have been conducted for the last 25 years. Based on all these data, there is a valuable nutrient and water quality database to compare with future lake water quality data. This database includes secchi depth (clarity), total phosphorus levels, dissolved oxygen and temperature profiles, chlorophyll concentrations, zooplankton analysis and sediment nutrient concentrations.

This monitoring effort should be conducted every three years and entail one set of measurements in the spring/early summer (post lake turnover), and one set late fall (just prior to lake turnover) at the three established sampling sites (Figure 5). Parameters to be measured would be total phosphorus concentrations at the surface and near the bottom, and a full range of Hydrolab measurements (temperature, dissolved oxygen, ORP, conductivity and pH). In addition, sediment sampling should be conducted at the three designated sampling sites every three years, concurrent with lake water quality sampling, to determine if there is a continuing trend of increasing sediment phosphorus concentrations, as has been indicated by previous monitoring. This sampling program would make it possible to determine if there has

Table 20. Anticipated monitoring projects for the Long Lake Watershed Management Plan, 2010-2019

Goal Referenced	Monitoring type	Frequency	Location	Start/End Date	Estimated Costs*	Organization
1	Dissolved Oxygen profile, Temperature, ORP, Conductivity, Secchi Depth	2 times per year (spring/fall), every three years	3 designated locations on Long Lake	2008- ongoing	$800	Long Lake Association
1	Total Phosphorus and nitrate-nitrite nitrogen, chlorophyll a	2 times per year (spring/fall), every three years	3 designated locations on Long Lake	2008- ongoing	$1000	Long Lake Association
1	Sediment phosphorus	1 time per year (fall), every two years	3 designated locations on Long Lake	2008- ongoing	$300	Long Lake Association
3	Aquatic Plant Survey	Once every 5 years	Designated transects around Long and Mickey Lakes	20011- 12 and ongoing	$3000	Long Lake Association
1,5	Shoreline survey of Long and Mickey Lakes	Once every 8 years	Continuous perimiter around Long and Mickey Lakes	2014- 15 and ongoing	$3500	Long Lake Association
1	Nearshore Sediment sampling of Long and Mickey Lakes	Once every 8 years	Continuous perimiter around Long and Mickey Lakes	2014- 15 and ongoing	$3250	Long Lake Association
1	Bacterial Sampling in Long and Mickey Lakes	Once every 4 years	12 sites around Long and Mickey Lakes, based on shoreline survey	2010- 11 and ongoing	$900	Long Lake Association

Goal Referenced	Monitoring type	Frequency	Location	Start/End Date	Estimated Costs*	Organization
5	**Impervious Surface Analysis, current and anticipated for Year 2020 Build-out**	**Once**	**Grid system in Watershed**	**2011-12**	**$3000**	**Long Lake Township**
1,3	**Soil Erosion Inventory**	**Once every 10 years**	**Watershed, focus on riparian areas**	**2012**	**$1500**	**Grand Traverse County**

* Costs associated with these Monitoring activities have already been incorporated into total costs for Watershed Project in Section 6.0

been any significant water quality degradation. In addition, these data can be used with the hydrologic/nutrient model to provide an updated assessment of sources and sinks of nutrients to Long Lake.

Long Lake Macrophyte Survey Update

The macrophyte study completed in 2000, and updated in 2005, on Long Lake has provided a reasonably comprehensive snapshot of the current rooted aquatic plant population in the lake. Because lakes are dynamic systems, it is expected that macrophyte distribution and abundance will change over time, particularly in response to local nutrient inputs (or lack of), and changing seasonal weather conditions. Of particular concern to some of the Long Lake residents is the distribution of Eurasian milfoil. Specific control measures have been utilized or are being contemplated. A follow-up assessment of the distribution of both exotic weed species and native plants is important in order to evaluate the success of past and future control programs, as well as to identify possible sources of nutrient or sediment input. The current macrophyte study has been compiled in a computer database, which simplifies for the production of maps describing the distribution of any of the identified plant species, including Eurasian milfoil. The foundation for an ongoing monitoring program is in place and the transect locations have been identified. Because of this foundation, future surveys can be easily added to the database, and a comparative analysis performed to assess changes to macrophyte distribution and abundance. Carefully monitoring changes is the only way to determine the success of past or future Eurasian milfoil control programs, as well as to provide input to determine the impact of lakeshore development on the distribution of aquatic plants in Long Lake.

Shoreline Survey of Long Lake

In addition to water quality monitoring of Long Lake, monitoring of the lake nearshore areas to determine instances of erosion, sedimentation, possible nutrient enrichment and well as observation of lakeside residences which might have outdated septic systems contributing nutrients or bacterial contamination to the lake should be completed every 8 years.

The shoreline survey was conducted by members of the Long Lake Association over several days in August, 2006. The survey was completed using a pontoon boat which was able to move close to shore to enhance the visual observations. Global

Positioning System (GPS) readings were taken at designated sites and relevant observations regarding shoreline characteristics (aquatic vegetation, erosion, homeowner landscaping, age of structures) was

Sediment Sampling of Long Lakes

The overall monitoring of the Long Lake Watershed indicates that a comprehensive sediment sampling of nearshore areas every 8 years could be useful in relating observed characteristics of the Lake, such as sparse or dense areas of aquatic vegetation, with sites of likely nutrient enrichment from groundwater runoff. By examining the sediment reservoir of one of the primary plant nutrients, total phosphorus, it was hoped that some insight could be gained to explain the distribution of aquatic plants, as well as identify problem areas which should be addressed through the Long Lake Watershed Management Plan or through an aquatic plant management plan (to be developed as part of this four year project).

Sampling sites for sediment sampling are determined by examining the data from the companion Shoreline Survey. Sites were chosen based on visual observation notes (possible areas of concern) and were also chosen to provide a geographical balance by distributing the sites around the lake. The sediment sampling should occur in concert with the shoreline survey.

Pathogen Monitoring of Long and Mickey Lakes

Bacterial monitoring on Long and Mickey Lakes was completed in summer of 2006. The frequency of this sampling should be every four years, unless circumstances suggest that bacterial contamination is present. Historical data do not suggest an ongoing problem. Samples are chosen based on observations from the shoreline survey completed in concert. Shoreline survey sites which identified older structures with probable original septic systems, older structures with little lakeside setback, and closely spaced groups of cabins or cottages were chosen as some of the bacterial monitoring sites. Twelve sites, geographically spread around Long and Mickey Lakes, should be chosen for monitoring). Samples are collected and analyzed within 6 hours of collection. Samples were all

analyzed for *E. coli* using EPA Method 1603. An indicator organism, such as *E. coli*, is used to determine fecal contamination. The presence of *E. coli*, a normally non-pathogenic intestinal organism of warm-blooded animals, is easy to test for and is relatively more abundant than the human enteric pathogens, thus leaving a safety margin for the detection of disease-causing organisms. *E. coli* is considered a more specific indicator of fecal contamination than fecal coliforms since the more general test for fecal coliforms also detects non-fecal coliform bacteria.

Impervious Surface Analysis

An impervious surface analysis of the Long Lake Watershed can be used to identify visually those areas of the watershed which are affected by development (Figure 10) and therefore are potential areas of increased surface water runoff. The current analysis was limited by a number of factors (see section 4.5), and revisions to this survey might yield additional valuable information. In particular, as Long Lake Township begins to review relevant zoning ordinances, especially the lakeside residential ordinance (which may have very specific language regarding impervious cover limits), a more accurate evaluation of what levels of impervious cover are important in limiting surface water runoff should be completed in order to accurately develop management strategies for protecting water quality. In river/stream situations, a 10-12% impervious cover was determined to be a critical limit for protecting water quality (Schueler, Center for Watershed Protection, 2000). However, a site specific analysis of the Long Lake Watershed, incorporating soil types, slopes, vegetative cover and impervious structures, is required to determine develop an appropriate cover limit for this watershed. This approach would determine the "potential" watershed impervious surface based on the existing and future land use as allowed in the watershed by land use criteria and zoning. This build-out analysis would be an invaluable tool in long-term management of the watershed.

Best Management Practices

The efforts to reduce non-point source pollutants in the Long Lake Watershed should be distributed between implementation of relevant lakeshore BMPs, stormwater

management BMPs and, to a lesser extent, agricultural BMPs for the protection of groundwater. The following is a brief summary of BMPs which have been implemented as part of this watershed planning process, as well as recommended types of BMPs which may be utilized to fully realize the goals and objectives of the Long Lake Watershed Management Plan.

Lakeshore

The designated critical areas of the Long Lake Watershed is the immediate area surrounding Long Lake itself, and other smaller waterbodies within the watershed. The threats to the designated uses focus on nutrients and sediments as sources of pollutants. These pollutants result in lake eutrophication, reduction of body contact recreation, potential impacts on warm water fisheries, and may influence the distribution of both native and invasive aquatic plant species.

The publication "Long Lake Watershed: A Landowner's Handbook" was distributed in 1999 (Resig and Stone, 1999) to all Long Lake Watershed residents (Appendix I). This publication contains a wealth of information on watershed maintenance, including landscaping, well and septic system maintenance, stormwater runoff control and shoreline stabilization. This publication was produced in conjunction with the Grand Traverse County Drain Commissioner's Office, the Grand Traverse Regional Land Conservancy, the Michigan DEQ, the Long Lake Association and Long Lake Township. The BMPs outlined in this handbook are relevant not only to lakeshore owners, but to all residents of the watershed.

Stormwater Management

Stormwater management is critical for controlling the near shore flow of nutrients and sediments into critical areas of the watershed, primarily Long Lake and other smaller waterbodies which serve as groundwater recharge basins.

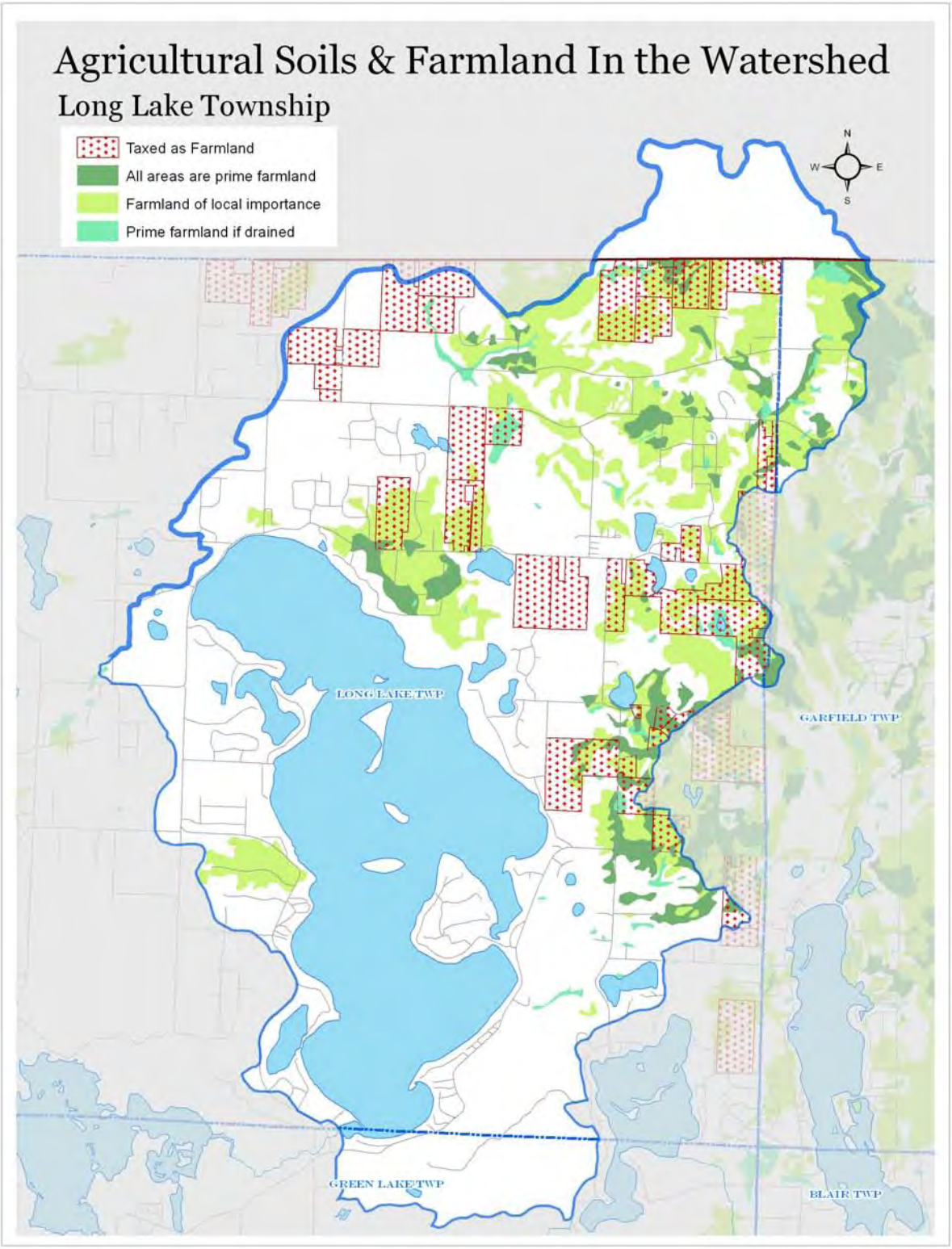
A variety of BMPs are noted in "Guidebook of Best Management Practices for Michigan Watersheds" (MDEQ, 1998), and in the Long Lake Watershed Landowners Handbook. The use of basins, trenches, swales, filter strips and porous pavement can be used, where appropriate, to reduce the rate of runoff and to enhance the process of water infiltration. Most pollutants can be effectively prevented from reaching the groundwater aquifers if the appropriate retention and infiltration times are provided. The Grand Traverse County Soil Erosion and Storm Water Runoff Control Ordinance, which is applicable to the Long Lake Watershed, is also effective in limiting surface water runoff.

Those areas which have been found to be susceptible to soil erosion, as described by the Soil Erosion Inventory (Section 4.0 and Appendix E), should be designated as priority improvement projects within the watershed. Addressing these documented erosion sites will immediately benefit the threatened designated uses in the Long Lake Watershed.

Agricultural

Agricultural areas currently make up approximately 28 % of the watershed. A map of agricultural farmland in the watershed in provided in (Figure 14) Traditional agricultural BMPs have focused on minimizing soil loss, based on the concept that most nutrients, pesticides and herbicides are adsorbed onto soil particles. However, agricultural BMPs should also include a comprehensive nutrient management strategy. Again, these BMPs can be found in "Guidebook of Best Management Practices for Michigan Watersheds" (MDEQ, 1998). It is important to note that education is an important component of agricultural BMPs, because many measures which reduce nutrient and agrochemical use may ultimately save the grower money.

Figure 14. Designated farmland in the Long Lake Watershed.



Evaluation Strategies

Evaluation is an important part of watershed planning. A well planned evaluation process can assess which efforts are successful, and can be used to provide valuable feedback for refining ongoing implementation strategies.

For monitoring activities which actively assess the general health and quality of the Watershed, it is helpful to provide specific criteria which have been currently assessed in the Long Lake Watershed, and can be used as benchmarks to establish the efficacy of implementation projects. Long Lake Watershed currently meets all Designated Uses for the State of Michigan, therefore it is important that continued assessments determine if problems may be occurring. Table 21 summarizes the process that will be used to evaluate the effectiveness of each of the proposed tasks. Water quality criteria (total phosphorus, chlorophyll a, sediment phosphorus, Eurasian Water Milfoil acreage) are set a currently measured levels, at which Long Lake is still considered oligotrophic.

In addition to water quality paramters, other aspects of the watershed plan can be assessed in a more qualitative fashion. These parameters and shown in Table 22.

Finally, an "administrative" evaluation strategy is required to assess whether the Watershed Management Plan is being used as intended, to guide protection and management of Long Lake's resource. To that end, an ongoing evaluation process will be utilized and conducted through Long Lake Township in conjunction with the project coordinators (currently Long Lake Township and the Long Lake Association). The project coordinators will meet at least two times per year to evaluate the above water quality and qualitative parameters, as well as to document the status of ongoing projects and accomplishments, and will maintain a list of upcoming designated projects or new created ones. The coordinators will assess the timeliness of completion of all projects, whether or not they met guidelines and expectations, the cost effectiveness of these initiatives. The Watershed Management Plan coordinators should also solicit feedback through information/outreach materials, at public events or by targeted focus groups. The primary objective is to determine if watershed activities are aligned with the goals and objectives developed in the plan. If not, the coordinators should realign the goals as appropriate. Finally, the entire watershed plan should be reevaluated every five years for to ensure that the plan remains current and relevant.

Table 21. Water Quality Monitoring parameters and levels of attainment as established by the State of Michigan or locally utilizing historical data where numerical criteria from the State are not specified.

Watershed Parameter	Measure of Success
Nutrients: Average Total Phosphorus in Long Lake (surface measurement)	Based on greater than 10 years of comprehensive monitoring, the average surface total phosphorus concentration (average of 3 sites, spring and fall) should not exceed 10.5 ug/L.
Chlorophyll a	Values should not exceed 4 ug/L, (average of 3 sites, spring and fall)
Secchi Depth	Minimum depth should be at least 13 feet (average of 3 sites, spring and fall)
Dissolved Oxygen	Dissolved Oxygen (D.O.) not less than 5.0 mg/L during summer stratification in the epilimnion (uppermost layer of the lake). Not less than 5.0 mg/L for the rest of the year for entire lake area
Eursian Water Milfoil, total acreage in Long and Mickey Lakes	Total acreage should not exceed 9 acres
Pathogens (E. coli)	Should not exceed Michigan State Standard: Total Body Contact: 130 CFU/100 mL sample, 30-day geometric mean of 3 replicates; 300 CFU/mL geometric mean of 3 samples single event Partial Body Contact: 1000 CFU/100 mL geometric mean of 3 samples
Sediment Total Phosphorus	Concentration should not exceed 40 mg/kg dry weight

Watershed Parameter	Measure of Success
Toxic Substances	**Toxic substances shall not be present in the surface waters of the state at levels that are or may become injurious to the public health, safety, or welfare, plant and animal life, or the designated uses of the waters.**
Temperature	**Not considered relevant to Long Lake**
Hydrogen Ion Concentraion (pH)	**Not considered a problem in Long Lake**

Table 22. Qualitative watershed parameters and success levels.

Watershed Parameter	Measure of Success
Calculated Phosphorus and sediment loading in watershed (L-Thia calculation-land use based)	Load estimates for this watershed are estimated, as there are no point source locations to measure actual load. Total load estimates can only be evaluated by examining changes in the land use values over time. A measure of success would be a prediction of increase nutrient and sediment loading by the L-thia model, but measured water quality parameters have not changed, or qualitative parameters still meet expectations.
Quantitative periodic assessment of warmwater fisheries	Maintenance of desired fishery characteristics, including species diversity
Aquatic macrophyte diversity	Maintenance of approximate macrophyte diversity in terms of number of species and relative distribution.
Land Protection and Land Management	Adoption and enforcement of local zoning measures targeted to reduce water pollution
Land Protection and Land Management	Qualtitative assessment of total area of preservated of critical habitat and riparian areas, view corridors – Natural Features Inventory

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11.0 APPENDICES AND FINAL REPORTS

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Appendix A

Preliminary Hydrologic Evaluation for Long Lake Drainage Basin

PRELIMINARY HYDROLOGIC EVALUATION

FOR

LONG LAKE DRAINAGE BASIN

LONG LAKE TOWNSHIP

APRIL, 1987

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PURPOSE

The purpose of this analysis is to determine if it is possible and/or practical to modify the outlet from Long Lake, known locally as Sucker Creek, in order to draw the water level in Long Lake down to a level that is acceptable to the riparian land owners around the perimeter of the lake. In addition, much of the information that will be presented in this evaluation will also be usefull for long range planning for future development within the drainage basin and the Township overall. For purposes of this study, the 100 year-24hour storm will be used to determine the amount and rate of runoff from the drainage basin.

WATERSHED CHARACTERISTICS

The east edge of Long Lake Township more or less lies along the drainage divide between Lake Michigan proper and the West Arm of Grand Traverse Bay. The topography within the Township varies from nearly level to very steep, with maximum slopes of 20%. Ground elevations within the Township range from 840 to 1,115 feet above mean sea level (the level of Lake Michigan is 580+).

The Long Lake drainage basin, which covers approximately 70% of Long Lake Township, drains to the west to Lake Michigan via Lake DuBonnet and the Platte River. Small portions of the drainage basin also extend north into Solon Township and Elmwood Township, east into Garfield Township and south into Green Lake Township (see Exhibit No. 1). Also, as shown on Exhibit No. 1, the other portions of Long Lake Township drain to the West Arm of Grand Traverse Bay via Silver Lake and Bass Lake through the Boardman River on the east and to Lake Michigan proper via Bellows Lake through the Platte River and Lake Leelanau through the Leland River on the west. Nearly all of Long Lake, which has a surface area of approximately 3,000 acres (including islands), except for a very small area at the south end of the lake is within Long Lake Township. The outlet, known locally as Sucker Creek, exits at the extreme south end of the lake. All of Sucker Creek is located in Green Lake Township. There is approximately 5,800 lineal feet of creek between Long Lake and Lake DuBonnet, which is the next body of water downstream of Long Lake. Lake DuBonnet is approximately 8 feet lower than Long Lake (see Exhibit No. 2). The water level in Lake DuBonnet is controlled by a dam at the west end of the lake.

The watershed characteristics that influence the amount and rate of runoff are as follows:

1. Area and shape of the drainage basin.
2. Steepness and length of slopes in the basin.
3. Kind and extent of cover.
4. Condition of surface soils - dry, saturated, frozen, etc.
5. Soil types.
6. Storage capacity within the watershed.

1. Area and shape of the drainage basin:

The area and shape of the drainage basin are both important parameters in determining the amount and rate of runoff in a drainage basin. The larger

the basin, the more area to develop runoff. The shape of the basin plays an important part in defining what the peak rate of runoff will be at any given point in the drainage system, and when the peak rate will occur at that point. The total area of the Long Lake drainage basin, including the area covered by the lake itself, is approximately 15,600 acres. The largest portion of the basin is located along the northeast side of the lake, including one area that extends northeast into portions of Solon, Elmwood and Garfield Townships. The remaining portions of the basin along the east, south, west and northwest sides of the lake are fairly uniform in depth back from the edge of the lake.

2. Steepness and length of slopes:

Steepness and length of slope also play an important part in defining what the peak rate of flow will be at any point in the system. In other words, how much water will get where, and when will it get there? The areas with the steepest slopes (greater than 10%) occur along the northeast and east sides of the lake, which is where the highest elevations in the basin occur. The areas along the south and west sides of the lake are generally low lying areas with the flatest slopes (less than 10%).

3. Kind and extent of cover:

Cover is any material, but usually vegetative, covering the soil and providing protection from the impact of rainfall. With good cover, the runoff coefficient (amount of runoff for different conditions) for each area is lower, resulting in less runoff for a given storm for that area. Cover usually consists of fallow, row crops, grains, meadow-pasture and woodlands. In general, most of the Long Lake basin is either woodland or farmland. About 75% of precipitation in woodland areas is held back and does not enter the system immediately, while about 40% of the total is retained by farmland type cover.

4. Condition of surface:

A saturated or frozen type of surface will produce the maximum amount of runoff from any given area; therefore, this type of surface is usually used as existing conditions for evaluating runoff. It is usually best to design for the most damaging situation so that when this condition occurs, the system can handle the flows without failure.

5. Soil types:

The soil survey of Grand Traverse County indicates that there are three (3) main types of soils within the Long Lake drainage basin. They are Rubicon Sand around the south end of the lake, Kalkasksa Sand on the west and north sides of the lake and Emmet- Kalkaska Sands on the east side of the lake (see Figure 1).

The hydrologic properties of a soil or a group of soils are an essential factor in the hydrologic analysis of watershed data. Soils can be classified according to their hydrologic properties if considered independently of watershed slope and cover. Four major soil groups are recognized for the primary classification of watershed soils:

Group A (Low Runoff Potential)

Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of sands or gravel that are deep and well to

TOPOGRAPHICAL FEATURES OF LONG LAKE TOWNSHIP

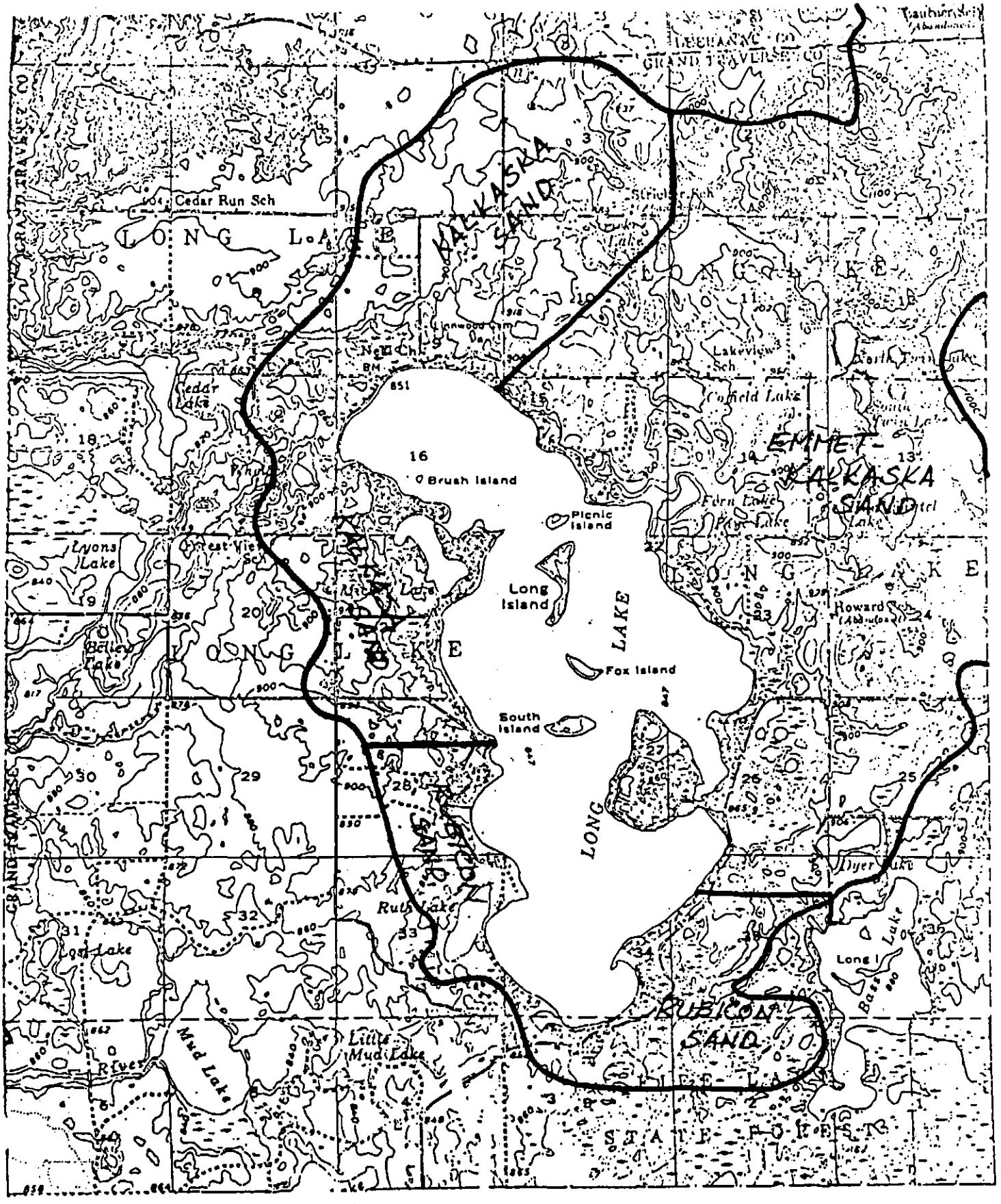

Figure 1. Major soil associations in Long Lake Drainage Basin.

excessively drained. These soils have a high rate of water transmission.

Group B

Soils having moderate infiltration rates when thoroughly wetted, chiefly moderately deep to deep, moderately well to well drained, with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C

Soils having slow infiltration rates when thoroughly wetted, chiefly with a layer that impedes the downward movement of water, or of moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission.

Group D (High Runoff Potential)

Soils having very slow infiltration rates when thoroughly wetted, chiefly clay soils with a high swelling potential; soils with a high permanent water table; soils with a clay pan or clay layer at or near the surface; and, shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission.

The U.S. Soil Conservation Service lists all three of the soils in the Long Lake drainage basin in Group A, which has the lowest runoff potential.

6. Storage capacity within the watershed:

Since water that is stored in ponds, potholes, swamps, etc. cannot directly enter the drainage system, storage capacity available within a basin will have a significant impact on the runoff and peak flow rates within a basin. Storage areas such as potholes, swamps, etc. are shown on Exhibit No. 1 as blackened areas. Ponds are shown as lightly shaded areas. After fully assessing all of the storage areas in the Long Lake drainage basin, it appears that nearly all of the surface runoff from the entire basin, except for a small portion on the west side and a small area on the north side of the lake, drains into such storage areas around the basin. This condition results in little, if any, surface runoff from a storm entering Long Lake. It is important to note; however, that some portion of this stored water will eventually find its way into Long Lake through the ground water system. Since water normally moves very slowly through the ground water system, it may take months or even years, depending on how far it has to travel, for some of this water to find its way into the lake. A large portion of this water will be lost to evaporation, plant uptake, etc., so it would extremely difficult, if not impossible, to try to predict how much of the total water that falls on the basin will actually find its way into Long Lake.

AMOUNT AND RATE OF RUNOFF FROM BASIN

Based on Item No, 6 above (Storage capacity within the watershed), the amount of runoff from a given storm that enters Long Lake via overland flow is more or less limited to the amount of precipitation that falls on the lake surface itself. Nearly all of the precipitation that falls on the overall basin around the lake is trapped in storage areas around the perimeter of the lake and throughout the basin and never reaches the lake via overland flow. Water trapped in such storage areas that is not lost to evaporation or plant uptake or to some other use eventually finds its way to Long Lake through the ground water system.

The actual amount of ground water recharge feeding Long Lake forms the base flow in Sucker Creek at the outlet from Long Lake. The 100 year-24 hour storm for Grand Traverse County area is 4.5 inches. As stated previously, the surface area of Long Lake is approximately 3,000 acres. Assuming that the amount of runoff from such a storm will be roughly equal to the amount of precipitation that falls on the lake surface, the amount of runoff expected from the 100 year storm will be:

$$\text{Volume of runoff (V)} = 3{,}000 \text{ acres} \times \frac{4.5 \text{ inches}}{12 \text{inches/foot}}$$

$$V = 1{,}125 \text{ acre-feet}$$

$$\text{or } 49{,}005{,}000 \text{ cubic feet}$$

$$\text{or } 366{,}557{,}400 \text{ gallons}$$

The peak rate of flow out of the lake through Sucker Creek from such a storm will not increase significantly over the existing base flow in Sucker Creek. The discharge capacity of Sucker Creek is controlled by the size of the creek channel (function of depth of water in channel) and the hydraulic gradient of the channel (slope of water surface in the creek - see Exhibit No. 2). Since the water level in Long Lake would raise only about 5 or 6 inches from the 100 year storm, the discharge capacity in Sucker Creek would increase, but not substantially over the existing base flow. The following example is presented to give the reader some idea of what might happen if a 100 year storm would have occurred earlier this year when Sucker Creek was being surveyed for this project:

The flow in Sucker Creek just downstream of Long Lake was estimated to be approximately 7cfs (cubic feet per second) on March 17, 1987. At this time Long Lake was still higher than normal from the heavy rains of last fall and snow melt this spring. With this in mind, the 7 cfs discharge consisted of the following components:

5 cfs. from excess water stored in Long Lake (based on high water level in lake)
2 cfs. from base flow from ground water recharge from water stored in basin around lake.

If a 100 year storm would have occurred under such existing conditions, the lake level would have risen another 5 to 6 inches and the total flow down Sucker Creek would have increased to approximately 10 cfs. The total increase in flow would be from the rise in lake level, or from the excess water stored in the lake. At a flow of 8 cfs., it would take about 71 days for the excess water from this storm to drain out of the lake through Sucker Creek:

$$\frac{49{,}005{,}000 \text{ cubic feet}}{8 \text{ cubic feet/second}} = 6{,}125{,}625 \text{ seconds}$$

$$\frac{6{,}125{,}625 \text{ seconds}}{60 \text{ seconds/minute}} = 102{,}094 \text{ minutes}$$

$$\frac{102{,}094 \text{ minutes}}{60 \text{ minutes/hour}} = 1{,}702 \text{ hours}$$

$$\frac{1{,}702 \text{ hours}}{24 \text{ hours/day}} = 71 \text{ days}$$

At the end of the 71 day period, the water stored from the most recent storm would be drained out of the lake; however, the excess water that was already stored in the lake prior to the most recent storm would still be present. If several such storms occur in succession, which is what happened last fall, the cummulative effect will result in a steady increase in the water level

in the lake, which is what has been observed in Long Lake over the past year or so.

Another key factor that must be considered is surface evaporation. During the warm weather months, evaporation can account for as much as 1" of water per week when the conditions are right. 1" of water over 3,000 acres is roughly 250 acre-feet, or 10,890,000 cubic feet. On a per week basis, this would amount to an effective rate of about 18 cfs., which is substantially greater than the expected dischage rate through Sucker Creek, which would be somewhere in the range of 7 to 10 cfs.

ENGINEERING ANALYSIS OF SUCKER CREEK

The hydraulic profile of Sucker Creek from Long Lake to Lake DuBonnet is shown in Exhibit No. 2. The total length of the creek between Long Lake and Lake DuBonnet is approximately 5,800 lineal feet. Long Lake is approximately 8 feet higher than Lake DuBonnet. There are 2 sets of twin culverts this stretch of creek; one at West Long Lake Road and the other at Fisher Road. The hydraulic gradient (slope of water surface because the bottom of the creek is so irregular) is relatively flat from Long Lake to Fisher Road, and becomes somewhat steeper from Fisher Road to Lake DuBonnet. The theoretical discharge in an open channel is usually calculated by the use of Mannings Equation, which is:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

where Q = discharge in cfs.
n = coefficient of roughness (ranges from 0.035 to 0.100 for irregular channel obstructed with vegetation and debris)
A = cross-sectional area of flow in square feet
R = hydraulic radius in feet = area/wetted perimeter
S = slope or gradient in feet per feet

By looking at the components of the above equation, the discharge in the creek could be increased by one or all of the following:

1. The coefficient of roughness (n) is dependent on the physical condition of the channel; the smoother and straighter the channel, the smaller the coefficient. The smaller the coefficient, the larger the discharge. Cleaning fallen trees, brush and other debris out of the channel would reduce the cofficent somewhat, which would result in an increase in flow. The coefficient for the existing channel ranges from about 0.040 to near 0.100, depending on the stretch of channel. This could be reduced to about 0.035 if the creek where cleaned out and dredged in some areas to smooth the bottom out. If the entire creek channel were cleaned and dredged as required and the coefficent were reduced the maximum amount (from 0.100 to 0.035), the discharge would be increased by a factor of 2 to 3 times the existing flow. Since it is more likely that the average existing value of n is something more like about 0.070, and the best that could be achieved with a good cleanout would be something in the range of 0.050, the increase in flow expected would be somewhere in the range of 1 to 1.5 times the existing flow.

2. The cross-sectional area of the flow of water in the channel is a function of depth of water in the channel and the width of the channel. Both depth and width can be modified by dredging. Since the discharge is directly proportional to the cross-sectional area, increasing the area by a factor of 2 will increase the flow by a factor of 2 and so forth.

3. The slope of the channel is the hydraulic gradient. In Sucker Creek it

is the slope of the water surface since the bottom of the creek is so irregular. The maximum slope attainable in Sucker Creek would be 0.00138 feet/feet (8'/5,800') if the entire creek from Long Lake to Lake DuBonnet were dredged and regraded. The existing slopes in the creek range from 0.0001'/' between Long Lake and West Long Lake Road to 0.0135'/' between stations 33+00 and 37+00 (see Exhibit No. 2). If the entire creek were dredged and the average slope increased from the minimum of 0.0001'/' at the outlet to the maximum slope of 0.00138'/', the discharge could be increased by a factor of about 10.

Based on the above, it is apparent that the flow out of Long Lake through Sucker Creek could be increased significantly by changing the physical conditions in the existing creek channel. One must keep in mind; however, that the actual increase in flow possible would be limited by the existing capacity of the rest of the system downstream of Lake DuBonnet, which is not known at this time.

The other remaining item that is of major concern with respect to the hydraulic capacity of Sucker Creek is the capacity of the culverts located at West Long Lake Road and Fisher Road. Noting that there is very little, if any, change in the water surface elevation through the two 43" x 27" corrugated steel pipe arch culverts at West Long Lake Road (see Exhibit No. 2), it is apparent that the actual capacity of these culverts is greater than the existing flow in Sucker Creek. Even though the alignment of both culverts is very poor (the downstream end of both culverts are too low, which has resulted in the bottom of both culverts filling in with gravel and sand to a depth of approximately 0.4'), the hydraulic capacity of both pipes combined would be in excess of 20 cfs. without backing water up on the upstream side of the culverts (based on nomographs for inlet and outlet control of culverts taken from the "Handbook of Steel Drainage & Highway Construction Products" by the American Iron and Steel Institute). 20cfs. is substantially greater than the 10 cfs. flow mentioned previously as the expected flow under flood conditions in Sucker Creek. These culverts, as is, would function much more efficiently if the grade of the bottom of Sucker Creek were straightened out as shown by line "A" on Exhibit No. 2, which extends downstream from West Long Lake Road to station 19+50.

The capacity of the two 30" steel pipe culverts at Fisher Road is not adequate to pass existing flows without noticeably changing the water level in Sucker Creek as shown on Exhibit No. 2. As shown, the culverts are installed too low for the bottom of the creek downstream of Fisher Road. This, along with the alignment of the culverts has created a buidup of gravel in the downstream end of the culverts, and in the creek for a short distance downstream of Fisher Road, which is restricting the end area of the culverts and reducing the capacity of the culverts. This is obvious from the drop in the water surface through the culverts as shown on Exhibit No. 2. From the nomographs mentioned above, the hydraulic capacity of these pipes would also exceed 20 cfs. without backing water up if they were installed properly. It appears that the hydraulic capacity of these culverts could be improved significantly by regrading the creek bottom from Fisher Road downstream to station 17+50 as shown by line "B" on Exhibit No. 2. Since these culverts would not flow full at normal flows, as is the case under existing conditions, it would be wise to replace them with 43' x 27" corrugated steel pipe arches, which would provide more end area and better hydraulic capacity at lower water levels (provide more end area in the bottom portion of the pipe).

ALTERNATIVE SOLUTIONS

After analyzing the information presented to this point, it is apparent that there is not any solution that would immediately solve the high water problems that currently exist in Long Lake. The volume of excess water stored in the lake is too large to be able to deal with in a short period of time. The following actions are presented as possible steps that could be taken to help to alleviate the existing problems in a much quicker manner than would occur if nothing were done.

1. Leave existing conditions unchanged (do nothing)

   Assuming that precipitation patterns return to normal, the excess water currently stored in Long Lake and the surrounding drainage basin would eventually drain out of Long Lake through Sucker Creek, or be lost to evaporation. There are not any changes in the physical conditions in Sucker Creek that would cause the water level in Long Lake to raise and stay at a higher level when the flow out of the lake returns to normal levels. At some point in the future, the excess water would be drained, and Long Lake would return to its normal level. The disadvantages with this approach are as follows:

   A. It offers no opportunity to control the level of Long Lake during periods of high precipitation, such as occurred last year.
   B. It is not known how long the high levels in Long Lake will persist without any action. Modifying the system would not solve the problem immediately, but it would help to speed up the process.

   The big advantage to this approach is that it does not cost anything.

2. Remove fallen trees, brush and other debris from creek

   As discussed under the engineering analysis of Sucker Creek, cleaning the creek out would certainly reduce the coefficient of roughness, thus increasing the flow in Sucker Creek by a factor of from 1 to 1.5. If such a cleanout were conducted in the area from Long Lake downstream to Fisher Road, the water level in Sucker Creek upstream of each blockage removed would drop slightly (there are 3 noticeable drops in the water level in this area - see Exhibit No.2). The total drop achieved would be about 3". Since the water level in Sucker Creek establishes the high water level in Long Lake, the water level in Long Lake would decrease accordingly during periods of high flow. Such a cleanout would also help to increase the flow in the creek, which would help to speed up the time required for the system to drain off excess water. This project could be undertaken with volunteer labor; therefore, the cost of this option would be minimal.

3. Dredge creek downstream of Fisher Road

   If the creek were dredged downstream of Fisher Road to station 17+50 (see line "B" on Exhibit No. 2), the hydraulics of the existing culverts through Fisher Road would be improved, which would alleviate some of the existing bottleneck at that point. Such action should eliminate most of the drop in water surface through the culverts, which would further drop the high water level in Long Lake by some 3 or 4 inches. Since only the bottom half of the pipe culverts would be utilized, which is not the most effecient part of a circular section, some drop would probably still be present, but it would be less than it is now. The cost of dredging, including clearing, regrading the spoils, seeding, etc.

would be about $25.00 per lineal foot of creek; therefore, the cost of 450 lineal feet of dredging would be about $11,250.00.

4. Replace culverts at Fisher Road and dredge downstream to sta. 19+50

Based on data presented as part of the engineering analysis, it appears that it would be wise to replace the culvert pipes at Fisher Road with 2 43" x 27" corrugated steel pipe arches to completely remove the existing bottleneck at this point. If the culverts are repalced, the invert of the new culverts should be placed on line "A" shown on Exhibit No. 2. This would eliminate the need to reset the culverts at a lower elevation if the dredging recommended in Item 5 were ever undertaken. The creek would then be dredged on line "A" from the downstream end of Fisher Road to station 19+50. The cost of this option is as follows:

650 L.F. of dredging @ $25.00 per L.F.	=	$16,250.00
Install 30L.F. of twin 43" x 27" C.S.P. @ $130.00 per L.F.	=	3,900.00
Estimated Construction Cost	=	$20,150.00
Engineering & Inspection	=	2,500.00
Total Estimated Cost of Project	=	$22,650.00

5. In conjunction with Item 4 above, dredge creek from West Long Lake Road to Fisher Road

This option would provide the maximum hydraulic capacity available without completely reconstructing the total length of the creek and replacing the culverts at both road crossings. Add the following cost to the cost in Item 4 above:

670 L.F. of dredging @ $25.00 per L.F.	=	$16,750.00
Engineering & Inspection	=	2,000.00
Total Estimated Cost of Project	=	$18,750.00

6. Dredge the entire length of creek and replace all culverts

This option would provide the maximum hydraulic capacity available from the system, but it would also be far and away the most costly. The cost would be as follows:

5,800 L.F. of dredging @ $25.00 per L.F.	=	$145,000.00
Replace culverts @ West Long Lake Road 80L.F. of 43" x 27" C.S.P. @ $150.00 per L.F.		12,000.00
Replace culverts at Fisher Road (from Item 4)		3,900.00
Total Estimated Construction Cost	=	$160,000.00
Engineering & Inspection	=	20,000.00
Total Estimated Cost of Project	=	$180,000.00

Considering the financial requirements, and the benefit gained per dollar spent, it appears that Item 4 would provide the best return for the money spent. If the actions presented in Item 4 were implemented, and the problem was not entirely taken care of, Item 5 could be implemented at a later date. One also shouldbear in mind that the above analysis has not included costs for land or easement acquisition and this is something that must be considered before actually proceeding with such a project.

SUMMARY AND CONCLUSIONS

Highwater levels have been a continuing problem in Long Lake since the later part of 1985. It is likely that such levels will continue to be a problem for some undetermined length of time into the near future; however, eventually it will subside even if no action is taken at this time to alleviate the probelm. The problems will subside much sooner if the weather pattern remains dry as it has much of this year so far; however, the problem could return or even become worse if above normal precipitation patterns similar to those that occurred last year return to the area again. If it were not for the numerous storage areas shown on Exhibit No. 1, the problem would be much more severe than it has been thus far; therefore, it is imperative that these areas be preserved as they are. Preservation of such storage areas should be an integral part of long range plans for development within the basin. Fortunately, nearly the entire drainage basin lies within Long Lake Township, which makes it much easier to control development when the area is under the jurisdiction of one political entity. In addition, adequate drainage plans, incorporating retention and slow release, should be required for all development within the basin to insure that runoff from such developments does not have an impact on the amount of runoff entering Long Lake directly via overland flow. Control of most drainage falls within P.A. 347, which is administered by the Drain Commissioner in Grand Traverse County. It is important to make sure that both Township officials and the Drain Commissioner are aware of all construction activities within the basin to insure that such activities are being done in accordance with existing rules and regulations. A large number of small projects uncontrolled can sometimes have a more pronounced effect on the system than one large project. It is possible to modify Sucker Creek to both lower the highest water level expected in Long Lake during periods of higher than normal precipitation, and to drain the excess water in the lake faster, which will result in quicker drawdown of the lake following higher levels. Some of the proposed modifications can be accomplished with volunteer labor (item 2), but the most important changes suggested would cost somewhere between $20,000.00 and $50,000.00 (items 4 & 5).

The proposed modifications to Sucker Creek, if implemented, will not completely eliminate the highwater problems currently existing in Long Lake; however, they will reduce the highest levels that occur after periods of unusual precipitation, and they will expedite the drawdown of the lake following such periods.

Appendix B

Long Lake Water Quality
Year 2000 Monitoring Program

Long Lake Water Quality
Year 2000 Monitoring Program

Prepared for:

The Long Lake Watershed Partnership

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Long Lake Water Quality
Year 2000 Monitoring Program

INTRODUCTION

1997 - 1999 Sampling. Comprehensive water quality monitoring of Long Lake was performed from1997 to 1999. A variety of limnological parameters were measured at several depths at three sampling locations, representing the deepest areas in the northern (Site 1), central (Site 2) and southern (Site 3) portions of the Lake (Figure 1). Parameters measured at all sites in this study were temperature, dissolved oxygen, total phosphorus, secchi depth, pH, oxidation-reduction potential and conductivity. In addition, nitrate-nitrite nitrogen (NOx), chlorophyll *a* and zooplankton were measured at Site 1 only in 1997 and 1998. In 1999, NOx and chlorophyll *a* were measured at all sampling sites.

Summer bottom water dissolved oxygen concentrations were nearly zero at Sites 1 and 2 from 1997 to 1999 and near zero periodically for Site 3, depending on the development of a temperature stratification (thermocline). Oxygen depletion at deep water sampling sites is the result of a naturally occurring thermocline that develops during the summer months. Bottom phosphorus concentrations were very elevated (average of 42 μg/L for July-September at Site 2) in 1998 and 1999. This is likely a result of release of phosphorus from the bottom sediments due to these low oxygen levels. Secchi depth measurements, chlorophyll a levels and nitrate-nitrite nitrogen levels were all characteristic of relatively good water quality although there was a temporal trend of increased chlorophyll a in the summer indicating a potential late-summer algal bloom.

METHODS

Long Lake monitoring was initiated again in 2000 by Great Lakes Environmental Center (GLEC) with the intent to supply additional information which could be combined with the 1997-1999 data and utilized in developing a hydrologic and nutrient budget model. Monitoring of additional parameters included: 1) sediment sampling at various depths throughout the lake and determination of phosphorus content, 2) analysis of rainfall from April through September including volume, total phosphorus, nitrate-nitrite nitrogen and

kjeldahl (organic) nitrogen content, 3) measurement of total phosphorus and nitrate-nitrite nitrogen content of groundwater, 4) measurement of tissue nutrient content from aquatic plants, and 5) continued monitoring of Long Lake water quality parameters (dissolved oxygen, temperature, conductivity, oxidation-reduction potential and pH) and water chemistry (total phosphorus levels at four depths in the water column). Monitoring of flow at Sucker Creek (Long Lake outlet) was also scheduled to be completed but lake water levels were lower than what was necessary for outflow to occur. Therefore, outflow rates and concomitant nutrient loss were assumed to be zero for the purposes of modeling. All these data were compiled and integrated with data from 1997-1999 into the hydrologic/nutrient model, presented as a separate report. Unless otherwise described, all techniques equipment for water sampling and analytical chemistry have been reported previously (Long Lake Water Quality Monitoring 1997-1998; Long Lake Monitoring Supplemental Report, 1999.

Water chemistry sampling was continued in 2000 at the same three sampling points as were used in 1997 through 1999 (Figure 1). Total phosphorus measurements were determined at the surface and near bottom in previous years. The current program added to intermediate depths (mid-epilimniom and mid-hypolimniom) to determine if there was a stratification of phosphorus concentration with depth. Sampling was conducted from late spring through late fall, consistent with prior years. Chlorophyll a concentrations were determined at all three principal sampling sites as were Hydrolab® and secchi depth measurements.

Sediment sampling was completed at these principal sampling points in August 1999 and was repeated again in August 2000. These sampling points were 65 , 82 and 52 feet for Sites 1,2 and 3, respectively. Supplemental sediment sampling was performed in 2000 at 12 additional sites in Long Lake (Figure 1) which included sediment from depths of approximately 10 feet to 50 feet and a range of sediment composition (sandy to organic).

The relative volume and concentration of nutrients from precipitation was necessary for completion of the nutrient/hydrologic model. Rainfall volume was measured using a RainWise model RGEL Electronic Recording Rain Gauge (RainWise, Bar Harbor, ME). The gauge was installed approximately 20 feet from the eastern shore of Long Lake on the Templeton property, clear of any overhanging trees or other structures which might affect rain collection. Data were collected from May through September, 2000 and downloaded

electronically to a laptop computer for analysis. Rainfall chemistry was primarily collected at the GLEC laboratory, located approximately 8 miles east of Long Lake. Sampling at this distance from the lake was not expected to yield chemistry data which would be significantly different that that collected at the lake itself as 8 miles is considered geographically insignificant with respect to precipitation chemistry (R. Flagler, personal communication). However, in order to compare the relative differences between rain chemistries collected at GLEC and Long Lake, rainfall collection was also completed from the dock of the Doerr residence on the western side of Long Lake peninsula. Rain samples at both sites were collected in an acid-washed glass Erlenmeyer flask with an 12 inch polypropylene funnel on top. In order to eliminate insects and extraneous material, a 0.8 mm mesh stainless steel screen covered the mouth of the collection funnel. Samples were removed from the flask within 6 hours at GLEC and within 1 day from the Doerr dock sampling site, acidified and held at 4 °C until analysis. Samples were bulked over several days to average the precipitation event. Water samples were analyzed for total phosphorus, nitrate-nitrite nitrogen and kjeldahl (organic) nitrogen using methods described previously (Long Lake Monitoring 1997-1998).

Groundwater water was monitored to provide nutrient data for the hydrologic/nutrient model. USGS groundwater contours suggest that the primary flow of subsurface water is toward the eastern/northeastern side of Long Lake. Groundwater flows away from the lake on the western side and therefore, monitoring was concentrated on the north, east and southern sides within 1000 feet of the shoreline.

There were two principal approaches for sampling groundwater. First, in order to increase the probability that drinking well water was hydrologically connected to Long Lake, a criterion was established that the static water level in the well must be within 20 feet of the lake surface elevation. In order to determine those well which met this criterion, the well log database from Grand Traverse County Health Department was consulted and all wells within 1000 feet of the shoreline of Long Lake and with appropriate static water levels were identified. These property owners were contacted and asked if they would be willing to participate in the study. Of the 25 identified property owners which were contacted, eight agreed to participate in the study (Figure 2). Samples were collected in 0.25 L acidified collection bottles from an outside water source, placed on ice during transport to the

laboratory and held at 4 °C until analysis. These samples were analyzed for total phosphorus and nitrate-nitrite nitrogen concentrations.

The second sampling approach was used to determine if high nutrient levels were present in near shore, subsurface groundwater (less than 8 feet deep and therefore connected to the lake water). Stainless steel 2 inch well points were placed in the ground at 15 foot intervals on a line perpendicular to the shoreline at two locations on Long Lake. One location was east of Long Lake Peninsula on the eastern shore and the other near the southeastern tip of the Lake. The well points were established at approximately 15, 30 and 45 feet from the lake water edge. Wells were driven down until at least 3 inches of water was evident in the bottom of the well point. In all cases, the maximum depth of the well was less than five feet. Water was pumped from the well through ¼ inch teflon tubing using a small volume electric pump. The first 50 mL was discarded on the ground and a 200 mL sample was pumped into a glass collection bottle (unacidified). The sample was the placed on ice during transport to the laboratory and held at 4 °C until analysis. It should be noted that all samples contained large amounts of suspended sediment. The sediment was allowed to settle out and the overlying water in the sample bottle was carefully removed and placed into an acidified sample bottle. The samples were analyzed for total phosphorus and nitrate-nitrite nitrogen concentrations.

RESULTS

The results of the 2000 monitoring year demonstrated water chemistry trends which were similar to 1997-1999. Bottom phosphorus levels were again elevated (approximately 15-27 μg/L) after mid-June, corresponding with the period of anoxic conditions at the lake bottom (Table 1). Surface concentrations were in the oligotrophic range (< 9 μg/L) and were consistent of levels found at other area lakes. The inherent temperature stratification (e.g., thermocline) of the lake at the deeper areas which occurs during summer was again evident after mid-June at the two deepest sampling sites (see temperature/dissolved oxygen profiles in the Appendix). Lake "turnover" or mixing occurred near the beginning of October. Chlorophyll *a* levels were very consistent throughout the sampling period (1.1-1.4 μg/L) but did show a slight elevation in the late fall which is consistent with previous years

and may be indicative of an increase in the algal community (see Hydrolab data, Appendix). Secchi depths continued to be characteristic of oligotrophic conditions.

Additional monitoring data (Table 2) indicated that rainfall was a significant source of nutrients, particularly phosphorus. Concentrations of total phosphorus ranged from 1.9 – 47.2 μg/L depending on rain event. Although there was considerable variability in phosphorus, NOx, and kjeldahl nitrogen levels between samples collected at GLEC and Long Lake, a comparison of the seasonal average concentrations for these nutrients were remarkably close (Table 2). This indicates that there were probably not significant differences in rainfall chemistry between these collection sites. Concentrations of inorganic and organic nitrogen were not excessively high but were much higher than is typically found in Long Lake.

Sediment phosphorus values verified results obtained in 1999 and were extremely high (maximum of 1754 mg/kg dry weight) at many of the deepest points in the lake (Table 3, Figure 1). However, low phosphorus concentrations were also evident in some shallow areas and in areas with apparent low bottom organic content. Sediment concentrations of phosphorus were used in the nutrient model calculations to determine internal loading of phosphorus under anoxic conditions at the lake bottom.

Groundwater phosphorus concentrations from drinking water wells averaged 9.7 μg/L and did not appear to be a major source of input into Long Lake (Table 4). Nitrate-nitrite levels were also very low (with the exception of two sampling sites) and were similar to levels measured in lake water. The two sites with elevated nitrate-nitrite levels may have been due to high background concentrations, localized nutrient leaching or perhaps from poorly functioning septic systems. However, the elevated nitrogen concentrations were well within the acceptable range for drinking water and did not pose a health risk. It would be difficult to determine the localized source of this nitrogen without extensive testing.

DISCUSSION

The data from the year 2000 sampling season continued to indicate that Long Lake would be considered oligotrophic but has verified extremely high concentrations of bottom sediment phosphorus. Bottom sediment phosphorus concentrations are distinctly higher than concentrations measured in 10 other area lakes (Table 5). This phosphorus can be a

significant source of nutrients to the Lake through an internal loading process when bottom oxygen concentrations drop to near zero. The amount of phosphorus which can be released under anoxic conditions can be approximated by the Nurnberg (1988) equation:

$$R = 6.3\ (TP)^{.76}$$

Where R is the Release Rate (mg P/sq. meter/day) and TP is total phosphorus expressed as mg P/kg Dry Weight. A calculation of phosphorus release rates (Table 5) demonstrates that there is a significant potential for phosphorus input from bottom sediments into Long Lake under anoxic conditions. Because anoxic conditions are known to consistently occur (based on 1997-2000 data), this potential flux of phosphorus from the sediments is an important component of the overall phosphorus budget for the Lake.

Atmospheric precipitation also appears to be a sizeable source of nutrient input. The extent of atmospheric input is, of course, dependent on the amount of rainfall but the average phosphorus concentration determined in the 2000 monitoring season was approximately twice the concentration measured in Long Lake surface water. Therefore the potential for significant uncontrolled inputs of nutrients, particularly phosphorus, from the atmosphere is very high. This source of nutrient input was incorporated into the nutrient/hydrologic budget developed as a separate task from this monitoring.

In contrast, examination of groundwater data did not seem to indicate that high concentrations of phosphorus are contributed through the aquifers which primarily feed the lake. Although high concentrations of phosphorus were found in the shallow subsurface wells (Table 4), the elevated suspended sediment content of this sampled water may have contributed to these high values and may not be indicative of near shore groundwater phosphorus concentrations.

In general, the water quality of Long Lake continues to be marginally acceptable as evaluated by the general trophic state classification of Chapra (Table 6). Using total phosphorus, chlorophyll a, and secchi depth Long Lake would be classified oligotrophic. However, percent saturation of hypolimnion oxygen (below thermocline) is consistently below levels considered to be oligotrophic and are more indicative of eutrophic conditions.. Although the development of a thermocline is a natural process, the combination of anoxic conditions coupled with extremely high sediment phosphorus levels demonstrates the potential of significant internal loading of phosphorus in Long Lake. This internal loading

may cause late season algal blooms and potential increases in aquatic plants within the lake ecosystem. Thus, water quality conditions in Long Lake are vulnerable to dangerous deterioration.

Although Long Lake is considered oligotrophic, the flushing rate (water replacement time) for the lake is roughly 9 years, and the lake has suffered from extremely low water levels over the past two years which have eliminated most outflow. The result of this situation is that most nutrients and sediment which enter into Long Lake through the watershed or from the atmosphere remain in the lake and continue to accumulate. Because the major sources of nutrient input (internal loading from bottom sediments, atmospheric deposition) are uncontrolled, it becomes even more critical to limit those sources of nutrients which are contributed through human activities within the watershed.

Although existing high sediment phosphorus levels are related to the long-term loading and low flushing rate characteristics of Long Lake, emphasis should be placed on limiting further phosphorus inputs to the Lake and surrounding watershed. The proposed watershed management plan can be used to evaluate the impacts of future development and help to structure zoning and development activities not only in Long Lake nearshore areas but also throughout the entire watershed. It is critical to control nutrient loading activities to ensure the water quality of Long Lake in the future.

REFERENCES

Chapra, S. C., 1997, Surface Water Quality Modeling, McGraw-Hill, New York

Flagler, R. 2000. Personal communication from former regional technical director of National Acidic Precipitation Assessment Program.

Nurnberg, G. K., 1988, "Prediction of Phosphorus Release Rates from Total and Reductant-Soluble Phosphorus in Anoxic Lake Sediments", Can J. Fish. Aquatic. Sci., Vol. 45

Table 1. Long Lake Phosphorus and Chlorophyll *a* Measurements Sampled in 2000.

All Values Expressed as µg/L

Sampling Site #1

Sample Point	5-Jun	19-Jun	30-Jun	12-Jul	3-Aug	25-Aug	13-Sep	28-Sep	9-Oct
Surface	5.7	4.7	17.9	3.1	4.3	6.1	8.1	4.4	7.2
Mid-Eiplimnion	6.1	3.3	8.3	8.4	4.2	7.0	6.9	6.0	10.6
Mid-Hypolim	7.0	7.1	7.9	7.8	4.2	14.7	13.1	8.3	10.8
Bottom	7.7	9.9	17.2	15.3	7.1	18.3	15.1	8.5	20.8
Chlorophyll a	1.4	1.1	1.6	1.1	1.2	1.4	2.0	1.2	2.0

Sampling Site #2

Sample Point	5-Jun	19-Jun	30-Jun	12-Jul	3-Aug	25-Aug	13-Sep	28-Sep	9-Oct
Surface	8.2	4.8	7.8	3.9	4.9	8.3	11.7	8.2	8.7
Mid-Eiplimnion	7.2	5.3	6.8	9.0	8.3	5.2	6.6	9.8	8.9
Mid-Hypolim	6.8	6.0	7.0	14.2	6.9	12.5	14.0	21.0	9.3
Bottom	12.2	10.4	13.0	18.9	9.3	17.2	15.5	27.4	9.1
Chlorophyll a	1.6	1.3	1.8	1.3	1.2	1.4	2.5	2.3	2.5

Sampling Site #3

Sample Point	5-Jun	19-Jun	30-Jun	12-Jul	3-Aug	25-Aug	13-Sep	28-Sep	9-Oct
Surface	6.4	4.0	34.4	6.4	7.0	6.7	9.0	6.5	9.0
Mid-Eiplimnion	nd	nd	nd	nd	7.8	nd	10.6	7.6	8.2
Mid-Hypolim									
Bottom	7.0	7.3	20.3	15.4	6.4	12.8	7.1	9.3	19.2
Chlorophyll a	1.5	0.6	1.8	1.5	0.2	1.6	2.9	2.5	2.6

Table 2. Rainfall Volume and Nutrient Chemistry for Long Lake 2000.

Rainfall Measured at GLEC

DATE	Total P (µg/L)	NOx (mg/L)	KJ-N (mg/L)
5/12 - 5/21	32.3	0.44	1.2
5/22	27.5	0.60	0.93
6/14	28.9	0.41	1.6
6/20	47.2	0.48	1.2
7/27	8.8	0.85	
7/28	1.9	0.30	
7/28 - 7/30	2.9	0.26	
8/15	7.3	0.75	0.71
8/26	6.3	0.24	0.54
9/1 - 9/2	4.9	0.68	0.72
9/8	17.6	1.00	1.3
9/11	9.6	0.47	0.39
9/12	5.6	0.22	0.57
9/21	17.9	0.28	0.63
Mean	15.6	0.50	0.89

Rainfall Measured at Long Lake

DATE	Total P (µg/L)	NOx (mg/L)	KJ-N (mg/L)
6/20	16.50	0.40	0.73
7/27	23.80	0.55	
7/28	11.70	0.85	
7/28 - 7/30	2.40	0.25	
Mean	13.6	0.51	0.73

Table 3. Long Lake Sediment Phosphorus Concentration and Sampling Depths in 2000.

Site ID #	Total P (mg/kg dry wt)	Depth (ft.)
Site 1	1754.0	65
Site 2	1211.3	82
Site 3	50.6	52
1-S	26.5	50
2-S	137.3	15
3-S	49.1	20
4-S	79.6	10
5-S	804.2	30
6-S	1042.0	50
7-S	1325.7	40
8-S	63.5	12
9-S	66.5	30
10-S	31.4	40
11-S	824.8	40
12-S	20.5	20

Site 1,2 and 3 are the principal sampling sites for all water quality measurements. All other sites (e.g., 1-S, 2-S, etc) are additional sediment sampling sites.

Table 4. Long Lake Drinking Water and Subsurface Well Nutrient Concentrations in 2000.

Drinking Water Wells*

Well ID #	Total P (μg/L)	Nitrate/ Nitrite - N (mg/L)	
219	3.5	0.01	
220	6.0	0.01	
223	1.5	0.01	
293	3.5	3.30	
705	25.0	0.01	
706	18.6	0.01	
870	18.2	0.06	
886	1.1	8.00	
	9.7	1.43	average
	18.6	8.00	maximum value

* Drinking water wells with static water level within 20 feet of lake surface level

Surface Water Wells**

Well ID #	Total P (mg/L)	Nitrate/ Nitrite - N (mg/L)	
WIN-A	51.9	0.01	
WIN-B	46.3	0.01	
WIN-C	40.0	0.04	
SHO-A	56.8	0.02	
SHO-B	40.3	0.01	
SHO-C	20.9	0.01	
	42.7	0.02	average
	51.9	0.04	maximum value

** 2 inch well points. Location A= 15 feet from lake water edge, B=30 feet from lake edge,
C=45 feet from lake edge

Table 5. Phosphorus Data for Area Lakes and Sediments

Lake	Water Total Phosphorus (μg/L)	Sediment Phosphorus (mg TP/ kg DW)	Release Rate (mg P/sq m/day)
Torch	1.7	86	0.98
Burt	2.2	119	1.25
Lime	4.4	200	1.85
Crystal	4.8	332	2.73
North Leelanau	4.8	489	3.71
South Leelanau	4.9	398	3.13
Glen	5.1	326	2.69
Little Traverse	5.1	401	3.15
Cedar	5.3	396	3.12
Platte	7.7	620	4.38
Long (Site 1)	**8.6***	**1742****	**9.61**
Long (Site 2)	**13.6***	**1051****	**6.54**
Long (Site 3)	**9.3***	**684****	**4.72**

*Average of all surface and bottom measurements for each sampling site for 1997 - 2000 monitoring seasons.

**Average of sediment phosphorus concentrations from 1999 and 2000 sampling seasons.

Table 6. Trophic State Classification (Chapra, 1997)

Variable	Oligotrophic	Mesothophic	Eutrophic
Total Phosphorus (μg/L)	< 10	10-20	>20
Chlorophyll a (μg/L)	<4	4-10	>10
Secchi depth (m)	>4	2-4	<2
Hypolimnion Oxygen (% sat)	>80	10-80	<10

Figure 1. Monitoring Sites on Long Lake for the Year 2000 Monitoring Program.

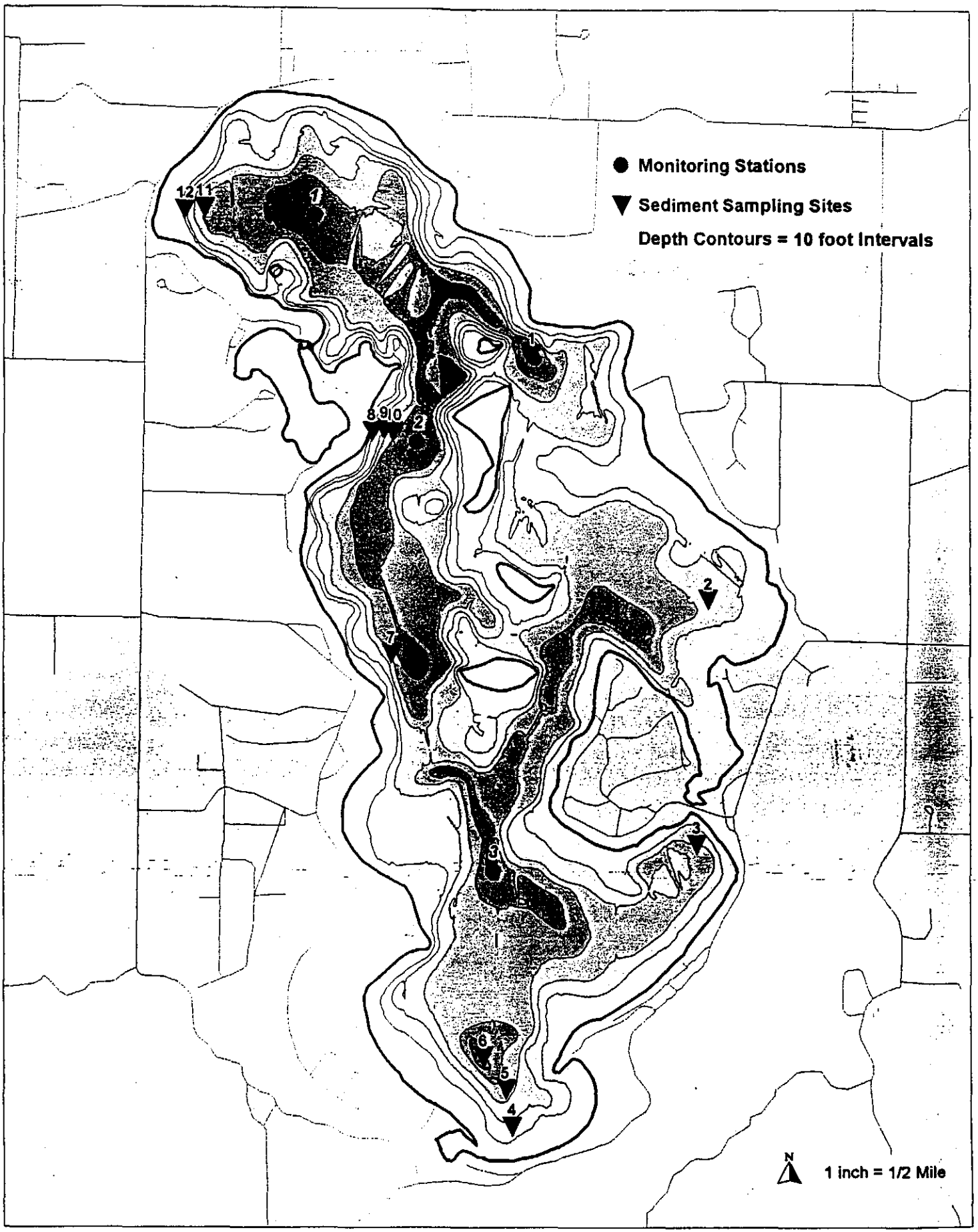
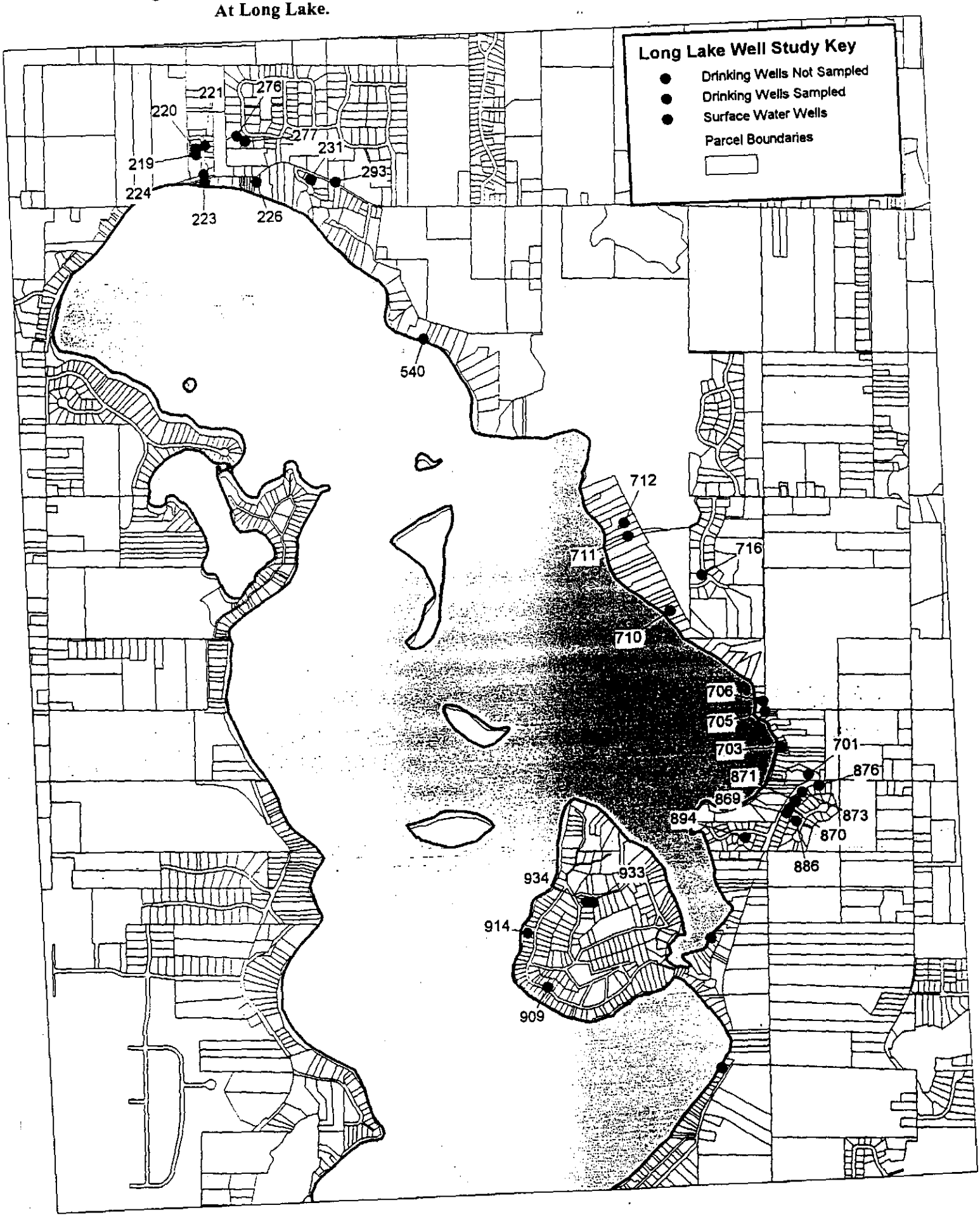


Figure 2. Well Sampling Sites Identified for Monitoring Groundwater At Long Lake.



APPENDIX

HYDROLAB DATA
TEMPERATURE AND DISSOVED OXYGEN PROFILES

YEAR 2000 MONITORING PROGRAM

Long Lake Station 1 Date: 06/05/00

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	16.9	11.24	9.72	115.60	0.442	0.274
1	17.0	11.23	9.71	115.62	0.443	0.270
2						
3						
4						
5	17.0	11.25	9.71	115.83	0.448	0.269
6						
7						
8	16.4	11.33	9.82	115.36	0.407	0.269
9	15.9	11.18	9.94	112.47	0.314	0.273
10	14.8	11.22	10.18	110.24	0.224	0.277
11	13.3	11.03	10.51	104.95	0.189	0.284
12	12.1	10.82	10.79	100.24	0.193	0.291
13	11.1	10.60	11.04	95.98	0.177	0.293
14	10.7	10.52	11.16	94.31	0.207	0.308
15	10.5	10.26	11.21	91.55	0.200	0.307
16						
17	9.8	8.31	11.38	73.01	0.186	0.314
17.4	9.8	4.65	11.39	40.82	0.221	0.177
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp = 64F; Clear, Windy

Secchi Depth: 31.5 ft

Long Lake Station 2 Date: 06/05/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	17.1	12.41	9.68	128.22	0.453	0.259
1	17.2	12.14	9.67	125.49	0.453	0.256
2						
3						
4						
5	16.8	11.95	9.75	122.57	0.464	0.258
6						
7						
8						
9						
10	14.7	11.14	10.18	109.40	0.223	0.283
11	14.3	10.76	10.28	104.71	0.119	0.288
12	11.7	10.68	10.90	98.00	0.204	0.295
13	10.9	10.33	11.09	93.12	0.188	0.299
14	10.7	10.14	11.15	90.92	0.207	0.302
15						
16						
17						
18						
19						
20	10.2	9.67	11.28	85.72	0.223	0.308
21						
22						
23						
24						
25	10.1	9.42	11.31	83.27	0.199	0.310
26						
27						
28						
29						
30						

Notes: Temp = 64F; Clear, Windy

Secchi Depth: 33.5 ft.

Long Lake Station 3 Date:06/05/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	17.5	13.73	9.61	142.87	0.440	0.338
1	17.5	13.23	9.61	137.72	0.442	0.337
2						
3						
4						
5	17.5	12.89	9.61	134.07	0.437	0.337
6						
7						
8						
9						
10	16.9	12.46	9.73	128.07	0.470	0.339
11						
12						
13.6	16.3	7.97	9.84	80.96	0.197	0.131
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp = 64F; Clear, Windy

Secchi Depth: 27.5 ft.

Long Lake Station 1 Date: 06/19/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	20.0	10.01	9.13	109.62	0.347	0.267
1	20.0	9.98	9.14	109.25	0.346	0.262
2						
3						
4						
5	19.8	9.92	9.16	108.27	0.363	0.261
6						
7						
8						
9						
10	19.4	9.59	9.24	103.83	0.288	0.263
11	16.2	9.46	9.87	95.85	0.184	0.276
12	13.7	9.37	10.41	89.97	0.217	0.283
13	12.1	8.80	10.79	81.52	0.215	0.289
14	11.6	8.08	10.92	74.01	0.202	0.292
15	11.5	7.65	10.94	69.94	0.205	0.294
16	11.0	5.57	11.06	50.34	0.195	0.297
17	10.9	4.37	11.11	39.33	0.217	0.191
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =77F; Sunny

Secchi Depth: 32 ft

Long Lake Station 2 Date: 06/19/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	19.9	10.08	9.14	110.28	0.352	0.283
1	19.9	10.08	9.14	110.28	0.352	0.282
2						
3						
4						
5	19.8	10.07	9.17	109.86	0.357	0.281
6						
7						
8						
9						
10	18.2	10.00	9.47	105.65	0.222	0.290
11	16.3	9.71	9.86	98.51	0.196	0.296
12	13.5	9.02	10.46	86.27	0.198	0.309
13	11.8	8.37	10.86	77.07	0.198	0.313
14	11.6	8.05	10.91	73.76	0.199	0.315
15	11.5	7.74	10.95	70.71	0.199	0.317
16						
17						
18						
19						
20	11.1	7.27	11.06	65.73	0.199	0.327
21						
22						
23						
24						
25	10.4	6.91	11.24	61.47	0.201	0.260
26	10.8	5.02	11.12	45.13	0.209	0.165
27						
28						
29						
30						

Notes: Temp =75F; Partly Cloudy

Secchi Depth: 32 ft

Long Lake Station 3 Date: 06/19/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	19.6	11.03	9.20	119.93	0.363	0.313
1	19.6	11.01	9.20	119.73	0.362	0.312
2						
3						
4						
5	19.6	10.84	9.21	117.67	0.370	0.312
6						
7						
8						
9						
10	19.4	10.66	9.24	115.32	0.367	0.312
11						
12						
13						
14						
15	17.6	8.62	9.59	89.92	0.189	0.330
16.5	17.2	6.51	9.66	67.40	0.214	0.335
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =75F; Partly Cloudy

Secchi Depth: 32 ft.

Lake Station 1 Date: 6/29/00

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	20.6	8.83	9.03	97.83	0.329	0.366
1	20.7	8.82	9.01	97.85	0.327	0.364
2						
3						
4						
5	20.7	8.84	9.00	98.17	0.326	0.363
6						
7						
8						
9						
10	20.2	8.35	9.09	91.84	0.263	0.369
11	17.3	7.31	9.64	75.86	0.196	0.380
12	15.7	6.46	9.98	64.71	0.198	0.389
13	13.3	6.40	10.51	60.90	0.198	0.393
14	12.6	6.13	10.69	57.37	0.200	0.395
15	11.9	5.21	10.85	48.01	0.200	0.397
16						
17.8	11.4	2.05	10.97	18.69	0.215	0.880
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =70F; intermitent rain

Secchi Depth: 21 ft

Long Lake Station 3 6/29/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	20.4	9.32	9.07	102.79	0.332	0.484
1	20.7	9.27	9.00	102.95	0.327	0.497
2						
3						
4						
5	20.7	9.24	9.01	102.60	0.326	0.478
6						
7						
8						
9						
10	20.6	9.79	9.02	108.55	0.329	0.475
11						
12						
13						
14						
15	20.0	3.90	9.13	42.73	0.379	0.403
15.2	19.3	2.05	9.27	22.12	0.217	0.119
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =70F; intermitent rain

Secchi Depth: 21 ft

Long Lake Station 1 7/12/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	22.3	8.85	8.72	101.46	0.161	0.245
1						
2						
3						
4						
5	22.2	8.90	8.75	101.74	0.161	0.243
6						
7						
8						
9						
10	21.6	8.55	8.84	96.67	0.162	0.248
11						
12	17.3	5.97	9.65	61.86	0.165	0.260
13	14.3	4.14	10.28	40.25	0.166	0.265
14	12.8	3.09	10.63	29.07	0.168	0.272
15	12.2	2.55	10.77	23.68	0.167	0.276
16						
17						
18	11.5	0.63	10.95	5.75	0.174	0.013
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =70F; Cloudy

Secchi Depth: 24 ft

Long Lake Station 2 7/12/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	20.7	8.79	9.01	97.56	0.162	0.338
1						
2						
3						
4						
5	22.5	8.88	8.70	102.10	0.162	0.329
6						
7						
8						
9						
10	20.7	8.00	9.00	88.86	0.160	0.331
11						
12	17.5	6.28	9.61	65.35	0.163	0.341
13	13.9	3.87	10.38	37.30	0.161	0.342
14	13.1	3.63	10.56	34.39	0.166	0.347
15	12.4	3.10	10.74	28.88	0.165	0.348
16	11.9	2.97	10.84	27.40	0.167	0.348
17						
18						
19						
20	11.5	2.47	10.94	22.58	0.167	0.349
21						
22						
23						
24						
25	11.3	2.07	11.00	18.82	0.166	0.349
26	11.2	1.86	11.01	16.89	0.168	0.312
27						
28						
29						
30						

Notes: Temp =70F; Cloudy

Secchi Depth: 25 ft

Long Lake Station 3 Date: 07/12/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	22.9	9.04	8.63	104.73	0.162	0.416
1						
2						
3						
4						
5	22.6	8.86	8.68	102.04	0.161	0.410
6						
7						
8						
9						
10	21.5	8.10	8.86	91.42	0.163	0.407
11						
12						
13						
14						
15	20.7	3.86	9.00	42.88	0.165	0.420
16	20.4	1.64	9.06	18.10	0.168	0.085
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =70F; Cloudy

Secchi Depth: 19.5 ft

Long Lake Station 1 8/3/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	22.4	9.56	8.71	109.79	0.270	0.325
1	22.4	9.39	8.71	107.84	0.271	0.325
2						
3						
4						
5	22.1	9.36	8.76	106.84	0.282	0.323
6						
7						
8						
9						
10	20.9	8.33	8.96	92.93	0.317	0.331
11						
12	18.8	4.86	9.36	51.93	0.195	0.346
13	16.3	2.37	9.85	24.07	0.199	0.355
14	14.1	1.60	10.33	15.49	0.199	0.359
15	12.8	1.52	10.62	14.32	0.215	0.359
16	12.5	1.44	10.69	13.47	0.217	0.358
17	12.5	1.31	10.70	12.24	0.205	0.358
18	12.2	1.28	10.78	11.87	0.260	-0.105
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =75F; Clear

Secchi Depth: 25.5 ft

Long Lake Station 2 Date: 08/03/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	22.6	9.52	8.68	109.69	0.266	0.320
1	22.5	9.38	8.70	107.87	0.267	0.317
2						
3						
4						
5	22.4	9.32	8.72	106.89	0.273	0.315
6						
7						
8						
9						
10	21.8	8.65	8.81	98.20	0.291	0.320
11						
12	19.6	5.05	9.21	54.85	0.197	0.338
13	15.7	2.65	9.97	26.57	0.200	0.348
14	14.1	2.14	10.33	20.72	0.203	0.350
15	13.7	1.98	10.42	19.00	0.203	0.350
16	13.2	1.92	10.53	18.24	0.204	0.350
17						
18						
19						
20	12.5	1.78	10.71	16.62	0.206	0.348
21						
22						
23						
24						
25	12.0	1.57	10.81	14.52	0.208	0.345
25.3	12.0	1.46	10.81	13.50	0.209	0.342
27						
28						
29						
30						

Notes: Temp =75F; Clear

Secchi Depth: 20.5 ft

Long Lake Station 3 Date: 08/03/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	22.5	10.00	8.69	115.06	0.275	0.357
1	22.5	9.71	8.69	111.70	0.265	0.358
2	22.5	9.59	8.70	110.22	0.268	0.358
3						
4						
5	22.4	9.50	8.71	109.04	0.266	0.358
6						
7						
8						
9						
10	22.2	9.20	8.75	105.09	0.285	0.358
11						
12	22.0	8.78	8.78	100.04	0.269	0.362
13	21.9	8.50	8.79	96.66	0.286	0.363
14	21.9	8.42	8.79	95.74	0.280	0.312
15	21.9	8.38	8.80	95.26	0.282	0.309
15.5	21.8	8.34	8.82	94.55	0.185	0.078
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =75F; Clear

Secchi Depth: 19.5 ft

Long Lake Station 1 Date: 08/25/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	22.2	9.52	8.74	108.89	0.161	0.222
1						
2						
3						
4						
5	21.7	9.61	8.83	108.82	0.160	0.220
6						
7						
8						
9						
10	21.6	9.34	8.85	105.56	0.160	0.217
11						
12						
13	15.7	0.58	9.97	5.81	0.167	0.233
14	14.3	0.28	10.28	2.72	0.169	0.238
15	13.3	0.15	10.52	1.43	0.170	0.240
16	12.7	0.05	10.65	0.47	0.175	0.228
17	12.3	0.05	10.75	0.47	0.182	-0.125
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =82F; Partly cloudy

Secchi Depth: 18.5 ft

Long Lake Station 2 Date: 08/25/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	21.9	9.61	8.79	109.27	0.161	0.458
1						
2						
3						
4						
5	21.8	9.67	8.81	109.80	0.161	0.450
6						
7						
8						
9						
10	21.4	8.99	8.88	101.29	0.162	0.450
11						
12						
13	18.2	1.37	9.47	14.47	0.166	0.429
14	15.5	0.40	10.02	3.99	0.167	0.431
15	13.8	0.14	10.40	1.35	0.169	0.430
16	13.2	0.05	10.54	0.47	0.169	0.426
17	12.9	0.05	10.60	0.47	0.172	0.405
18	12.7	0.05	10.66	0.47	0.171	0.322
19						
20	12.3	0.05	10.74	0.47	0.172	0.147
21						
22						
23						
24						
25	11.9	0.05	10.84	0.46	0.172	-0.070
26						
27	11.8	0.05	10.86	0.46	0.174	-0.146
28						
29						
30						

Notes: Temp =84F; Sunny

Secchi Depth: 18.5 ft

Long Lake Station 3 Date: 08/25/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	22.1	10.16	8.77	115.83	0.161	0.504
1						
2						
3						
4						
5	22.0	9.83	8.77	112.03	0.160	0.493
6						
7						
8						
9						
10	21.5	8.86	8.86	99.94	0.161	0.488
11						
12						
13						
14						
15	21.4	8.10	8.89	91.14	0.162	0.489
16	21.3	7.30	8.90	82.03	0.162	0.488
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =72F; Sunny

Secchi Depth: 17.5 ft

Long Lake Station 1 Date: 09/13/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	21.1	9.65	8.94	107.91	0.157	0.129
1						
2						
3	21.1	9.50	8.94	106.23	0.158	0.129
4						
5						
6	21.1	9.40	8.94	105.17	0.157	0.128
7						
8						
9	21.1	9.33	8.94	104.35	0.157	0.129
10						
11						
12	20.8	7.95	8.98	88.50	0.160	0.137
13						
14						
15	16.7	0.37	9.77	3.79	0.168	0.150
16	14.3	0.19	10.29	1.85	0.169	0.057
17	13.3	0.15	10.52	1.43	0.181	0.033
18	12.9	0.10	10.60	0.94	0.192	-0.060
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =77F; Cloudy

Secchi Depth: 17 ft

Long Lake Station 2 Date: 09/13/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	21.0	9.58	8.95	107.08	0.156	0.166
1						
2						
3	21.0	9.46	8.95	105.68	0.157	0.166
4						
5						
6	21.0	9.18	8.95	102.57	0.156	0.167
7						
8						
9	20.9	9.21	8.97	102.68	0.157	0.168
10						
11						
12	20.8	9.33	9.00	103.72	0.156	0.169
13						
14						
15	15.6	0.91	10.00	9.10	0.158	0.181
16	14.4	0.14	10.27	1.36	0.171	0.050
17	14.1	0.14	10.33	1.35	0.171	0.049
18	13.2	0.10	10.53	0.95	0.174	0.029
19	12.8	0.10	10.62	0.94	0.174	0.006
20	12.5	0.10	10.69	0.94	0.176	-0.034
21	12.5	0.10	10.71	0.93	0.172	-0.045
22						
23						
24	12.5	0.10	10.71	0.93	0.176	-0.066
25						
26						
27						
28						
29						
30						

Notes: Temp =67F; Cloudy

Secchi Depth: 17 ft

Long Lake Station 3 Date: 09/13/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	20.6	9.50	9.02	105.27	0.157	0.208
1						
2						
3	20.7	9.36	9.01	103.89	0.157	0.208
4						
5						
6	20.7	9.33	9.01	103.57	0.157	0.208
7						
8						
9	20.7	9.29	9.01	103.13	0.157	0.208
10						
11						
12	20.7	9.29	9.01	103.13	0.157	0.209
13						
14						
15	20.7	9.28	9.01	102.96	0.157	0.209
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =68F; Cloudy

Secchi Depth: not determined

Long Lake Station 1 9/28/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	16.1	9.70	9.90	97.97	0.158	0.081
1						
2						
3	16.2	9.35	9.88	94.64	0.159	0.081
4						
5						
6	16.2	9.26	9.88	93.75	0.159	0.082
7						
8						
9	16.2	9.23	9.88	93.44	0.159	0.083
10						
11						
12	16.1	9.20	9.89	93.04	0.159	0.083
13						
14						
15	16.0	9.20	9.92	92.75	0.160	0.084
16	15.9	9.08	9.93	91.46	0.159	-0.022
17	15.8	8.13	9.96	81.60	0.190	-0.057
18	13.5	0.31	10.46	2.96	0.197	-0.163
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =56F; Clear

Secchi Depth: 20 ft

Long Lake Station 2 9/28/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	15.9	10.41	9.93	104.81	0.158	0.161
1						
2						
3	16.0	10.21	9.92	102.91	0.158	0.160
4						
5						
6	16.0	10.04	9.92	101.19	0.159	0.160
7						
8						
9	15.9	10.00	9.92	100.77	0.158	0.160
10						
11						
12	15.9	9.96	9.93	100.32	0.158	0.160
13						
14						
15	15.9	9.69	9.94	97.46	0.159	0.161
16						
17						
18	15.8	9.45	9.95	94.94	0.158	0.162
19						
20						
21	15.2	6.88	10.08	68.24	0.162	0.114
22	12.5	0.16	10.70	1.50	0.178	-0.185
23	12.2	0.16	10.77	1.49	0.179	-0.196
24	12.1	0.01	10.80	0.09	0.181	-0.212
25	12.0	0.01	10.83	0.10	0.182	-0.215
26						
27	11.9	0.05	10.84	0.46	0.184	-0.226
28						
29						
30						

Notes: Temp =56F; Clear

Secchi Depth: 20 ft

Long Lake Station 3 Date: 09/28/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	15.5	10.85	10.03	108.22	0.158	0.190
1						
2						
3	15.5	10.57	10.02	105.47	0.158	0.189
4						
5						
6	15.4	10.41	10.03	103.77	0.158	0.188
7						
8						
9	15.4	10.34	10.03	103.05	0.158	0.188
10						
11						
12	15.4	10.27	10.04	102.26	0.157	0.188
13						
14						
15	15.3	10.23	10.06	101.64	0.157	0.188
16						
17	15.1	10.05	10.10	99.47	0.158	0.159
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =52F; Clear

Secchi Depth: 18 ft

Long Lake Station 1 10/9/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	14.3	8.77	10.28	85.35	0.174	0.111
1						
2						
3	14.3	8.23	10.27	80.11	0.173	0.111
4						
5						
6	14.3	8.30	10.28	80.70	0.172	0.111
7						
8						
9	14.2	8.32	10.29	80.82	0.171	0.111
10						
11						
12	14.1	8.29	10.32	80.32	0.171	0.109
13						
14						
15	14.0	8.29	10.36	80.04	0.170	0.109
16						
17						
18	14.0	1.96	10.36	18.92	0.198	0.132
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =54F; Clear

Secchi Depth: not determined

Long Lake Station 2 10/9/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	14.1	8.60	10.32	83.34	0.174	0.110
1						
2						
3	14.1	8.58	10.33	83.06	0.171	0.109
4						
5						
6	13.7	8.70	10.42	83.52	0.170	0.109
7						
8						
9	13.6	8.62	10.43	82.64	0.170	0.109
10						
11						
12	13.6	8.63	10.44	82.68	0.170	0.109
13						
14						
15	13.5	8.55	10.47	81.63	0.170	0.109
16						
17						
18	13.5	8.58	10.47	81.93	0.170	0.109
19						
20						
21	13.5	8.41	10.47	80.31	0.170	0.109
22						
23						
24	13.4	8.48	10.48	80.89	0.170	0.109
25						
26	13.4	6.07	10.48	57.90	0.187	0.120
27						
28						
29						
30						

Notes: Temp =54F; Clear

Secchi Depth: not determined

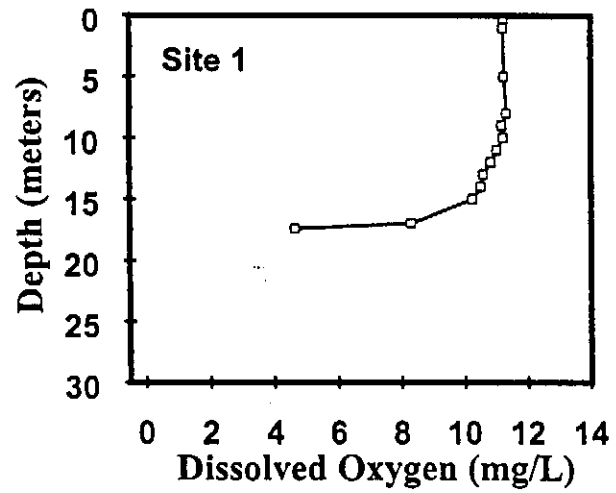
Long Lake Station 3 Date: 10/09/2000

Depth (m)	Temp (C)	D.O. (mg/L)	O2 Solubility (mg/L)	%O2 Saturation	Cond.	ORP
0.5	13.1	9.11	10.55	86.36	0.180	0.113
1						
2						
3	13.1	8.99	10.56	85.12	0.171	0.110
4						
5						
6	13.1	9.02	10.57	85.37	0.170	0.109
7						
8						
9	13.1	8.93	10.56	84.54	0.170	0.109
10						
11						
12	13.0	8.94	10.58	84.54	0.170	0.109
13						
14						
15	12.8	8.99	10.64	84.50	0.170	0.109
15.8	13.6	8.94	10.45	85.56	0.196	0.126
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Notes: Temp =51F; Clear

Secchi Depth: 19 ft

June 5, 2000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5
10
15
20
25
30
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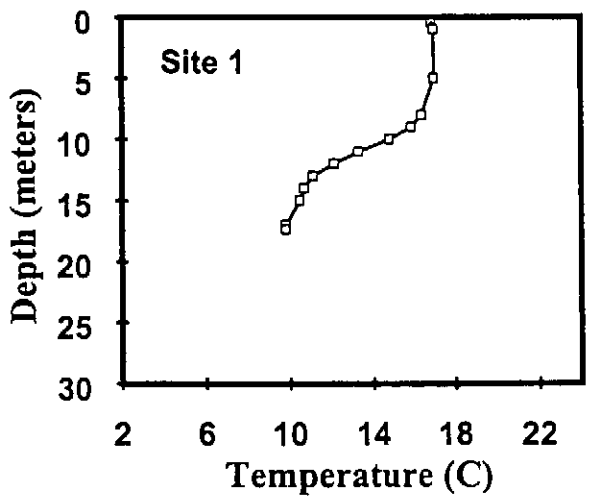
Dissolved Oxygen (mg/L)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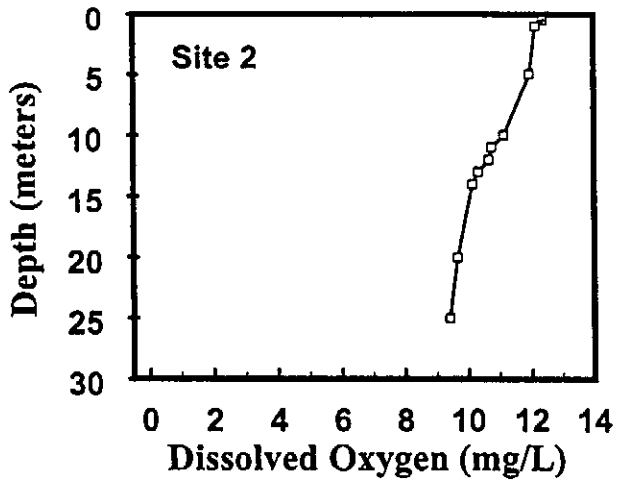
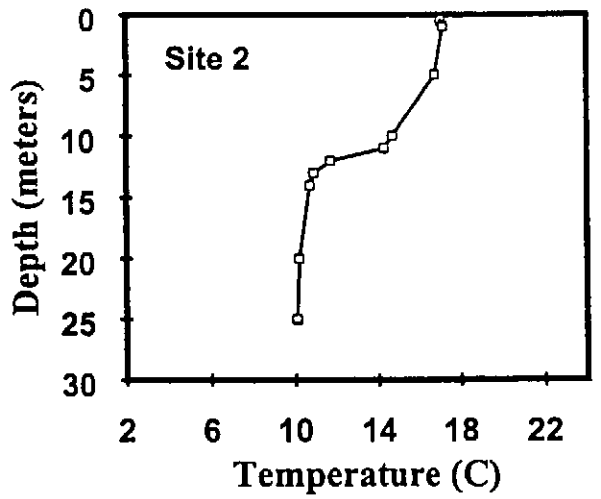
5
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)


Site 2
Depth (meters)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 2
Depth (meters)
0
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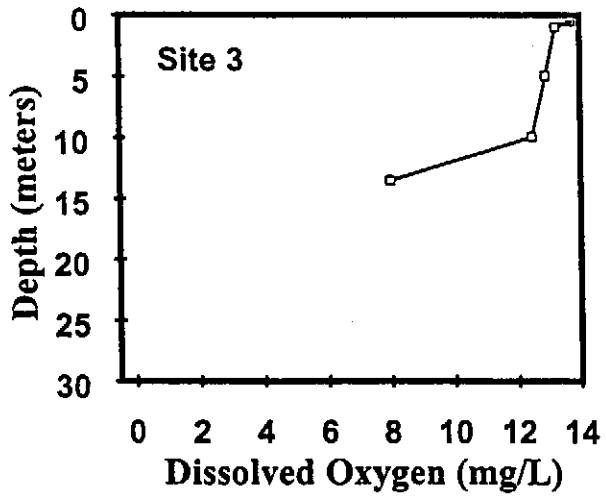
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)


Site 3
Depth (meters)
0
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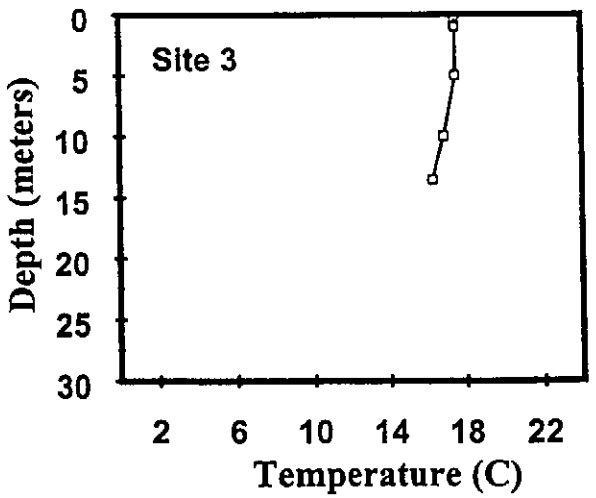
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 3
Depth (meters)
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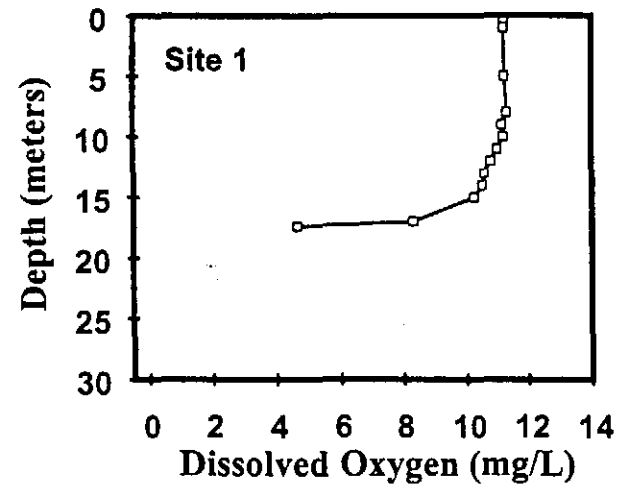
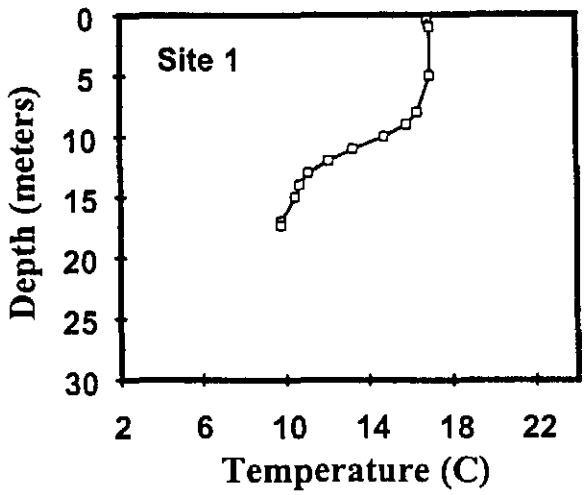
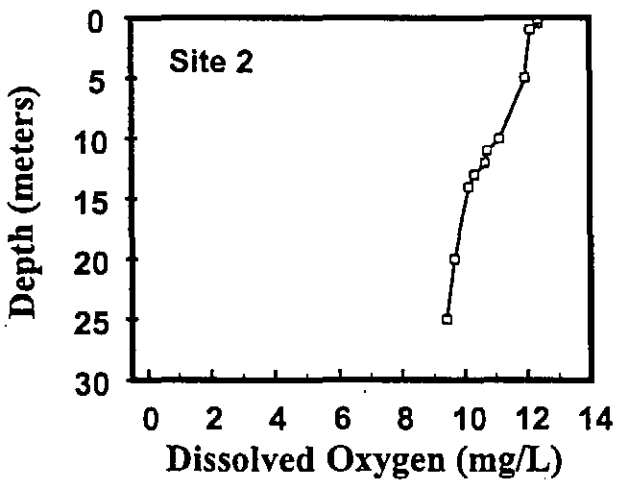
5
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)

June 5, 2000


Site 1
Depth (meters)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 1
Depth (meters)
0
5
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)


Site 2
Depth (meters)
0
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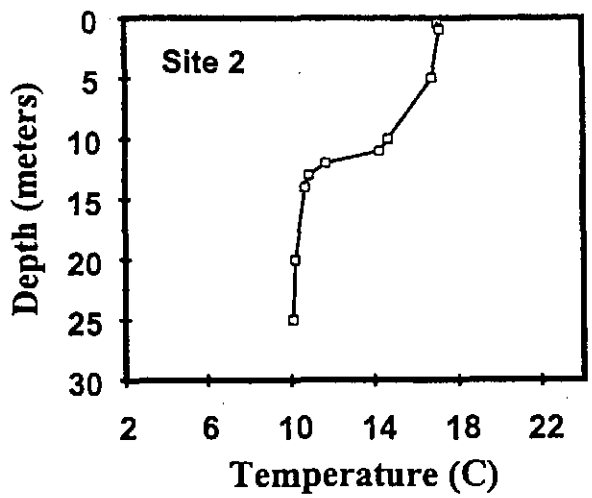
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 2
Depth (meters)
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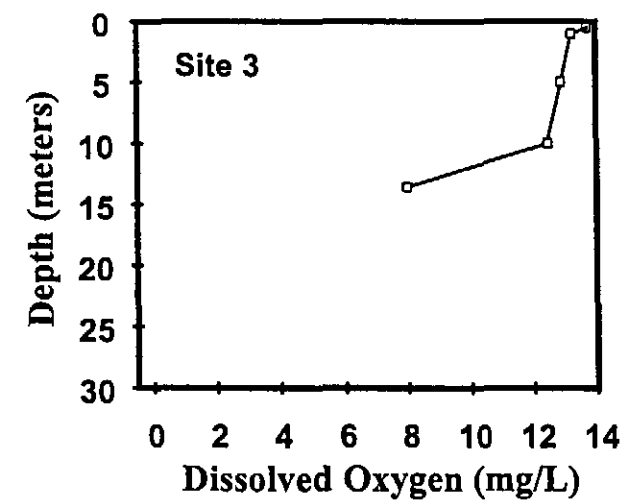
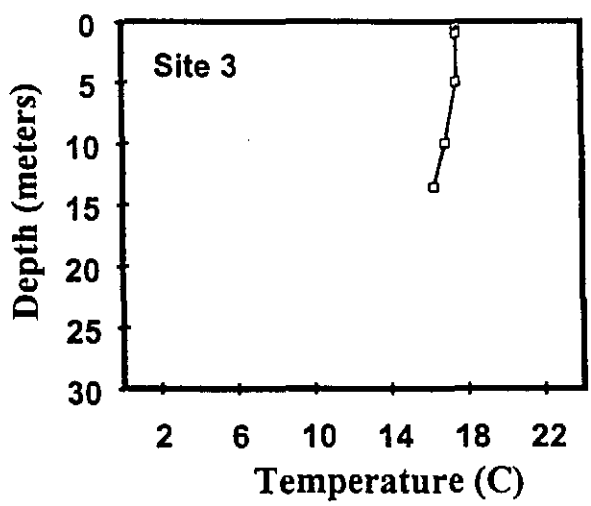
30
2 6 10 14 18 22
Temperature (C)


Site 3
Depth (meters)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 3
Depth (meters)
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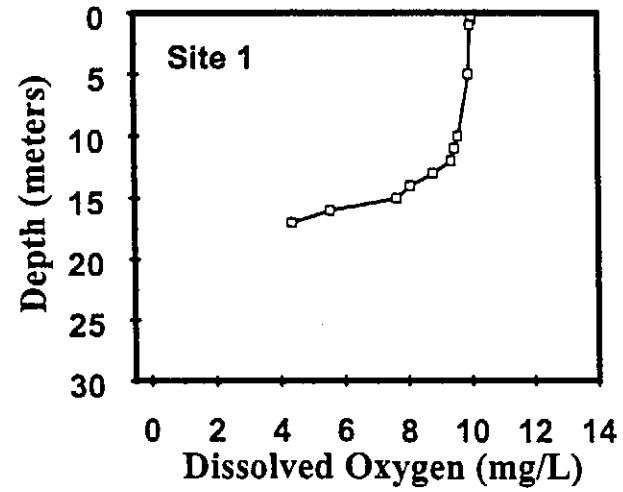
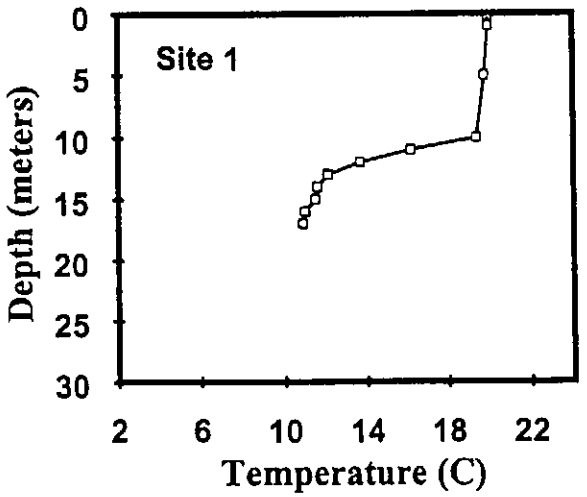
5
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)

June 19, 2000


Site 1
Depth (meters)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 1
Depth (meters)
0
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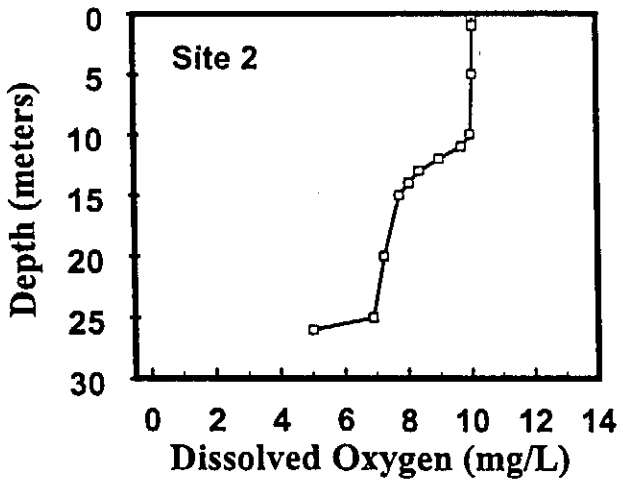
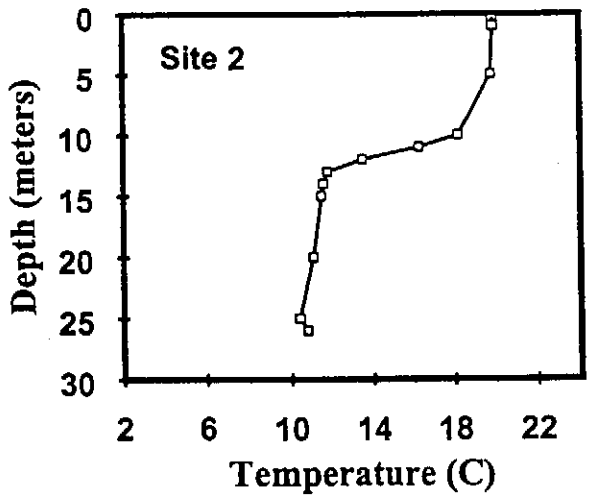
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)


Site 2
Depth (meters)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 2
Depth (meters)
0
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10
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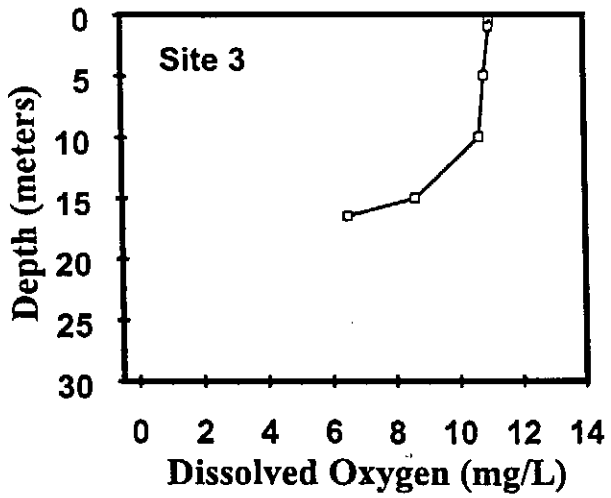
20
25
30
2 6 10 14 18 22
Temperature (C)


Site 3
Depth (meters)
0
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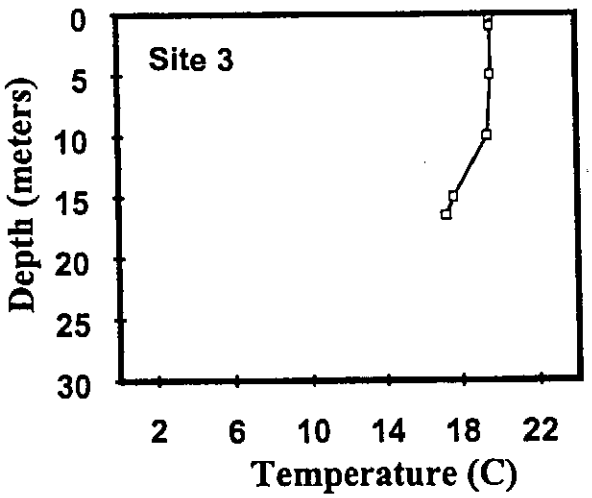
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 3
Depth (meters)
0
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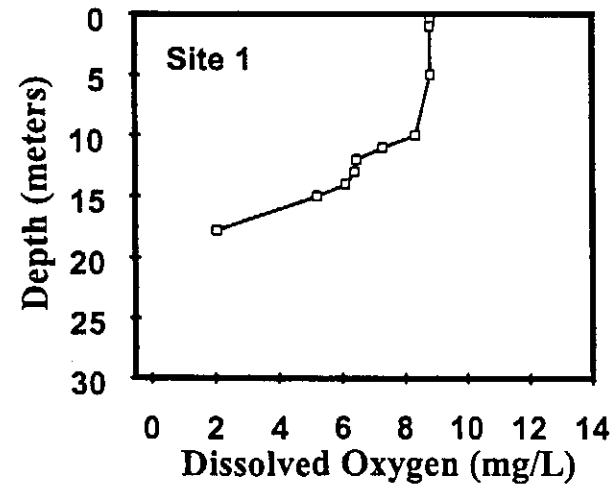
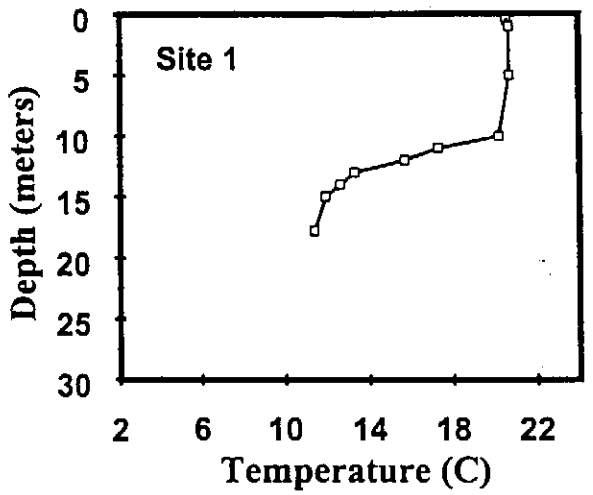
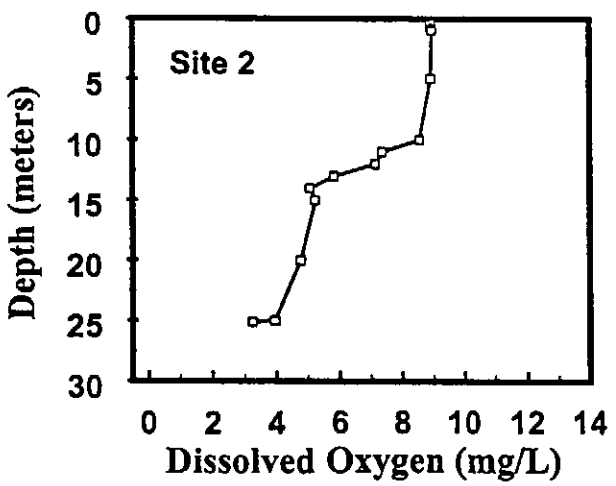
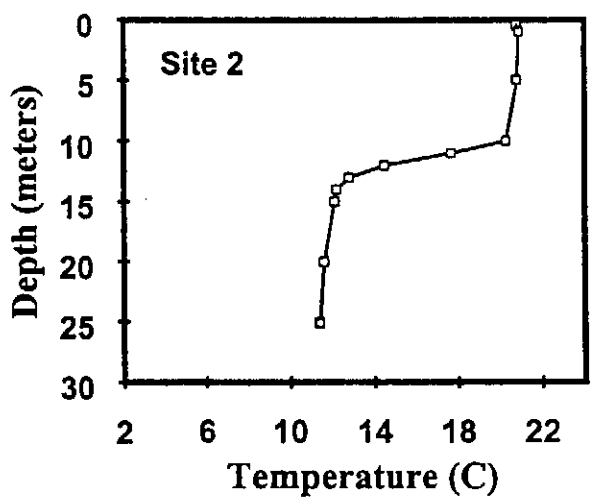
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)

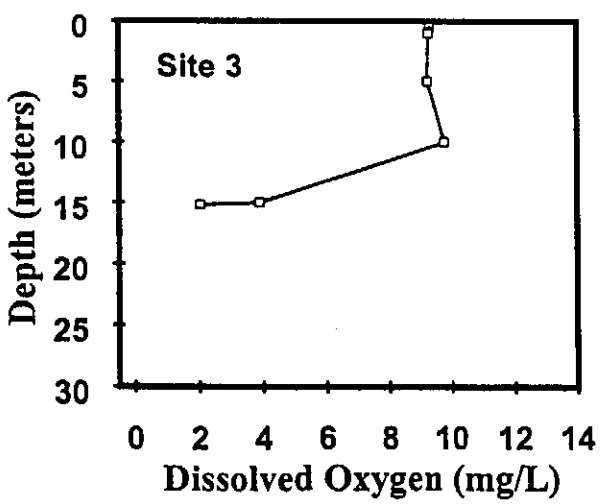
June 29, 2000


Site 1
Depth (meters)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 1
Depth (meters)
0
5
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)


Site 2
Depth (meters)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 2
Depth (meters)
0
5
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)


Site 3
Depth (meters)
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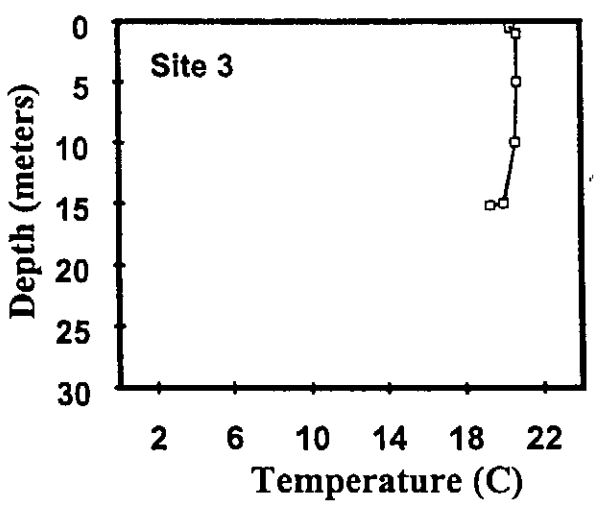
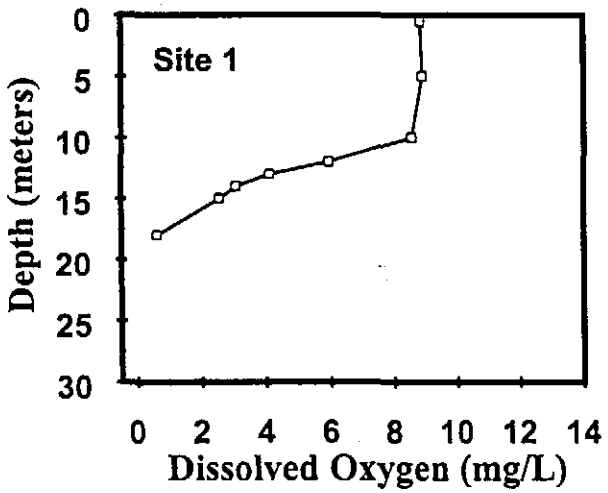
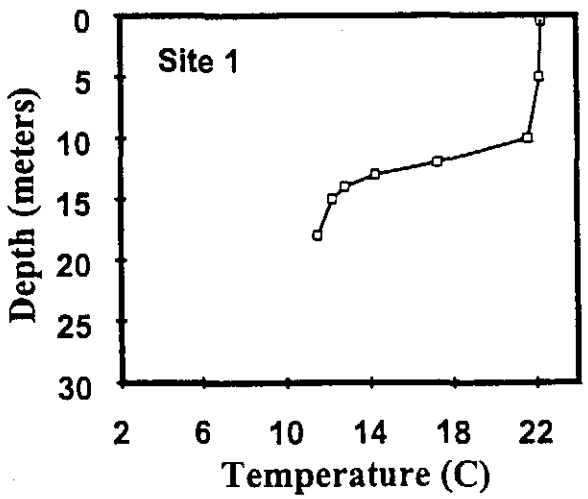
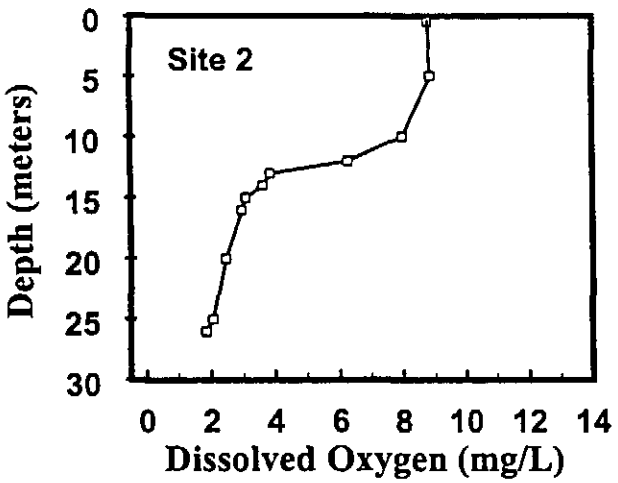
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)

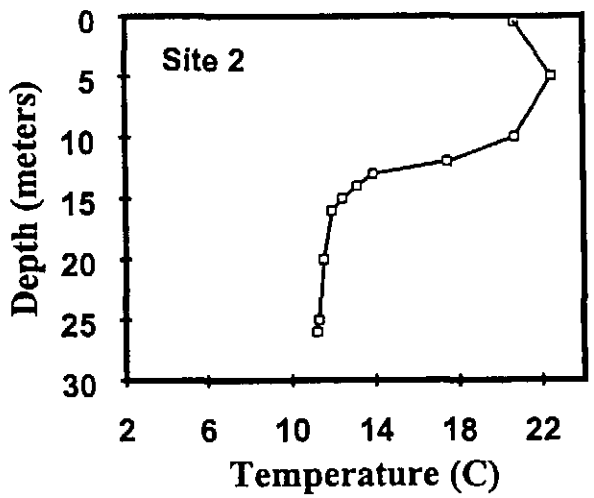

Site 3
Depth (meters)
0
5
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)

July 12, 2000


Site 1
Depth (meters)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 1
Depth (meters)
0
5
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)


Site 2
Depth (meters)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)


Site 2
Depth (meters)
0
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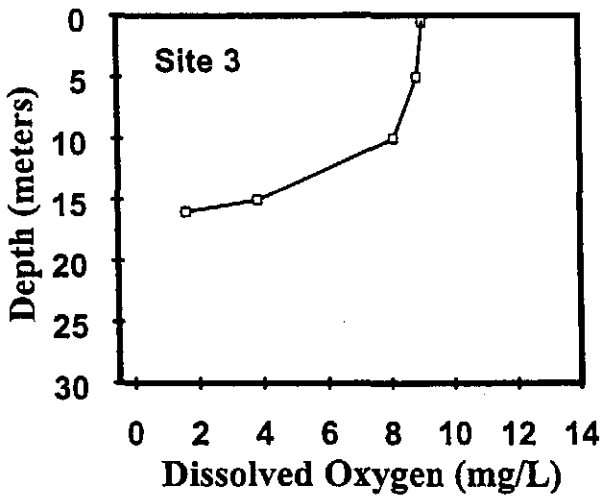
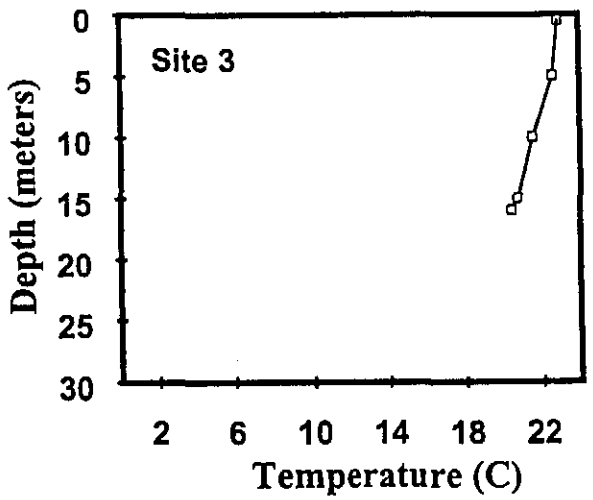
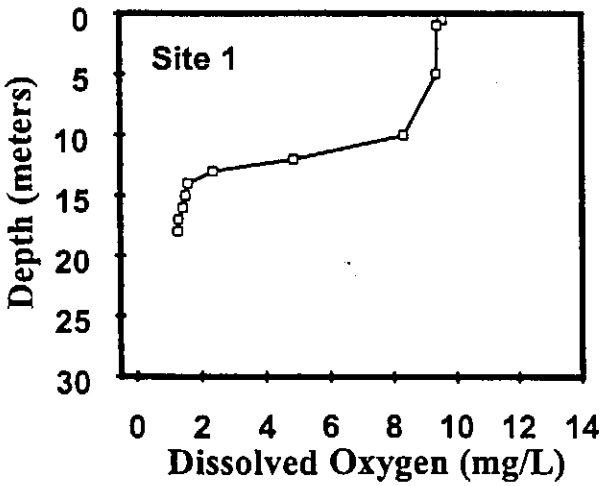
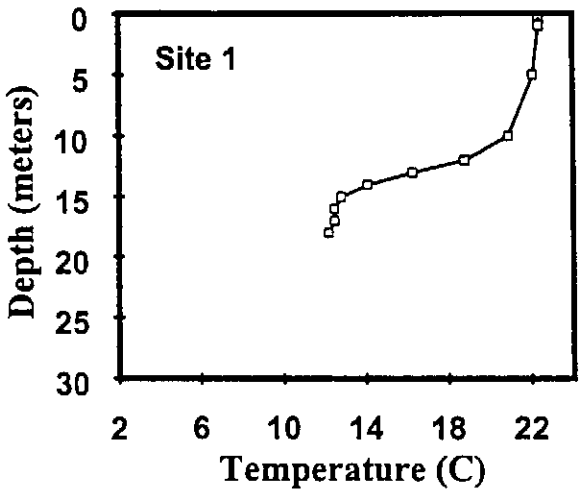
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)

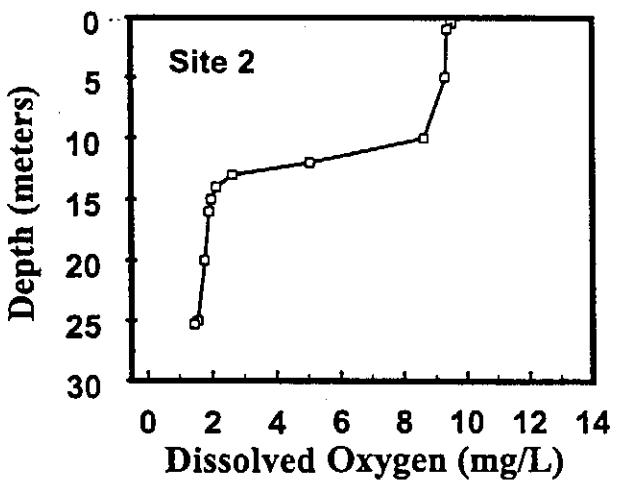

Site 3
Depth (meters)
0
5
10
15
20
25
30
0 2 4 6 8 10 12 14
Dissolved Oxygen (mg/L)

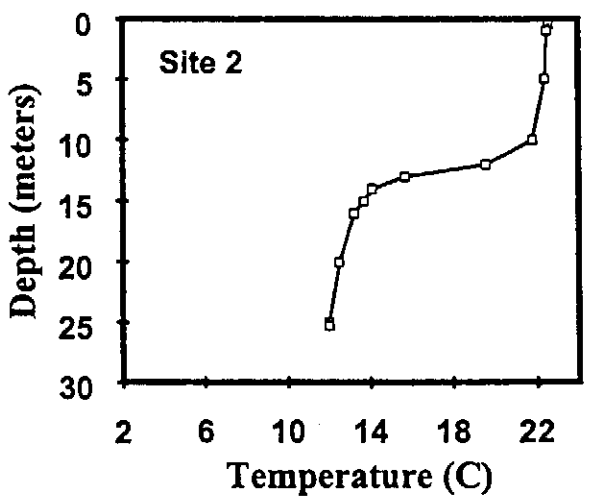

Site 3
Depth (meters)
0
5
10
15
20
25
30
2 6 10 14 18 22
Temperature (C)

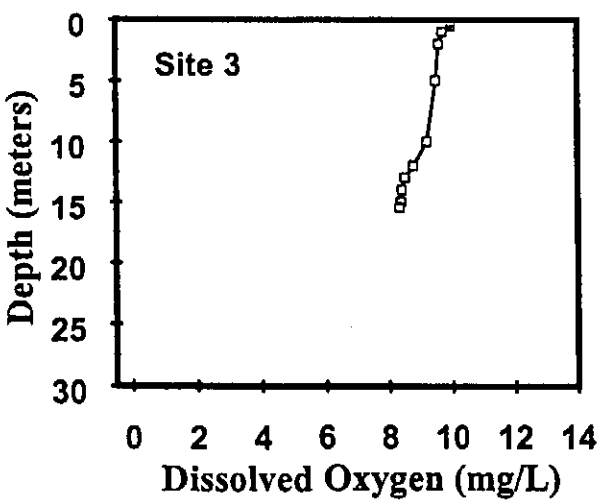
August 3, 2000

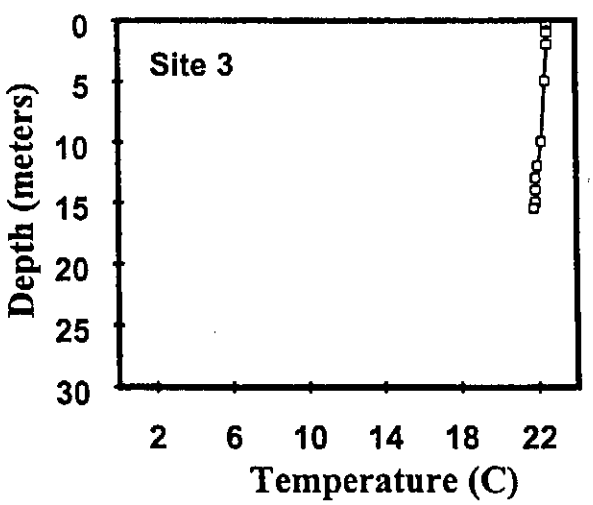




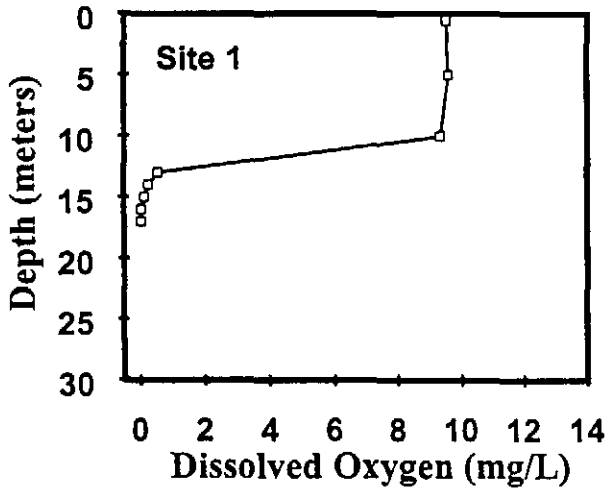


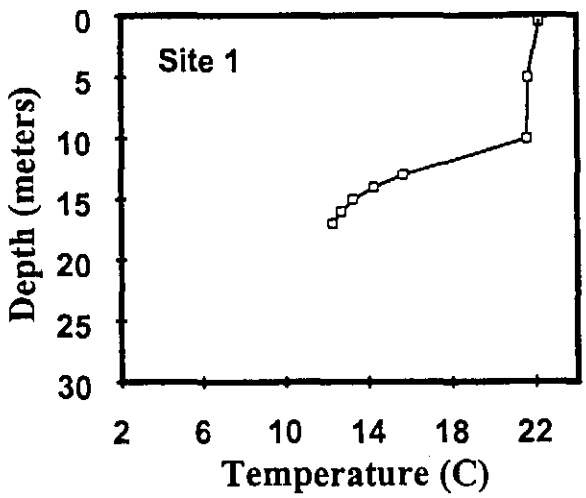


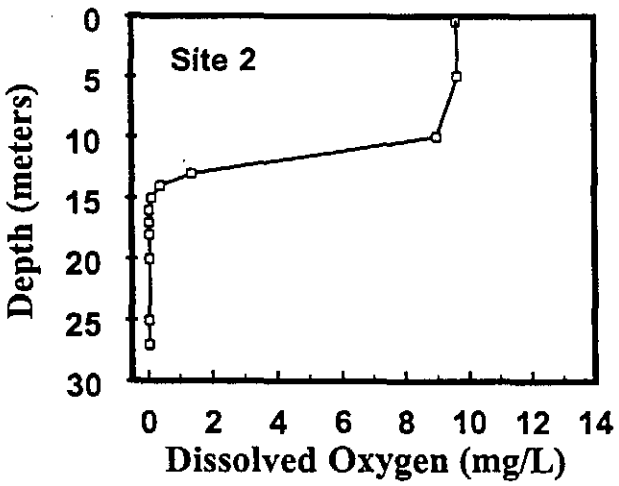


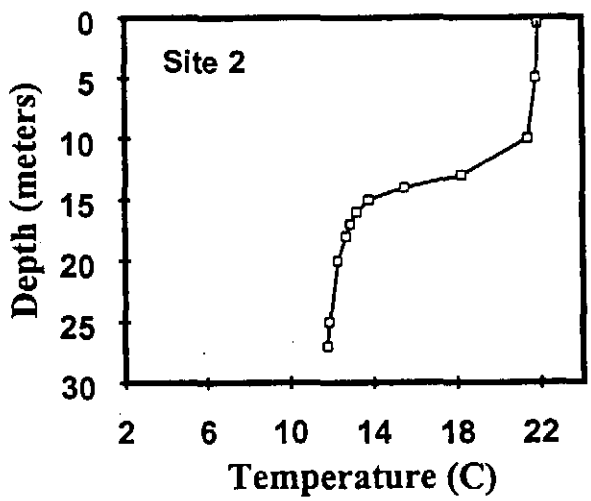


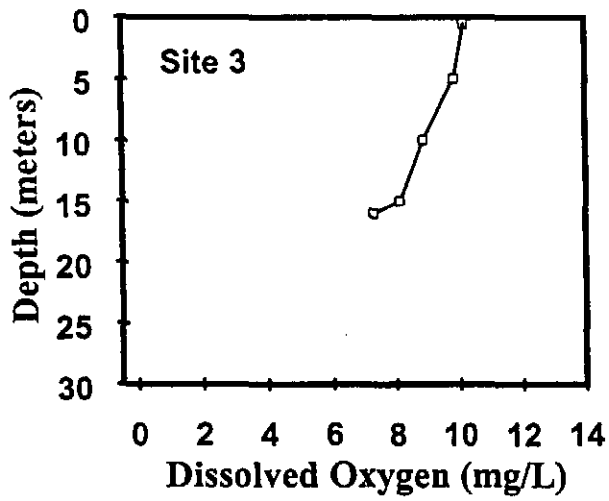
August 25, 2000

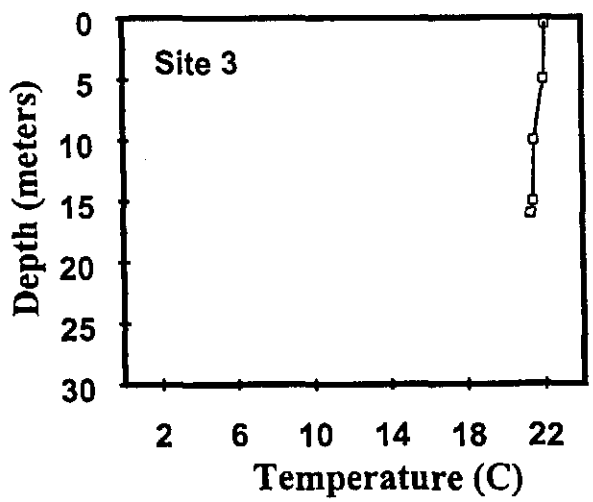




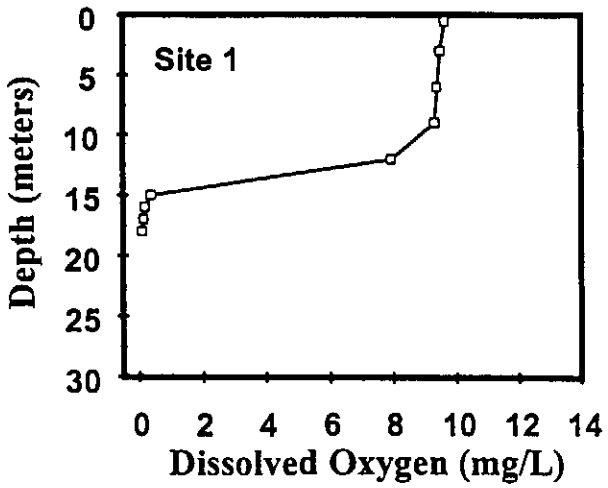


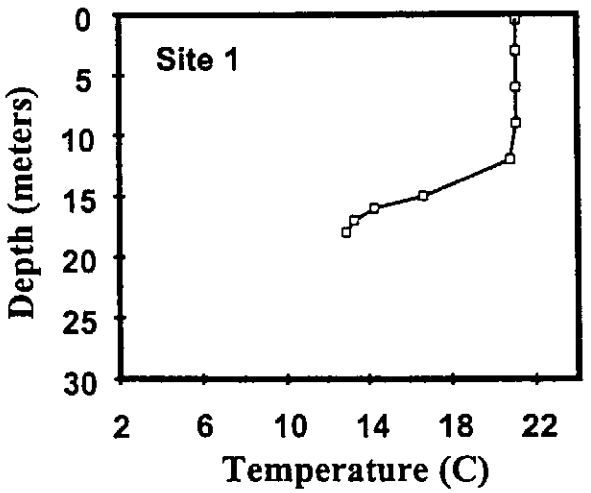


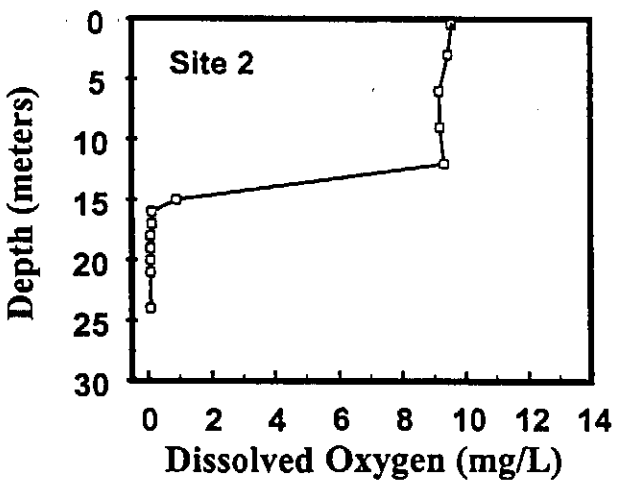


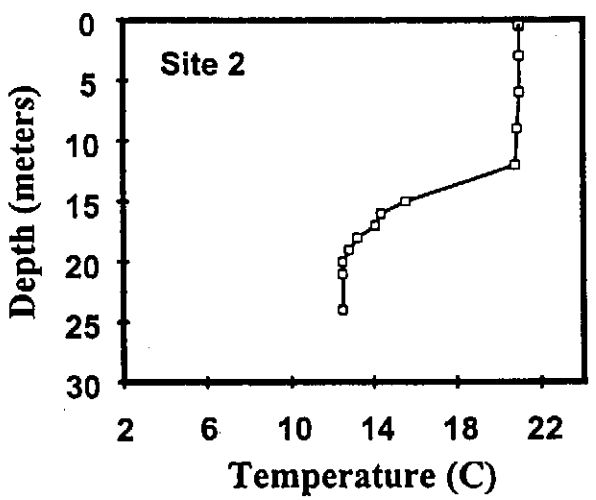


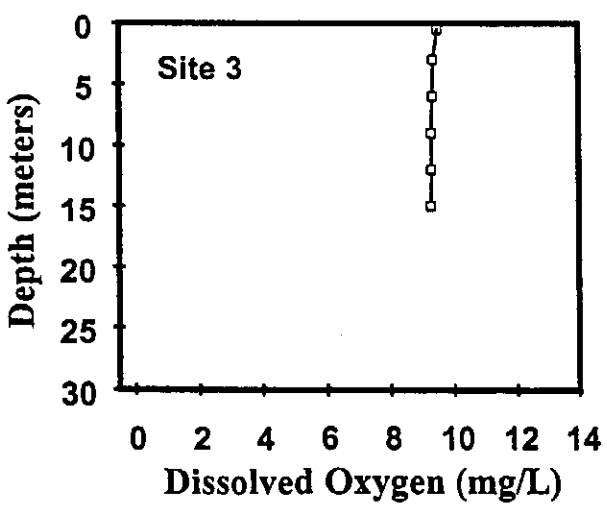
September 13, 2000

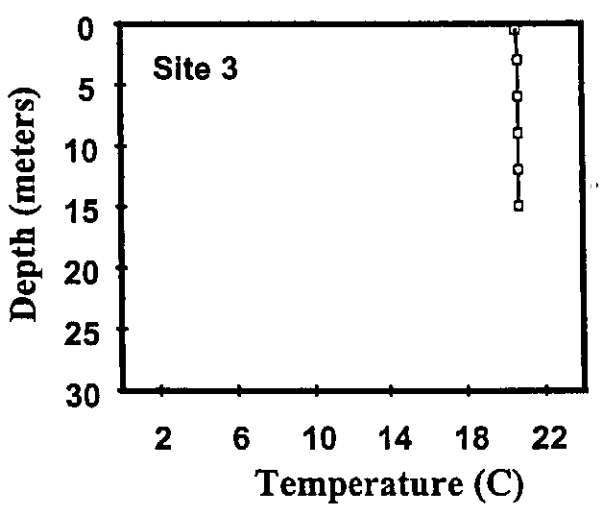




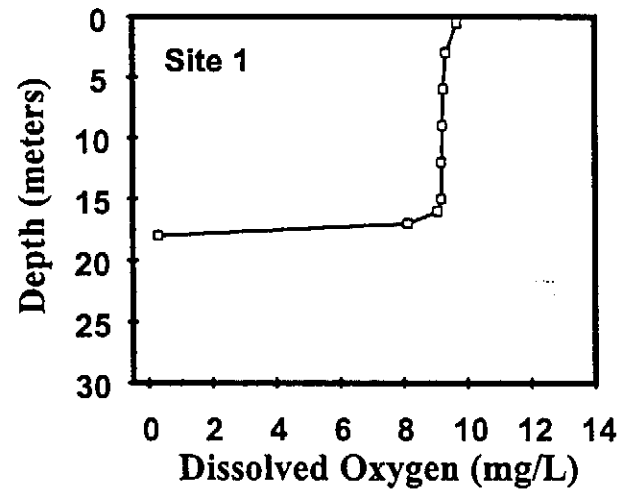


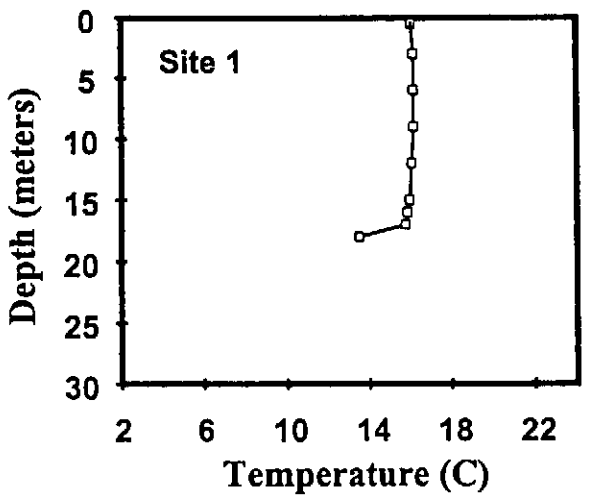


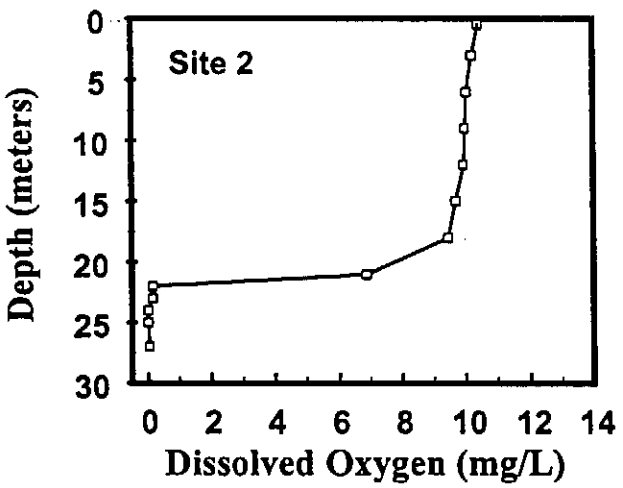


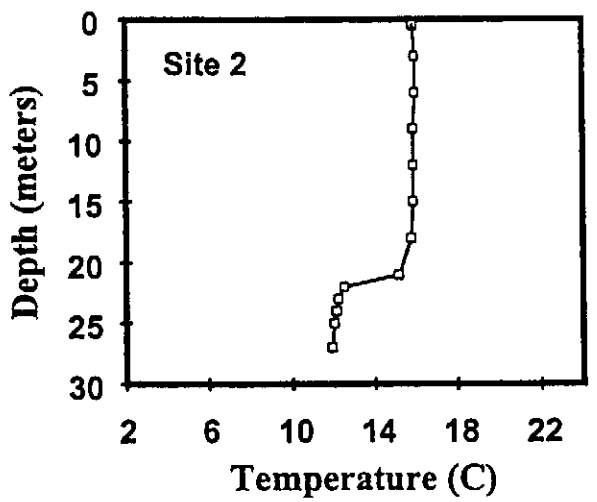


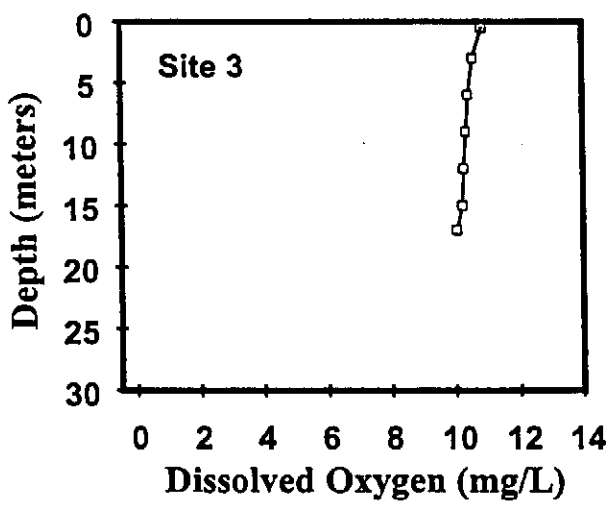
September 28, 2000

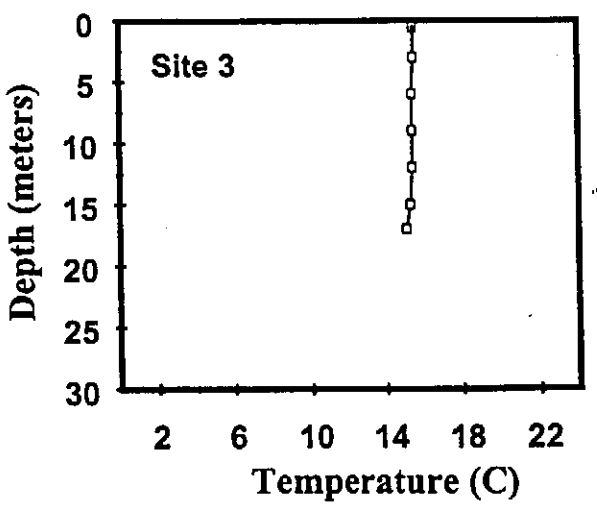












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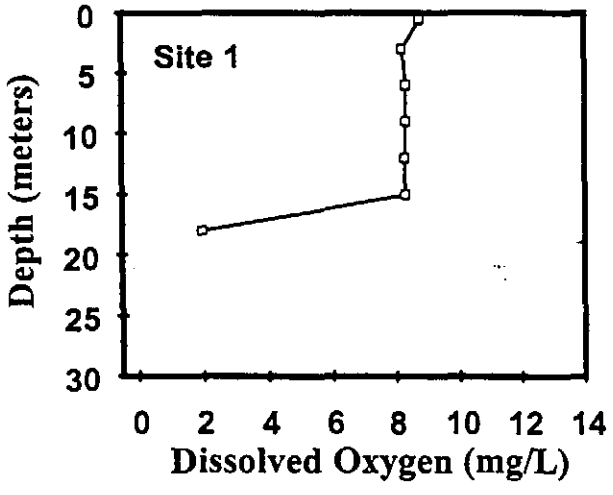
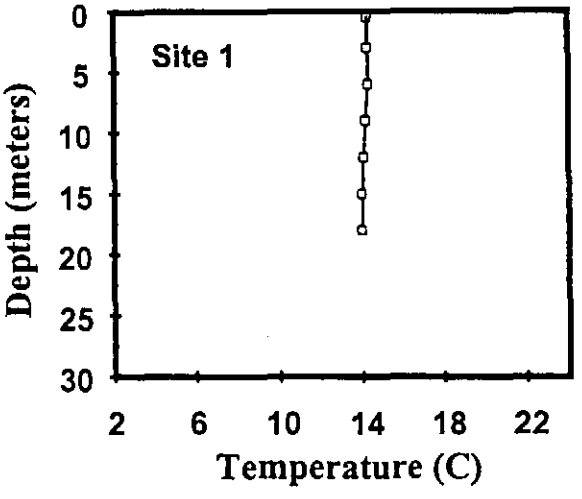
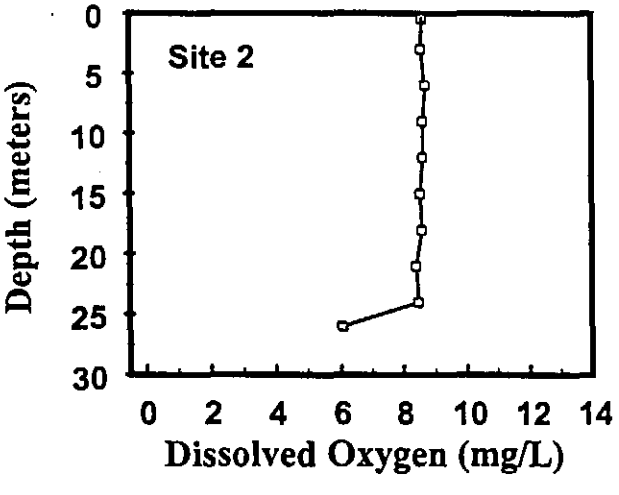
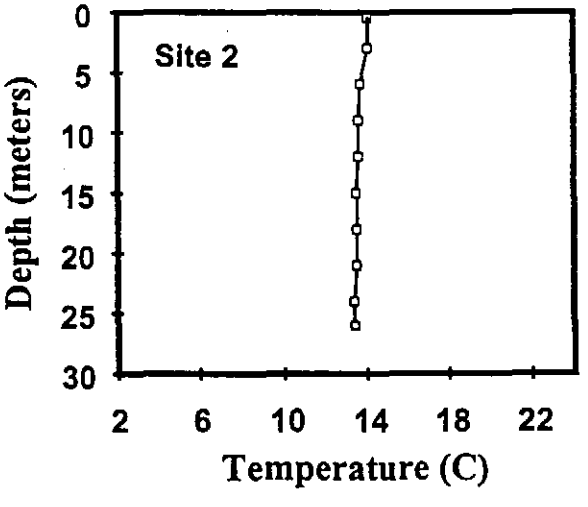
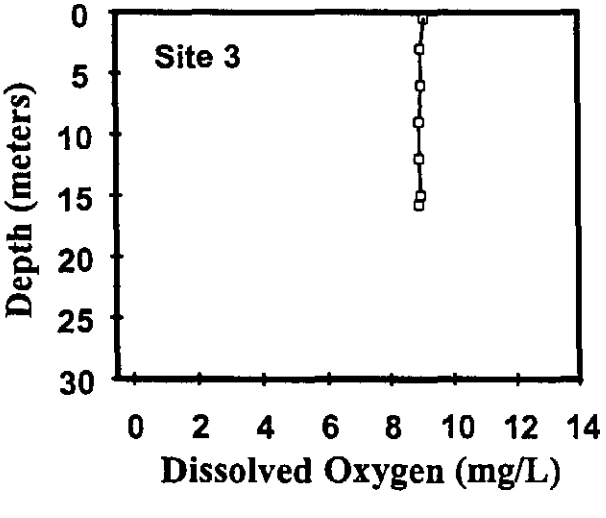
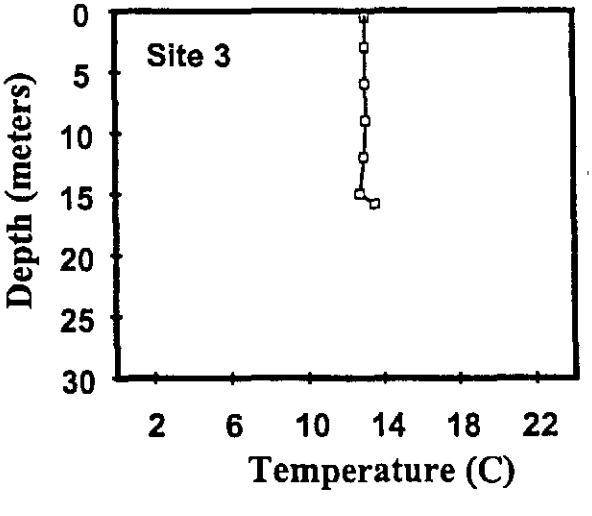












Appendix B1

2005 Long Lake Water Quality Monitoring

2005 LONG LAKE WATER QUALITY MONITORING

Long Lake monitoring was initiated in 2005 by Great Lakes Environmental Center (GLEC) with the intent to supply additional information which could be combined with the 1997-2000 data and utilized in continued assessment of Long Lake water quality. Monitoring of Long Lake included a number of parameters: 1) monitoring of Long Lake water quality parameters (dissolved oxygen, temperature, conductivity, oxidation-reduction potential and pH) every three meters from surface to bottom at three established sampling sites; 2) measurement of water chemistry (total phosphorus, nitrate-nitrite nitrogen levels at the surface and near bottom in the water column); 3) levels of Chlorophyll a at each sampling site (an indirect indicator of algae in the water column); 4) determination of sediment phosphorus levels at the three established sampling points; and 5) measurement of secchi disk depth at each of the three sampling points..

The results of the 2005 monitoring year demonstrated water chemistry trends that were similar to 1997-2000. Bottom phosphorus levels were elevated (approximately 16-20 μg/L) at the two deepest monitoring sites (Sites 2 and 3) in the late fall sample, corresponding with the period of anoxic conditions at the lake bottom (Table 1). Bottom phosphorus concentrations were not elevated at the much shallower Site 1, which did not exhibit an oxygen deficit at the bottom during the summer. Surface concentrations were in the oligotrophic range (3 – 12 μg/L) and were consistent of levels found at other area lakes. Combined averages of surface and bottom phosphorus levels were nearly identical to averages calculated for 1997-2000 (Table 2) for all three sampling sites. A comparison of water phosphorus values in comparison to other area lakes is shown in Table 2. In addition, these values agree with data collected by Dr. Fusilier from 1993 to 2005. The inherent temperature stratification (e.g., thermocline) of the lake at the deeper areas that occurs during summer was again evident in the fall at the two deepest sampling sites (see temperature/dissolved oxygen profiles, Figures 1 and 2). Chlorophyll *a* levels were very consistent throughout the sampling period (1.6-2.8 μg/L) but did show a slight elevation in the late fall (Table 1) which is consistent with previous years and may be

indicative of an increase in the algal community. Secchi depths (Table 1) continued to be characteristic of oligotrophic conditions (greater than 13 feet).

Sediment phosphorus values were much lower than measured in 1999 and 2000 for Sites 1 and 2 (Table 2). The concentration was so low for Site 2 that the data may be suspect. The value for Site 3 was almost identical to that measured in 1999-2000.

The data from the year 2005 sampling season continued to indicate that Long Lake would be considered oligotrophic based on total phosphorus in the water, chlorophyll a levels and secchi depth (Table 3). However, Long Lake has historically high concentrations of bottom sediment phosphorus. Bottom sediment phosphorus concentrations have been shown to be distinctly higher than concentrations measured in 10 other area lakes (Table 3). This phosphorus can be a significant source of nutrients to the Lake through an internal loading process when bottom oxygen concentrations drop to near zero. Because anoxic conditions are known to consistently occur (based on 1997-2005 data), this potential flux of phosphorus from the sediments is an important component of the overall phosphorus budget for the Lake. Because of the inconsistency with previous sampling in 1999 and 2000, it is recommended that additional sediment samples be taken from the three sampling points and analyzed for phosphorus.

In general, the water quality of Long Lake continues to be acceptable as evaluated by the general trophic state classification of Chapra (Table 3). Using total phosphorus, chlorophyll a, and secchi depth Long Lake would be classified oligotrophic. Although the development of a thermocline is a natural process, the combination of anoxic conditions coupled with extremely high sediment phosphorus levels demonstrates the potential of significant internal loading of phosphorus in Long Lake. This internal loading may cause late season algal blooms and potential increases in aquatic plants within the lake ecosystem. Thus, water quality conditions in Long Lake continue to be vulnerable to dangerous deterioration.

Table 1. Concentrations of Total Phosphorus (TP), Nitrate-nitrite Nitrogen (NOx), Chlorophyll a and Secchi Disk depth at each of three sampling sites on Long Lake, 2005.

Sampling Site #1

Sampling Date	Total Phosphorus (ug/L)			Nitrate-Nitrite Nitrogen (mg/L)			Chlorophyll a (ug/L)		Secchi Depth (ft)
	Surface	**Bottom**		**Surface**	**Bottom**				
Jun 21, 2005	10.7	5.7		0.0378	<0.0014		1.62		28.5
Oct 4, 2005	7.5	8.1		0.0015	0.008		2.02		18.5

Sampling Site #2

Sampling Date	Total Phosphorus (ug/L)			Nitrate-Nitrite Nitrogen (mg/L)			Chlorophyll a (ug/L)		Secchi Depth (ft)
	Surface	**Bottom**		**Surface**	**Bottom**				
Jun 21, 2005	12.9	11.3		<0.0014	0.0341		1.68		27.0
Oct 4, 2005	9.7	19.9		0.0061	0.0067		2.0		18.5

Sampling Site #3

Sampling Date	Total Phosphorus (ug/L)			Nitrate-Nitrite Nitrogen (mg/L)			Chlorophyll a (ug/L)		Secchi Depth (ft)
	Surface	**Bottom**		**Surface**	**Bottom**				
Jun 21, 2005	3.3	82.5**		<0.0014	0.0154		1.6		28.5
Oct 4, 2005	11.7	16.5		0.0047	0.0051		2.8		18.5

****Possible contaminated sample from bottom sediment.**

Table 1. Concentrations of Total Phosphorus (TP), Nitrate-nitrite Nitrogen (NOx), Chlorophyll a and Secchi Disk depth at each of three sampling sites on Long Lake, 2005.

Sampling Site #1

Sampling Date	Total Phosphorus (ug/L)			Nitrate-Nitrite Nitrogen (mg/L)			Chlorophyll a (ug/L)		Secchi Depth (ft)
	Surface	**Bottom**		**Surface**	**Bottom**				
Jun 21, 2005	10.7	5.7		0.0378	<0.0014		1.62		28.5
Oct 4, 2005	7.5	8.1		0.0015	0.008		2.02		18.5

Sampling Site #2

Sampling Date	Total Phosphorus (ug/L)			Nitrate-Nitrite Nitrogen (mg/L)			Chlorophyll a (ug/L)		Secchi Depth (ft)
	Surface	**Bottom**		**Surface**	**Bottom**				
Jun 21, 2005	12.9	11.3		<0.0014	0.0341		1.68		27.0
Oct 4, 2005	9.7	19.9		0.0061	0.0067		2.0		18.5

Sampling Site #3

Sampling Date	Total Phosphorus (ug/L)			Nitrate-Nitrite Nitrogen (mg/L)			Chlorophyll a (ug/L)		Secchi Depth (ft)
	Surface	**Bottom**		**Surface**	**Bottom**				
Jun 21, 2005	3.3	82.5**		<0.0014	0.0154		1.6		28.5
Oct 4, 2005	11.7	16.5		0.0047	0.0051		2.8		18.5

****Possible contaminated sample from bottom sediment.**

Table 2. Phosphorus Data for Area Lakes and Sediments

Lake	Water Total Phosphorus (μg/L)	Sediment Phosphorus (mg TP/ kg DW)
Torch	1.7	86
Burt	2.2	119
Lime	4.4	200
Crystal	4.8	332
North Leelanau	4.8	489
South Leelanau	4.9	398
Glen	5.1	326
Little Traverse	5.1	401
Cedar	5.3	396
Platte	7.7	620
Long Lake 1997 – 2000		1999-2000
Long (Site 1)	8.6*	1742**
Long (Site 2)	13.6*	1051**
Long (Site 3)	9.3*	684**

*Average of all surface and bottom measurements for each sampling site for 1997 - 2000 monitoring seasons.
**Average of sediment phosphorus concentrations from 1999 and 2000 sampling seasons.

Long Lake 2005		
Long (Site 1)	**8.0**	**322**
Long (Site 2)	**13.5**	**33**
Long (Site 3)	**10.5**	**654**

Table 3. Trophic State Classification (Chapra, 1997)

Variable	Oligotrophic	Mesothophic	Eutrophic
Total Phosphorus (μg/L)	< 10	10-20	>20
Chlorophyll a (μg/L)	<4	4-10	>10
Secchi depth (ft)	>13	6.6 - 13	<6.6

Figure 1. Temperature and dissolved oxygen profiles as measured by depth at three sampling sites in Long Lake.

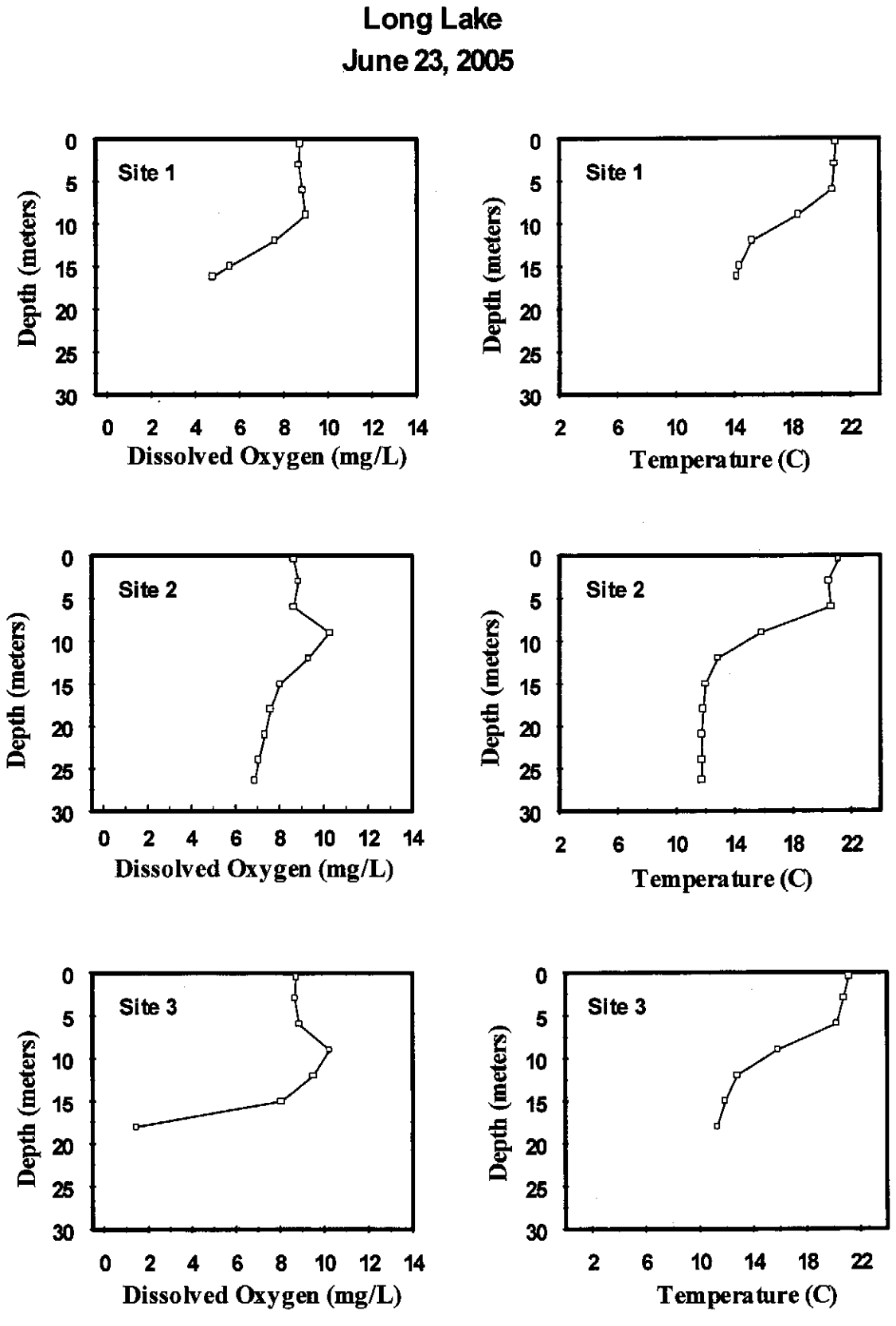
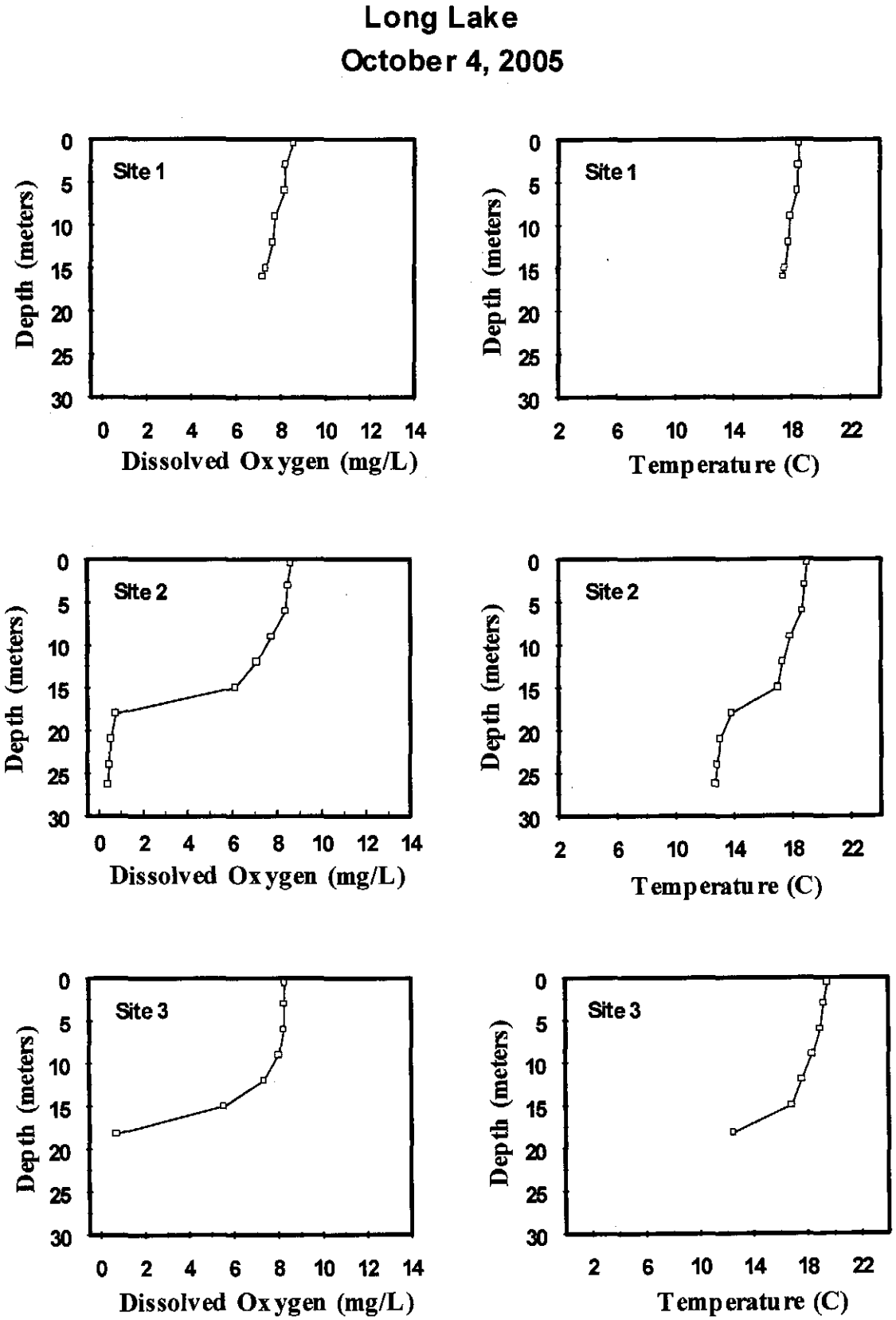


Figure 2. Temperature and dissolved oxygen profiles as measured by depth at three sampling sites in Long Lake.



Appendix C

Long Lake Nutrient/Hydrologic Model

LONG LAKE NUTRIENT AND HYDROLOGIC MODEL

Prepared for
The Long Lake Watershed Partnership

Prepared:
January 15, 2001

Authors:

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The University of Michigan

Patrick M. McCool, Ph.D.
Great Lakes Environmental Center

Long Lake Water Quality Model

Introduction

Water quality monitoring of Long Lake since 1997 has indicated that high phosphorus concentrations can be found in both in the water column and in the sediments. These high phosphorus concentrations, coupled with the observed long flushing time for the lake (approximately nine years) and low water levels since 1999 which have virtually eliminated flow in Sucker Creek (the outlet), constitute a warning sign that nutrient loading is occurring. Continued buildup of phosphorus levels in the lake may result in an increased rate of eutrophication, increased incidence of algal blooms and aquatic plants and overall lower water quality and recreational desirability. The sources and strengths of nutrient input to Long Lake are not well understood, and the relative hydrologic contribution of groundwater, surface water and atmospheric precipitation have not been defined.

The objective of this project was to develop a screening model that gives a preliminary estimate of the affects of groundwater, surface runoff, sediment release, and aquatic macrophytes on the water quality of Long Lake. The model was for lake-wide total phosphorus (TP) and did not include dissolved oxygen, algal productivity or water transparency (secchi disk) parameters. The model was intended to describe steady-state conditions during the summer and did not include dynamic mechanisms such as lake turnover or algal blooms. Furthermore, although the model calculated the impact of the sediments on water quality, it did not simulate the long-term accumulation of organic materials in the sediments. The model assumed the lake was stratified into two well-mixed layers, an upper layer (epilimnion) and the lower layer (hypolimnion). The model also did not include near-shore impacts of watershed activities.

Materials and Methods

In order to develop the model, specific data were required for a number of parameters. Some of these parameters had been previously measured in the water quality monitoring program which has been conducted on Long Lake since 1997. These

variables included dissolved oxygen levels, number of days of oxygen depletion in bottom waters, depth of the thermocline and the depth where oxygen depletion occurs, total phosphorus concentrations in surface and bottom waters as well as in the sediments, chlorophyll *a* concentrations and flow measurements and nutrient concentrations in the Long Lake outlet. Variables which were measured in the year 2000 monitoring season were the total volume and nutrient concentration of the rainfall during the spring to late fall season (approximately May to October), estimates of water evaporation from the lake surface, lake levels recorded at the Long Lake Township park, and approximated concentrations of nutrients in groundwater.

Precipitation and Evaporation. The relative volume and concentration of nutrients from precipitation was necessary for completion of the nutrient/hydrologic model. Rainfall volume was measured using a RainWise model RGEL Electronic Recording Rain Gauge (RainWise, Bar Harbor, ME). The gauge was installed approximately 20 feet from the eastern shore of Long Lake on the Templeton property, clear of any overhanging trees or other structures which might affect rain collection. Data were collected from May through September, 2000 and downloaded electronically to a laptop computer for analysis. Rainfall chemistry was primarily collected at the GLEC laboratory, located approximately 8 miles east of Long Lake. Sampling at this distance from the lake was not expected to yield chemistry data which would be significantly different that that collected at the lake itself as 8 miles is considered geographically insignificant with respect to precipitation chemistry (R. Flagler, personal communication). However, in order to compare the relative differences between rain chemistries collected at GLEC and Long Lake, rainfall collection was also completed from the dock of the Doerr residence on the western side of Long Lake peninsula. Rain samples at both sites were collected in an acid-washed glass Erlenmeyer flask with an 12 inch polypropylene funnel on top. In order to eliminate insects and extraneous material, a 0.8 mm mesh stainless steel screen covered the mouth of the collection funnel. Samples were removed from the flask within 6 hours at GLEC and within 1 day from the Doerr dock sampling site, acidified and held at 4 °C until analysis. Samples were bulked over several days to average the precipitation event. Water samples were analyzed for total

phosphorus, nitrate-nitrite nitrogen and kjeldahl (organic) nitrogen using methods described previously (Long Lake Monitoring 1997-1998).

Evaporation was estimated from data collected at the Northwest Michigan Horticultural Station, located in Bingham Township, Leelanau County, approximately 15 miles from Long Lake. Evaporation was measured by a Class A evaporation pan as utilized by the National Weather Service. Evaporation from the four foot diameter pan was measured daily and recorded. The evaporation from the pan varies from what would be expected from a free water surface (e.g. a lake) and so the data were adjusted using a correction factor of 0.8 which is characteristic of Northern Michgian (National Weather Service). The data were summarized (Table 1) on a daily basis and a monthly net precipitation, measured in inches, was calculated for Long Lake for May through September. Using the lake area (approximately 3000 acres), the net gain or loss of water per month (in inches) was converted to a volume (gallons). In addition, the level of Long Lake was recorded on a weekly basis on an established static height gauge established at the Long Lake Township park located on the northeast side of the lake. This measurement was used as a method to calculated the relative volume contribution of groundwater to the lake.

Groundwater Hydrologic and Nutrient Contributions. There is no direct way to physically measure the volume of groundwater entering the lake. However, if the atmospheric inputs are known, along with evaporation losses and outflow measurements from the lake outlet, the groundwater contribution can be approximated by using lake level measurements and calculating the difference from all other sources and losses. During the 2000 monitoring season, there was essentially no flow in the lake outlet, therefore it can be assumed that there was no appreciable direct loss by surface outflow.

Groundwater water was monitored to provide nutrient data for the hydrologic/nutrient model. USGS groundwater contours (Figure 1) suggest that the primary flow of subsurface water is toward the eastern/northeastern side of Long Lake. Groundwater flows away from the lake on the western side and therefore, monitoring was concentrated on the north, east and southern sides within 1000 feet of the shoreline.

There were two principal approaches for sampling groundwater. First, in order to increase the probability that drinking well water was hydrologically connected to Long Lake, a criterion was established that the static water level in the well must be within 20 feet of the lake surface elevation. In order to determine those well which met this criterion, the well log database from Grand Traverse County Health Department was consulted and all wells within 1000 feet of the shoreline of Long Lake and with appropriate static water levels were identified. These property owners were contacted and asked if they would be willing to participate in the study. Of the 25 identified property owners which were contacted, eight agreed to participate in the study (Figure 2) Samples were collected in 0.25 L acidified collection bottles from an outside water source, placed on ice during transport to the laboratory and held at 4 °C until analysis. These samples were analyzed for total phosphorus and nitrate-nitrite nitrogen concentrations and the summarized results are presented in Table 2.

The second sampling approach was used to determine if high nutrient levels were present in near shore, subsurface groundwater (less than 8 feet deep and therefore connected to the lake water). Stainless steel 2 inch well points were placed in the ground at 15 foot intervals on a line perpendicular to the shoreline at two locations on Long Lake. One location was east of Long Lake Peninsula on the eastern shore and the other near the southeastern tip of the Lake. The well points were established at approximately 15, 30 and 45 feet from the lake water edge. Wells were driven down until at least 3 inches of water was evident in the bottom of the well point. In all cases, the maximum depth of the well was less than five feet. Water was pumped from the well through ¼ inch teflon tubing using a small volume electric pump. The first 50 mL was discarded on the ground and a 200 mL sample was pumped into a glass collection bottle (unacidified). The sample was the placed on ice during transport to the laboratory and held at 4 °C until analysis. It should be noted that all samples contained large amounts of suspended sediment. The sediment was allowed to settle out and the overlying water in the sample bottle was carefully removed and placed into an acidified sample bottle. The samples were analyzed for total phosphorus and nitrate-nitrite nitrogen concentrations. However, examination of the results of this method determined that the high sediment concentration present in the bottle most likely contributed excessive amounts of phosphorus to the

sample (Table 2) and thus these data were not utilized in the model. Only data collected from the drinking water wells were included.

Physical Characteristics. The lake area and volume for various depths were determined using GIS depth and surface area maps developed by Meridian Geographics. The model requires area, depth, and volume for the upper (epilimnion) and lower (hypolimnion) water partititions, as well as the total bottom area affected by low dissolved oxygen conditions and macrophyte growth.

Flow Calculations. Development of an appropriate flow model was the most qualitative and challenging aspect of the project. Table 3 shows measured rainfall, evaporation, and changes in lake elevation during the summer of 1997 and 2000. These data can be used to calculate the net inflow, Qnet. This flow is given by

Qnet = Change in Lake elevation + evaporation – rainfall

where all quantities expressed as inches/month. The equivalent flow of these quantities in units of m^3/day is obtained by the formula

m^3/day = inches/month (.0254)(lake surface area in m^2)/30.

Note in Table 3 that the calculated value for Qnet is relatively constant for both dry and wet periods. The only exception is for September 2000 during a period of extremely high rainfall where the calculated Qnet was less than zero. This is clearly unrealistic. However, if it is assumed that the actual rainfall was 5 inches rather than 8.16, Qnet equals 1.76 inches which is consistent with other observations. The fact that these values are rather constant for a wide range of rainfall conditions is quite surprising. However it is convenient take advantage of this observation and therefore assume for the model that Qnet = 2 in/month for all rainfall conditions.

Qnet can also be expressed as

Qnet = Qgin + Qrunoff – Qgout – Qoutlet

where Qgin is the groundwater inflow, Qrunoff is the direct surface runoff inflow, Qgout is the groundwater outflow, and Qoutlet is the surface outlet flow.

We also assume that Qgin is not a strong function of rainfall over the summer and that Qgin = 3 in/month.

Next, it is required to define how Qrunoff and Qgout vary with rainfall. For very dry conditions, the rainfall is about 1.5 in/month. Field observations for such periods suggest that Qrunoff = 0 and Qoutlet = 0. Therefore, for these conditions, Qgout = 1 in/month. For typical wet conditions, the rainfall is about 4.5 in/month. If we assume for these conditions that Qrunoff = 1 in/month and Qoutlet = .5 in/month, then Qgout has a value of 1.5 in/month.

If we assume linear relationships among the flows,

Qrunoff = (R-1.5)/3 where R is the rainfall for R>1.5 and Qrunoff = 0 for R<1.5

Qgout = 1 + (R-1.5)/6

And

Qoutlet = Qrunoff – Qgout +1.

These assumptions and equations are applied for a range of rainfall with the results shown in Table 3. Obviously many assumptions were employed, but the flow sub-model gives results that are in reasonable agreement with the measurements. Of particular note is the close agreement between the model and measurements of Qoutlet during the summer and fall of 1997. The accuracy is judged adequate for the preliminary screening calculations intended here. More accuracy and reliability might result from the development of a quantitative hydrologic model. However such an effort would require data and resources well beyond those allocated for this project.

Groundwater. Groundwater flows were computed by the flow sub-model and are described in Table 3. Groundwater TP concentrations were measured by GLEC as described previously and ranged in value from 3.3 to 25 mg/m^3. These are listed in Table

4. It is assumed here that the high values represent concentrations in more developed areas. The undeveloped areas are assumed to have a background value of 3 mg/m^3.

Macrophytes. A survey was conducted to measure type, area, and TP tissue content of resident macrophytes. The density of the macrohytes was not measured in this study. However Freedman and Canale (1977) measured densities of similar species in White Lake, Michigan. A range for these density measurements is listed in Table 5. These values are used in the model to calculate the mass of macrophytes in the lake, the amount of phosphorus in the lake in the form of macrophytes, and subsequently the impact of macrophyte decay and death on water quality.

The average %TP of the macrophyte tissue is 0.13% as shown in Table 4. This value is quite low and suggests that macrophyte growth may limited by phosphorus availability. The observed macrophytes generally derive their nutrition form the sediments rather than the water. Thus, when the plants excrete, decompose, or die they represent a source of phosphorus to the water. These phenomena are included in the model using a first-order decay coefficient as shown in Table 5.

Sediments. The sediments were sampled for TP at 15 sites having various depths in Long Lake. The TP values ranged from 20.5 to 1754 mg/kg dry wt. The lower values were mostly associated with depths less than 30 feet, whereas the high values were mostly associated with depths greater than 30 feet. The average value of the rich sediments was 1160 mg/kg as shown in Table 4. When the bottom water dissolved oxygen concentration falls below 2 mg/l or less, we expect release of phosphorus from the sediments to the water. Empirical equations developed by Nurnberg (1988) give the sediment release rate as shown in Table 5.

Sediment Release = 6.3 $(TP)^{.76}$ in units $mg/m^2/day$.

Rainfall. Rainfall quantity and TP concentrations were measured by GLEC as described previously. The values and ranges utilized in the model are listed in Table 4.

Model Equations. Mass balance equations are developed for each layer in the lake. The mass balance equations for each layer have terms that represent both sources and losses of phosphorus. These sources and losses must balance at steady state. The terms in the mass balance equations are listed below.

Epilimnion TP Sources

Rainwater
Direct surface runoff
Macrophyte decay and death
Groundwater Inflow
Exchange from the hypolimnion

Epilimnion Losses

Settling to the hypolimnion layer
Groundwater outflow
Surface outlet flow

Hypolimnion Sources

Settling from the epilimnion layer
Sediment release

Hypolimnion Losses

Exchange with epilimnion
Burial to the sediments

Discussion

The model equations are solved using Microsoft EXCEL and are shown in Table 5. The model calibration coefficients are the macrophyte decay rate, the vertical exchange rate, and the epilimnion and hypolimnion settling velocities. The macrophyte decay and the vertical exchange rates were typical values from Chapra (1997). The settling velocities were subsequently adjusted to match the average measurements gathered by GLEC. Good agreement between the model and the data was achieved using settling values typical for other area lakes.

The model is applied by adjusting any of five different Management Parameters as shown in Figure 3. The number of Days for O2< 2 mg/l at Station 3 can be varied to reflect different mixing and thermal conditions in the lake. It is determined that the model output is not very sensitive to different conditions. Rainfall can be varied from wet to dry conditions. The model suggests that water quality in the lake declines as rainfall increases. The overall water quality decreases as the area of the macrophytes increases. If macrophyte populations increase, a significant increase in the total phosphorus concentration is expected. Surface and groundwater TP concentrations can be varied to reflect different levels of watershed development. Figure 3 shows reasonable ranges to represent different conditions. The user can modify the values of any or all the Management Parameters to compute subsequent changes in water quality.

References

Chapra, S.C. (1997) *Surface Water-Quality Modeling*, McGraw-Hill.

Freedman P.L. and R.P. Canale (1977) "Aquatic Macrophytes in White Lake Michigan", Journal of the Environmental Engineering Division, ASCE, Volume 103, No. EE3, pg. 431-444

Nurnberg, Gertrud (1988) "Prediction of Phosphorus Release Rates from Total and Reductant-Soluble Phosphorus in Anoxic Lake Sediments", Can. J. Fish. Aquat. Sci., Volume 45, pg. 453-462

Table 1. Rainfall/Evaporation Summary Sheet - Long Lake 2000

	Total Rainfall (inches)	Total Evaporation (inches)	Net Water Input (gallons)	Net Water Input (liters)	Lake Level Change (inches)**	Lake Level Change (gallons)**
May*	2.16	3.68	-60886414	-230473738	0.0	0
June	2.39	6.11	-288899821	-1093574370	-2.4	-186387019
July	2.26	6.64	-340156241	-1287595629	-2.4	-186387019
August	2.36	5.13	-215121641	-814301346	1.2	93193510
September	8.16	4.36	295112720	1117092099	2.4	186387019
Totals	17.33	25.92	-609951397	-2308852984	-1.2	-93193509

*Beginning May 8, 2000

**Measured at Long Lake Park - level = change from 1st to 31st of month

Note: 1 acre-inch = 27154.286 gallons, Long Lake is 2860 acres: therefore 1 inch water at Long Lake = 77,661,258 gallons

Table 2. Long Lake Drinking Water and Subsurface Well Nutrient Concentrations in 2000.

Drinking Water Wells*

Well ID #	Total P (µg/L)	Nitrate/ Nitrite - N (mg/L)	
219	3.5	0.01	
220	6.0	0.01	
223	1.5	0.01	
293	3.5	3.30	
705	25.0	0.01	
706	18.6	0.01	
870	18.2	0.06	
886	1.1	8.00	
	9.7	1.43	average
	18.6	8.00	maximum value

* Drinking water wells with static water level within 20 feet of lake surface level

Surface Water Wells**

Well ID #	Total P (mg/L)	Nitrate/ Nitrite - N (mg/L)	
WIN-A	51.9	0.01	
WIN-B	46.3	0.01	
WIN-C	40.0	0.04	
SHO-A	56.8	0.02	
SHO-B	40.3	0.01	
SHO-C	20.9	0.01	
	42.7	0.02	average
	51.9	0.04	maximum value

** 2 inch well points. Location A= 15 feet from lake water edge, B=30 feet from lake edge, C=45 feet from lake edge

Table 3. Rainfall Measurements and Model Calculations for Hydrologic Budget.

GLEC 2000 Measurements (Inches/Month)

	Rainfall	Evaporation	Qnet	Qgin	Qgout	Qrunoff	Qoutlet	Change in Lake level
May-00	2.16	3.68	1.52			0	0	0
Jun-00	2.39	6.11	1.32			0	0	-2.4
Jul-00	2.26	6.64	1.98			0	0	-2.4
Aug-00	2.36	5.13	3.97			0	0	1.2
Sep-00	8.16	4.36	-1.4			0	0	2.4
Assumed Sep-00	5	4.36	1.76					2.4
Aug-Oct 1997	2.58	5.26	2.08				0.32	-0.6

Model Calculations for Long Lake Summer Flows (Inches/Month)

Rainfall	Evaporation	Qnet	Qgin	Qgout	Qrunoff	Qoutlet	Change in Lake level
0	6	2	3	0.75	0	0.00	-4
1.5	6	2	3	1.00	0	0.00	-2.5
2	6	2	3	1.08	0.17	0.08	-2
2.5	6	2	3	1.17	0.33	0.17	-1.5
3	6	2	3	1.25	0.50	0.25	-1
3.5	6	2	3	1.33	0.67	0.33	-0.5
4	6	2	3	1.42	0.83	0.42	0
4.5	6	2	3	1.50	1.00	0.50	0.5
5	6	2	3	1.58	1.17	0.58	1
6	6	2	3	1.75	1.50	0.75	2
8	6	2	3	2.08	2.17	1.08	4

Table 4. Summary of Long Lake Monitoring Parameters for 1997 to 1999. Measurements Made by Great Lakes Environmental Center.

Measurement	High	Low	Most Likely
Rainfall TP, mg/m3	47.2	1.9	15
Rainfall, in/month	8.16	2.16	2.5
Change in Lake Level, in/month	2.4	-2.4	0
Evaporation, in/month	6.64	3.68	6
Macrophyte Density, gm dry weight/m2	150	20	125
Macrophyte Area, acres	100	10	47
Marcophyte TP, % dry weight	0.16	0.11	0.13
Groundwater TP, mg/m3	25	3.3	10
Rich Sediment TP, mg/kg dry weight	1754	804	1160
Min Bottom Dissolved Oxygen, mg/l	0.1	0.1	0.1
Days D.O. < 2 mg/l at Station 1 & 2	90	60	75
Epilimnion TP, mg/m3	8.3	4.7	7.1
Hypolimnion TP, mg/m3	31.4	7.7	13.4
Chlorophyll a, mg/m3	2.4	1.3	1.8
Secchi Depth, feet	23.4	17	20.4
Top Volume, m3	---	---	71305252
Top Depth, m	---	---	9.1
Top-Bottom Area, m2	---	---	3901042
Bottom Volume, m3	---	---	20221471
Bottom Depth, m	---	---	6.6
Bottom-Sediment Area, m2	---	---	2213558
Surface Area, m2	---	---	11695032

Table 5. Model coefficients, management parameters and internal calculations for the model.

Model Coefficients	High	Low	Most Likely
Rainfall TP, mg/m3	172	19	15
Macrophyte Density, gm dry weight/m2	150	20	100
Macrophyte TP, % dry weight	0.16	0.11	0.13
Macrophyte TP Decay Rate, per day	0.05	0.01	0.025
Vertical Exchange Coefficient, m2/day	0.5	0.05	0.22
Top Settling Velocity, m/day	0.5	0.05	0.07
Bottom Settling Velocity, m/day	0.5	0.05	0.112
Rich Sediment TP, mg/kg dry weight	1754	804	1160

Internal Calculations	
Rainfall, in/month	2.5
Evaporation, in/month	6
Net Groundwater, in/month	2.00
Groundwater Inflow, in/month	4
Groundwater Outflow, in/month	1.17
Surface Runoff, in/month	0.33
Surface Outlet Flow, in/month	0.17
Change in Lake Depth, in/month	1.5
Sediment Release, mg/m2/day	7.05

Management Parameter	High	Low	Test Value
Days O2<2mg/l at Station3	45	0	20
Rainfall, in/month	4.5	1.5	2.5
Macrophyte Area, acres	100	10	47
Surface Runoff TP, mg/m3	50	10	20
Groundwater TP, mg/m3	30	3	10

Geometric Properties	High	Low	Most Likely
Top Volume, m3			71305252
Top Depth, m			9.1
Top-Bottom Area, m2			3901042
Bottom Volume, m3			20221471
Bottom Depth, m			6.6
Bottom Sediment Area, m2			2213558
Surface Area,m2			11695032

Internal Calculations	
Rainfall, gm/day	371
Macrophyte Decay, gm/day	618
Surface Runoff, gm/day	66
Groundwater Inflow, gm/day	297
Sediment Release, gm/day	2076
Surface Outlet, gm/day	12
Groundwater Outflow, gm/day	82
Sediment Burial, gm/day	3334
Top to Bottom Settling, gm/day	1947
Exchange from Bottom, gm/day	688
a11, m3/day	395200
a12, m3/day	108925
a21, m3/day	381998
a22, m3/day	356844
b1, gm/day	1353
b2, gm/day	2076
c1, gm/m3	0.01
c2, gm/m3	0.01

Figure 1. Groundwater elevation contours in Grand Traverse County near Long Lake. Reproduced from Cunnimgs, et.al., 1990

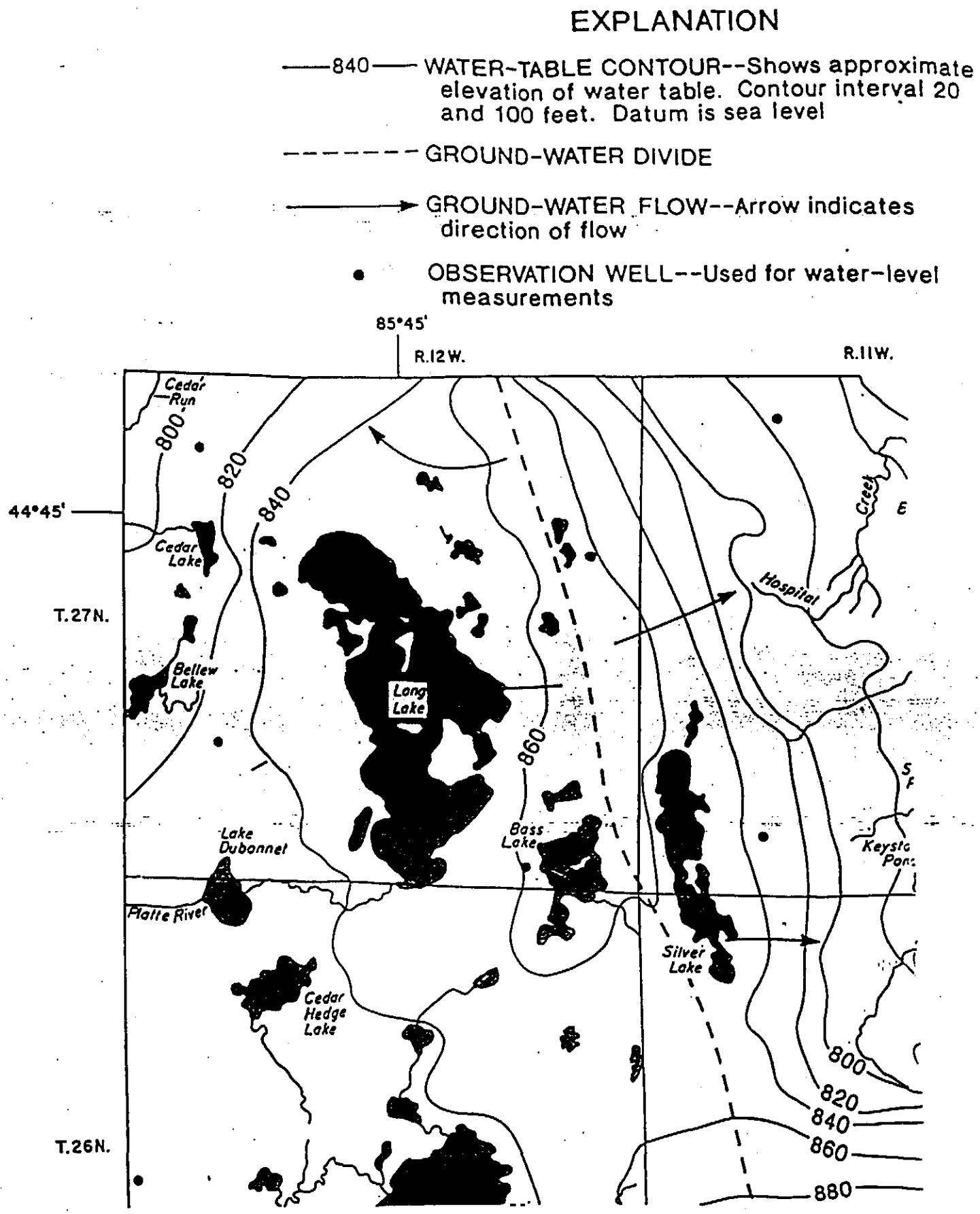


Figure 2. Well Sampling Sites Identified for Monitoring Groundwater At Long Lake.

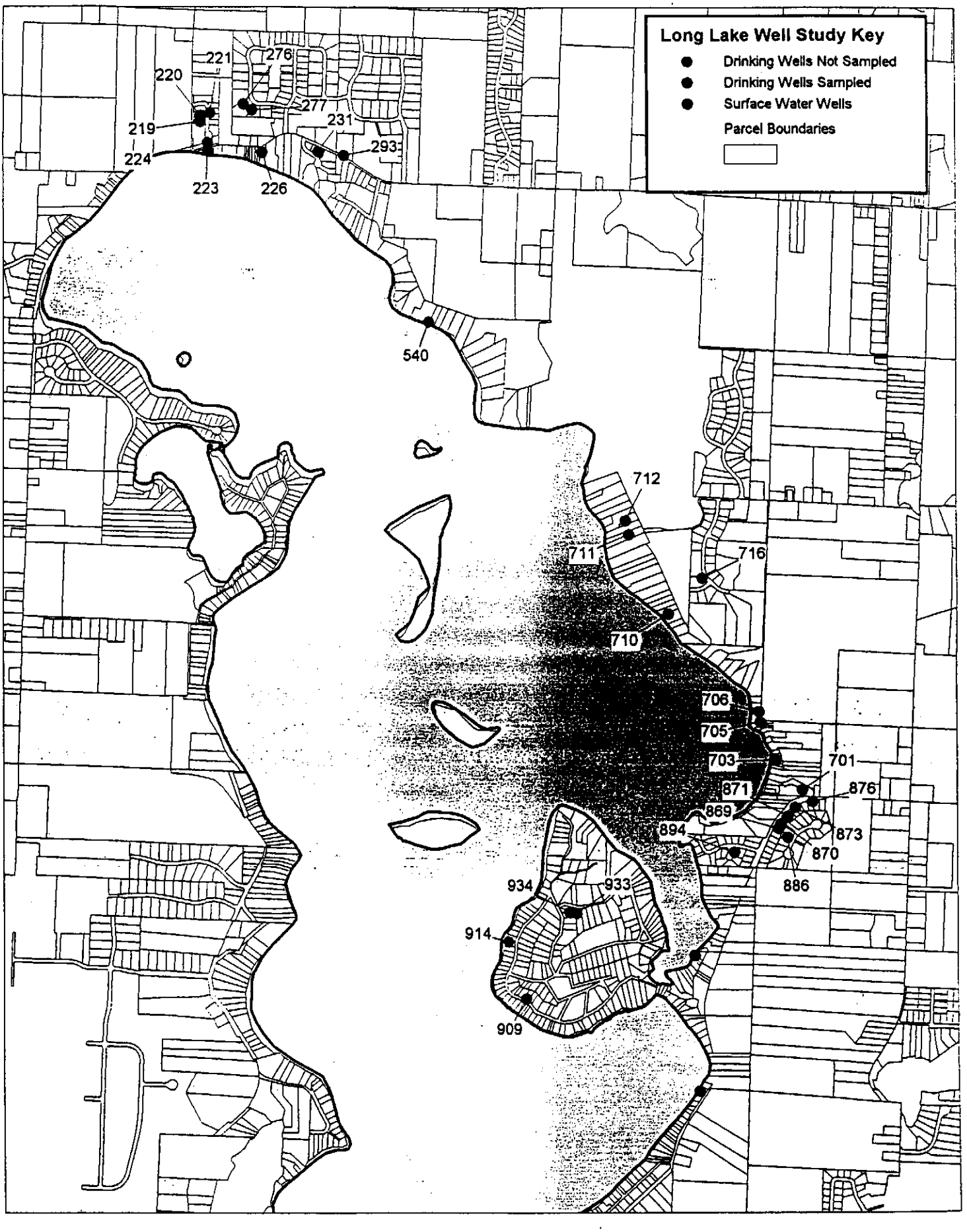
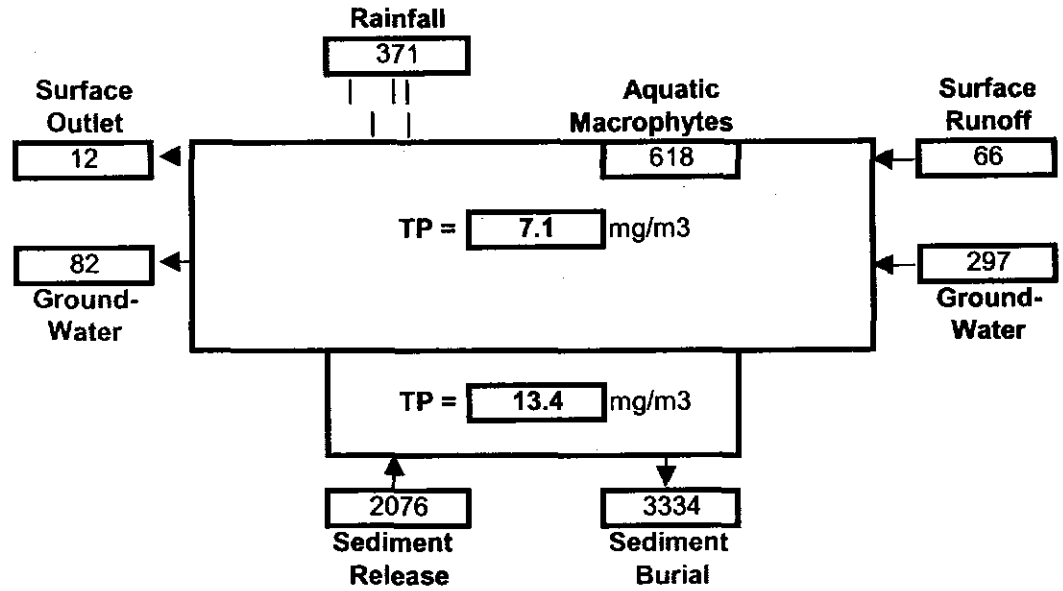


Figure 3. Management Parameters and Calculated Nutrient Partitioning in Long Lake Using the Nutrient/Hydrologic Model

Management Parameter	High	Low	Test Value
Days O2<2mg/l at Station3	45	0	20
Rainfall, in/month	4.5	1.5	2.5
Macrophyte Area, acres	100	10	47
Surface Runoff TP, mg/m3	50	10	20
Groundwater TP, mg/m3	30	3	10

Sources	gm/day	%
Rainfall	371	11%
Macrophyte Decay	618	18%
Surface Runoff	66	2%
Groundwater Inflow	297	9%
Sediment Release	2076	61%

Losses	gm/day	%
SurfaceOutlet Flow	12	0%
Groundwater Outflow	82	2%
Sediment Burial	3334	97%



Steady State Water Quality Planning Model For Long Lake

Developed by Dr. Ray Canale, November 2000

Appendix

Raw Rainfall Data
Long Lake Monitoring - 2000

Rainfall and Evaporation Data - Long Lake 2000

Month: **April, 2000**

Date	Rainfall (inches)	Lake Input Volume (Liters)	Evaporation Pan Data (inches)	Lake Evap. Volume (Liters)	Net Lake Input (Liters)
1		0		0	0
2		0		0	0
3		0		0	0
4		0		0	0
5		0		0	0
6		0		0	0
7		0		0	0
8		0		0	0
9		0		0	0
10		0		0	0
11		0		0	0
12		0		0	0
13		0		0	0
14		0		0	0
15		0		0	0
16		0		0	0
17		0		0	0
18		0		0	0
19		0		0	0
20		0		0	0
21		0		0	0
22		0		0	0
23		0		0	0
24		0		0	0
25		0		0	0
26		0		0	0
27		0		0	0
28		0		0	0
29		0		0	0
30		0		0	0
31		0		0	0
Totals	0	0	0	0	0

Assumptions: 1 acre = 40468564 cm2, Long Lake = 2860 acres

Rainfall and Evaporation Data - Long Lake 2000

Month: **May, 2000**

Date	Rainfall (inches)	Lake Input Volume (Liters)	Evaporation Pan Data (inches)	Lake Evap. Volume (Liters)	Net Lake Input (Liters)	
1		0	0	0	0	May 1-7 no data
2		0	0	0	0	
3		0	0	0	0	
4		0	0	0	0	
5		0	0	0	0	
6		0	0	0	0	
7		0	0	0	0	
8		0	0.23	54090775.3	-54090775.3	Rainfall Start Date
9		0	0.14	32924819.75	-32924819.75	
10		0	0.18	42331911.1	-42331911.1	
11	0.17	49975172.83	0.2	47035456.78	2939716.049	
12	0.56	164624098.7	0	0	164624098.7	
13	0	0	0.1	23517728.39	-23517728.39	
14	0.01	2939716.049	0.22	51739002.46	-48799286.41	
15	0	0	0.16	37628365.43	-37628365.43	
16	0.4	117588642	0.22	51739002.46	65849639.49	
17	0.31	91131197.51	0.1	23517728.39	67613469.12	
18	0.36	105829777.8	0.1	23517728.39	82312049.37	
19	0.01	2939716.049	0.11	25869501.23	-22929785.18	
20	0	0	0.19	44683683.94	-44683683.94	
21	0	0	0.2	47035456.78	-47035456.78	
22	0.23	67613469.12	0.19	44683683.94	22929785.18	
23	0.02	5879432.098	0.17	39980138.26	-34100706.17	
24	0.02	5879432.098	0.11	25869501.23	-19990069.13	
25	0	0	0.15	35276592.59	-35276592.59	
26	0	0	0.21	49387229.62	-49387229.62	
27	0	0	0.19	44683683.94	-44683683.94	
28	0	0	0.17	39980138.26	-39980138.26	
29	0	0	0.13	30573046.91	-30573046.91	
30	0.06	17638296.29	0.18	42331911.1	-24693614.81	
31	0.01	2939716.049	0.03	7055318.517	-4115602.468	
Totals	2.16	634978666.6	3.68	865452404.8	-230473738.2	
Total in Gallons:		167748283.1		228634697	-60886413.88	

Assumptions: 1 acre = 40468564 cm2, Long Lake = 2860 acres, Evaporation Coefficient = 0.8

Rainfall and Evaporation Data - Long Lake 2000

Month: **June, 2000**

Date	Rainfall (inches)	Lake Input Volume (Liters)	Evaporation Pan Data (inches)	Lake Evap. Volume (Liters)	Net Lake Input (Liters)
1	0.61	179322679	0.15	44095740.73	135226938.2
2	0.16	47035456.78	0.03	8819148.147	38216308.64
3	0	0	0.25	73492901.22	-73492901.22
4	0	0	0.1	29397160.49	-29397160.49
5	0	0	0.29	85251765.42	-85251765.42
6	0	0	0.24	70553185.17	-70553185.17
7	0.01	2939716.049	0.29	85251765.42	-82312049.37
8	0.22	64673753.07	0.09	26457444.44	38216308.64
9	0.21	61734037.03	0.3	88191481.47	-26457444.44
10	0.07	20578012.34	0.29	85251765.42	-64673753.07
11	0	0	0.31	91131197.51	-91131197.51
12	0	0	0.16	47035456.78	-47035456.78
13	0	0	0.15	44095740.73	-44095740.73
14	0	0	0.03	8819148.147	-8819148.147
15	0.01	2939716.049	0.25	73492901.22	-70553185.17
16	0.43	126407790.1	0.23	67613469.12	58794320.98
17	0	0	0.21	61734037.03	-61734037.03
18	0	0	0.23	67613469.12	-67613469.12
19	0.22	64673753.07	0.27	79372333.32	-14698580.24
20	0.17	49975172.83	0.19	55854604.93	-5879432.098
21	0.01	2939716.049	0.03	8819148.147	-5879432.098
22	0.07	20578012.34	0.38	111709209.9	-91131197.51
23	0	0	0.24	70553185.17	-70553185.17
24	0	0	0.18	52914888.88	-52914888.88
25	0	0	0.16	47035456.78	-47035456.78
26	0.2	58794320.98	0.26	76432617.27	-17638296.29
27	0	0	0.14	41156024.68	-41156024.68
28	0	0	0.26	76432617.27	-76432617.27
29	0	0	0.17	49975172.83	-49975172.83
30	0	0	0.23	67613469.12	-67613469.12
31	0	0	0	0	0
Totals	2.39	702592135.7	6.11	1796166506	-1093574370
Total in Gallons:		185610368.8		474510189.8	-288899821

Assumptions: 1 acre = 40468564 cm2, Long Lake = 2860 acres

Rainfall and Evaporation Data - Long Lake 2000

Month: **July, 2000**

Date	Rainfall (inches)	Lake Input Volume (Liters)	Evaporation Pan Data (inches)	Lake Evap. Volume (Liters)	Net Lake Input (Liters)
1	0	0	0.22	64673753.07	-64673753.07
2	0.02	5879432.098	0.32	94070913.56	-88191481.47
3	0.01	2939716.049	0.24	70553185.17	-67613469.12
4	0	0	0.17	49975172.83	-49975172.83
5	0	0	0.26	76432617.27	-76432617.27
6	0.19	55854604.93	0.28	82312049.37	-26457444.44
7	0	0	0.16	47035456.78	-47035456.78
8	0.11	32336876.54	0.23	67613469.12	-35276592.59
9	0.05	14698580.24	0.03	8819148.147	5879432.098
10	0	0	0.22	64673753.07	-64673753.07
11	0	0	0.25	73492901.22	-73492901.22
12	0	0	0.31	91131197.51	-91131197.51
13	0	0	0.2	58794320.98	-58794320.98
14	0	0	0.32	94070913.56	-94070913.56
15	0	0	0.3	88191481.47	-88191481.47
16	0	0	0.25	73492901.22	-73492901.22
17	0	0	0.25	73492901.22	-73492901.22
18	0	0	0.4	117588642	-117588642
19	0	0	0.11	32336876.54	-32336876.54
20	0.02	5879432.098	0.24	70553185.17	-64673753.07
21	0.02	5879432.098	0.08	23517728.39	-17638296.29
22	0	0	0.17	49975172.83	-49975172.83
23	0	0	0.14	41156024.68	-41156024.68
24	0	0	0.13	38216308.64	-38216308.64
25	0.02	5879432.098	0.29	85251765.42	-79372333.32
26	0	0	0.28	82312049.37	-82312049.37
27	0.55	161684382.7	0.29	85251765.42	76432617.27
28	0.72	211659555.5	0.12	35276592.59	176382962.9
29	0.16	47035456.78	0.1	29397160.49	17638296.29
30	0.06	17638296.29	0.04	11758864.2	5879432.098
31	0.33	97010629.61	0.24	70553185.17	26457444.44
Totals	2.26	664375827	6.64	1951971456	-1287595629
Total in Gallons:		175514407.4		515670648.2	-340156240.8

Assumptions: 1 acre = 40468564 cm2, Long Lake = 2860 acres

Rainfall and Evaporation Data - Long Lake 2000

Month: **August, 2000**

Date	Rainfall (inches)	Lake Input Volume (Liters)	Evaporation Pan Data (inches)	Lake Evap. Volume (Liters)	Net Lake Input (Liters)
1	0	0	0.12	35276592.59	-35276592.59
2	0	0	0.22	64673753.07	-64673753.07
3	0	0	0.16	47035456.78	-47035456.78
4	0	0	0.24	70553185.17	-70553185.17
5	0.02	5879432.098	0.22	64673753.07	-58794320.98
6	0.04	11758864.2	0.19	55854604.93	-44095740.73
7	0	0	0.11	32336876.54	-32336876.54
8	0.68	199900691.3	0.27	79372333.32	120528358
9	0	0	0	0	0
10	0	0	0.12	35276592.59	-35276592.59
11	0	0	0.18	52914888.88	-52914888.88
12	0	0	0.21	61734037.03	-61734037.03
13	0	0	0.25	73492901.22	-73492901.22
14	0	0	0.15	44095740.73	-44095740.73
15	0.18	52914888.88	0.21	61734037.03	-8819148.147
16	0	0	0.25	73492901.22	-73492901.22
17	0.05	14698580.24	0.22	64673753.07	-49975172.83
18	0.1	29397160.49	0.02	5879432.098	23517728.39
19	0	0	0.19	55854604.93	-55854604.93
20	0	0	0.2	58794320.98	-58794320.98
21	0	0	0.19	55854604.93	-55854604.93
22	0.01	2939716.049	0.16	47035456.78	-44095740.73
23	0	0	0.03	8819148.147	-8819148.147
24	0	0	0.14	41156024.68	-41156024.68
25	0	0	0.23	67613469.12	-67613469.12
26	1.27	373343938.2	0.2	58794320.98	314549617.2
27	0.01	2939716.049	0.05	14698580.24	-11758864.2
28	0	0	0.23	67613469.12	-67613469.12
29	0	0	0.18	52914888.88	-52914888.88
30	0	0	0.03	8819148.147	-8819148.147
31	0	0	0.16	47035456.78	-47035456.78
Totals	2.36	693772987.5	5.13	1508074333	-814301345.5
Total in Gallons:		183280531.6		398402172.5	-215121640.9

Assumptions: 1 acre = 40468564 cm2, Long Lake = 2860 acres

Rainfall and Evaporation Data - Long Lake 2000

Month: **September, 2000**

Date	Rainfall (inches)	Lake Input Volume (Liters)	Evaporation Pan Data (inches)	Lake Evap. Volume (Liters)	Net Lake Input (Liters)
1	4.96	1458099160	0.27	79372333.32	1378726827
2	0.02	5879432.098	0	0	5879432.098
3	0.28	82312049.37	0.09	26457444.44	55854604.93
4	0	0	0.16	47035456.78	-47035456.78
5	0	0	0.22	64673753.07	-64673753.07
6	0	0	0.15	44095740.73	-44095740.73
7	0.04	11758864.2	0.15	44095740.73	-32336876.54
8	0	0	0.17	49975172.83	-49975172.83
9	0	0	0.15	44095740.73	-44095740.73
10	0.23	67613469.12	0.15	44095740.73	23517728.39
11	0.94	276333308.6	0.17	49975172.83	226358135.8
12	0.22	64673753.07	0.14	41156024.68	23517728.39
13	0	0	0.22	64673753.07	-64673753.07
14	0.2	58794320.98	0.14	41156024.68	17638296.29
15	0.6	176382962.9	0.17	49975172.83	126407790.1
16	0.01	2939716.049	0.15	44095740.73	-41156024.68
17	0	0	0.15	44095740.73	-44095740.73
18	0	0	0.15	44095740.73	-44095740.73
19	0.12	35276592.59	0.33	97010629.61	-61734037.03
20	0.14	41156024.68	0.17	49975172.83	-8819148.147
21	0.05	14698580.24	0.09	26457444.44	-11758864.2
22	0.29	85251765.42	0.1	29397160.49	55854604.93
23	0.06	17638296.29	0	0	17638296.29
24	0	0	0.08	23517728.39	-23517728.39
25	0	0	0.1	29397160.49	-29397160.49
26	0	0	0.11	32336876.54	-32336876.54
27	0	0	0.17	49975172.83	-49975172.83
28	0	0	0.11	32336876.54	-32336876.54
29	0	0	0.11	32336876.54	-32336876.54
30	0	0	0.19	55854604.93	-55854604.93
31		0		0	0
Totals	8.16	2398808296	4.36	1281716197	1117092099
Total in Gallons:		633715736.3		338603016	295112720.3

Assumptions: 1 acre = 40468564 cm2, Long Lake = 2860 acres

Rainfall and Evaporation Data - Long Lake 2000

Month: **October, 2000**

Date	Rainfall (inches)	Lake Input Volume (Liters)	Evaporation Pan Data (inches)	Lake Evap. Volume (Liters)	Net Lake Input (Liters)
1		0		0	0
2		0		0	0
3		0		0	0
4		0		0	0
5		0		0	0
6		0		0	0
7		0		0	0
8		0		0	0
9		0		0	0
10		0		0	0
11		0		0	0
12		0		0	0
13		0		0	0
14		0		0	0
15		0		0	0
16		0		0	0
17		0		0	0
18		0		0	0
19		0		0	0
20		0		0	0
21		0		0	0
22		0		0	0
23		0		0	0
24		0		0	0
25		0		0	0
26		0		0	0
27		0		0	0
28		0		0	0
29		0		0	0
30		0		0	0
31		0		0	0
Totals	0	0	0	0	0
Total in Gallons:		0		0	0

Assumptions: 1 acre = 40468564 cm2, Long Lake = 2860 acres

Appendix C1

Long Lake Watershed Loading Estimates
Current and Projected (Year 2020)

Long-Term Hydrological Impact Analysis (L-THIA)

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What Is the Model's Purpose and Capabilities?

L-THIA was developed as a straightforward analysis tool to provide estimates of changes in runoff, recharge and nonpoint source pollution resulting from past or proposed land use changes. It gives long-term average annual runoff for a land use configuration, based on actual long-term climate data for that area. By using many years of climate data in the analysis, L-THIA focuses on the average impact, rather than an extreme year or storm.

L-THIA results are intended to provide insight into the relative hydrologic impacts of different land use scenarios. The results can be used to generate community awareness of potential long-term problems and to support physical planning aimed at minimizing disturbance of critical areas. It is an ideal tool to assist in the evaluation of potential effects of land use change and to identify the best location of a particular land use so as to have minimum impact on the natural environment of the area. Recent concern over urban sprawl has focused on several land use change issues, including the failure to account for hydrologic aspects of land use change that can result in flooding, stream degradation, erosion, and loss of groundwater supply. L-THIA was developed to provide a quick, accessible tool to use in assessing the long-term impacts of land use change.

L-THIA results can be used to aid land use planners in a variety of ways. For instance, a planner may decide to change the land use based on soil type, to minimize impact in a given area. That is because the same land use located on different hydrologic soil types has different impacts. Also, since the amount of runoff generated by different land uses is a function of the hydrologic soil type and the land use, relocating land uses based on the hydrologic soil type can in some cases significantly reduce the long-term impact of the development.

L-THIA is currently available in three forms:

1. L-THIA WWW is a spreadsheet version that models runoff and NPS pollution changes;

2. L-THIA GIS is a set of Avenue scripts that automate the process of runoff impact modeling within ArcView; and

3. L-THIA GIS WWW allows interactive mapping of an area of interest with a custom java interface within a web browser.

SUMMARY OF SCENARIOS
State: Michigan
County: Grand Traverse

YEAR 2020

Land Use	Hydrologic Soil Group	Current	acres Scenario 1	Scenario 2
Industrial	A	9	168	0
Commercial	A	22	210	0
Low Density Residential	A	1775	3164	0
Agricultural	A	4098	3792	0
Forest	A	3633	2328	0
Grass/Pasture	A	1450	1325	0
Water/Wetlands	A	3448	3448	0

RUNOFF RESULTS
Avg. Annual Runoff Volume (acre-ft)

YEAR 2020

Land Use	Current	Scenario 1	Scenario 2
Industrial	1.87	34.99	0
Commercial	9.95	94.99	0
Low Density Residential	26.51	47.27	0
Agricultural	180.27	166.81	0
Forest	0	0	0
Grass/Pasture	2.40	2.19	0
Water/Wetlands	0	0	0
Total Annual Volume (acre-ft)	221.02	346.27	0

Avg. Annual Runoff Depth (in)

Current	Scenario 2	Scenario 3
0.18	0.28	0

Avg. Runoff Depth by Landuse

Land Use	Hydrologic Soil group	Curve Number	Runoff Depth (in)
Industrial	A	81	2.51
Commercial	A	89	5.45
Low Density Residential	A	54	0.18
Agricultural	A	64	0.53
Forest	A	30	0
Grass/Pasture	A	39	0.02
Water/Wetlands	A	0	0
Average Annual Rainfall Depth (in)			29.85

NONPOINT SOURCE POLLUTANT RESULTS

Nitrogen (lbs)

YEAR 2020

Land Use	Current	Scenario 1	Scenario 2
Industrial	6	120	0

Commercial	36	346	0
Low Density Residential	131	234	0
Agricultural	2161	1999	0
Forest	0	0	0
Grass/Pasture	4	4	0
Water/Wetlands	0	0	0
Total	2338	2703	0

Phosphorous (lbs)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	1	26	0
Commercial	8	82	0
Low Density Residential	41	73	0
Agricultural	638	590	0
Forest	0	0	0
Grass/Pasture	0.065	0.059	0
Water/Wetlands	0	0	0
Total	688.065	771.059	0

Suspended Solids (lbs)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	309	5769	0
Commercial	1504	14364	0
Low Density Residential	2962	5280	0
Agricultural	52555	48631	0
Forest	0	0	0
Grass/Pasture	6	5	0
Water/Wetlands	0	0	0
Total	57336	74049	0

Lead (lbs)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	0.076	1	0
Commercial	0.352	3	0
Low Density Residential	0.650	1	0
Agricultural	0.736	0.681	0
Forest	0	0	0
Grass/Pasture	0.032	0.029	0
Water/Wetlands	0	0	0
Total	1.846	5.71	0

Copper (lbs)			
Land Use	Current	Scenario 1	Scenario 2
Industrial	0.076	1	0
Commercial	0.393	3	0

Low Density Residential	0.650	1	0
Agricultural	0.736	0.681	0
Forest	0	0	0
Grass/Pasture	0.065	0.059	0
Water/Wetlands	0	0	0
Total	1.92	5.74	0

Zinc (lbs)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	1	23	0
Commercial	4	46	0
Low Density Residential	5	10	0
Agricultural	7	7	0
Forest	0	0	0
Grass/Pasture	0.039	0.035	0
Water/Wetlands	0	0	0
Total	17.039	86.035	0

Cadmium (lbs)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	0.010	0.190	0
Commercial	0.026	0.248	0
Low Density Residential	0.054	0.096	0
Agricultural	0.491	0.454	0
Forest	0	0	0
Grass/Pasture	0.006	0.005	0
Water/Wetlands	0	0	0
Total	0.587	0.993	0

Chromium (lbs)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	0.035	0.667	0
Commercial	0.271	2	0
Low Density Residential	0.151	0.270	0
Agricultural	4	4	0
Forest	0	0	0
Grass/Pasture	0.049	0.044	0
Water/Wetlands	0	0	0
Total	4.506	6.981	0

Nickel (lbs)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	0.042	0.791	0
Commercial	0.319	3	0
Low Density Residential	0.722	1	0

Agricultural	0	0	0
Forest	0	0	0
Grass/Pasture	0	0	0
Water/Wetlands	0	0	0
Total	1.083	4.791	0

BOD (lbs)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	71	1335	0
Commercial	623	5952	0
Low Density Residential	1842	3284	0
Agricultural	1964	1817	0
Forest	0	0	0
Grass/Pasture	3	2	0
Water/Wetlands	0	0	0
Total	4503	12390	0

COD (lbs)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	232	4338	0
Commercial	3145	30023	0
Low Density Residential	3576	6375	0
Agricultural	0	0	0
Forest	0	0	0
Grass/Pasture	0	0	0
Water/Wetlands	0	0	0
Total	6953	40736	0

Oil & Grease (lbs)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	15	286	0
Commercial	244	2329	0
Low Density Residential	122	218	0
Agricultural	0	0	0
Forest	0	0	0
Grass/Pasture	0	0	0
Water/Wetlands	0	0	0
Total	381	2833	0

Fecal Coliform (millions of coliform)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	225	4204	0
Commercial	850	8117	0
Low Density Residential	6568	11708	0
Agricultural	58048	53713	0

Forest	0	0	0
Grass/Pasture	5	5	0
Water/Wetlands	0	0	0
Total	65696	77747	0

Fecal Strep (millions of coliform)		YEAR 2020	
Land Use	Current	Scenario 1	Scenario 2
Industrial	141	2644	0
Commercial	2218	21176	0
Low Density Residential	18391	32784	0
Agricultural	0	0	0
Forest	0	0	0
Grass/Pasture	0	0	0
Water/Wetlands	0	0	0
Total	20750	56604	0

These results were generated by the L-THIA (Long-Term Hydrologic Impact Assessment) model at "http://www.ecn.purdue.edu/runoff/lthianew"

Appendix D

Long Lake Macrophyte Study

MACROPHYTE (ROOTED AQUATIC PLANT) SURVEY OF LONG AND MICKEY LAKES IN GRAND TRAVERSE COUNTY, MICHIGAN

CONDUCTED JUNE-SEPTEMBER, 2000

Prepared for:

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March 12, 2001

EXECUTIVE SUMMARY

Background. A survey of the rooted aquatic plants in Long and Mickey Lakes was conducted by Great Lakes Environmental Center (GLEC) in the summer of 2000, as part of a larger watershed management study. The objective of this survey was to map the major macrophyte growth areas in the lakes, and to characterize the vegetation in Long and Mickey Lakes. This survey established macrophyte baseline data, which will be an important resource to be used for future comparative monitoring efforts by the Long Lake Association. Plant species composition, average lakewide density, and the distribution of macrophyte growth areas was determined from transect data and from direct observation of the lake bottom during the peak growing periods. Sediment samples and plant tissue samples were also collected at a limited number of selected sites for phosphorus analyses.

A macrophyte survey can be particularly valuable in watershed management efforts because lake fertility is an important factor affecting aquatic plant growth, and the distribution of aquatic plants can be a reflection of the characteristics of the surrounding watershed. Watershed characteristics (size, land uses, soil types, and drainage patterns) influence the quantity of plant growth nutrients which enter a lake from the land.

Transects were established in July at 22 locations on Long and Mickey Lakes, and plant surveys were performed. The transects were established in association with a number of the aquatic growth areas identified in a preliminary survey, but transects were also established at public access sites (including boat launches and swimming beaches), which are common areas for exotic species introduction. In addition, because inlets can often be significant sources of nutrient introduction to lakes, a transect was established in the outlet pond area on the south end of Long Lake, and at a small inlet (Girl Scout Creek) on the east side of Long Lake. Surveys were also conducted in August and September to include the species that grow later in the season. During the late summer surveys some of the early summer transects were re-visited, and 16 new transects were established at macrophyte growth areas. Thus, for the entire program, transects were established at a total of 38

different locations (2 on Mickey Lake and 36 on Long Lake). Each transect was identified by shoreline landmarks and/or GPS (Global Positioning System) coordinates. The GPS data were used to prepare macrophyte location maps and to measure the dimension of large macrophyte growth areas. The actual boundaries of the larger macrophyte growth areas were estimated using GPS coordinates from near-shore and mid-depth observations, and by extrapolating to a 20 foot depth contour. The individual macrophyte growth areas that were too small to measure using GPS and those that were very sparsely vegetated, were each estimated to be one half acre for simplicity, although some were probably slightly larger or smaller.

For comparison purposes, plant tissue samples and sediment samples were collected for total phosphorus analyses both in areas with dense and sparse macrophyte growth. A total of six surface sediment samples were collected using an Eckman stainless steel dredge in water less than 4 feet water deep, and analyzed at GLEC for total phosphorus. A total of 4 plant tissue samples were shipped to an outside laboratory for total phosphorus analysis.

Results and Discussion. It is important for the public to recognize that rooted aquatic plants are a natural and essential part of a healthy lake ecosystem. Aquatic plants stabilize the water temperature and moderate wave action, and the roots of aquatic plants stabilize sediments and in so doing reduce erosion. Aquatic plants also provide essential habitat for fish, and for the organisms that provide food for both young and adult fish (such as invertebrates, forage fish species, and plankton). Fish also depend on aquatic plants for cover to protect their young, as an area to obtain food and for predator avoidance. Waterfowl, shorebirds, reptiles, amphibians and aquatic mammals also need aquatic plants as food sources, for cover and for nesting. Nutrient cycling and other ecological processes are also dependent on the existence of aquatic plants in lakes.

The vegetation in Long Lake is indicative of a well balanced aquatic plant community, with a low quantity of plant growth which is typical of oligotrophic lakes like Long Lake. The inventoried macrophyte growth areas account for about 4 percent of the lake bottom (48 acres out of a possible 1,329) encompassed by the 0-20 foot contour which is

the typical growth region for rooted aquatic plants in northern Michigan lakes.

The quantity of macrophyte growth areas was lower than might be expected in Mickey Lake since the entire lake is shallow, and fairly protected. An exotic plant species, Eurasian milfoil was observed growing in various densities around the Long Lake and in the north end of Mickey Lake. Eurasian milfoil did not appear to pose a significant threat to the plant community, or to recreational activities on either of these lakes this summer. However, aquatic plant control was actively occurring throughout the summer months during this survey, thus the macrophyte study is not a true representation of the plant growth on Long Lake.

Nutrient and sediment loading from the watershed are most likely stimulating plant growth in some areas. The presence of macrophyte growth areas corresponded with physical features of the lake that resulted in sheltered environments. There was a wide range of phosphorus concentrations found in the near-shore samples collected during the survey. Further, it appears sediments with higher phosphorus concentrations could be correlated with dense macrophyte growth areas, however, more studies need to be done to confirm this.

Chemical control efforts are reducing the occurrence of Eurasian milfoil, particularly on Mickey Lake. However, some of the transect data and some of the scientific literature indicate there may be a reduction in native species as well due to the control program. Mickey Lake historically was known to have had dense populations of Eurasian milfoil in the past which have been greatly reduced by control efforts. It is important to understand that chemical treatments are not long-term management tools. At this point the use of herbicides needs to be re-evaluated and perhaps discontinued since applications have occurred for at least three consecutive years. It is essential that Mickey Lake be closely monitored and an aquatic plant management strategy needs to be addressed as soon as possible. Because of the ecological importance of native plant species, every effort should be made to protect the native plants that currently exist in Mickey Lake and in Long Lake. Therefore, options for limiting nutrient inputs where possible, by protecting shoreline vegetation, and reducing shoreline erosion should be incorporated into an aquatic plant management plan, as should consideration of hand removal of Eurasian milfoil and biological controls.

The current plant community data from this macrophyte study can be used in conjunction with the information provided in the Watershed Management Plan for Long Lake to formulate an aquatic plant management strategy, and eventually a long term management plan. Based on the information from the macrophyte survey of Long and Mickey Lakes monitoring the lakes and plant community for future problems is essential. The maps and data generated from this study are a valuable tool that can be used in the future to address changing lake conditions. The native plant species present need to be protected. Watershed management controls are recommended to provide long-term control of nutrient and sediment loading.

MACROPHYTE (ROOTED AQUATIC PLANT) SURVEY OF LONG AND MICKEY LAKES IN GRAND TRAVERSE COUNTY, MICHIGAN CONDUCTED JUNE-SEPTEMBER, 2000

Introduction

A survey of the rooted aquatic plants in Long and Mickey Lakes was conducted by Great Lakes Environmental Center (GLEC) in the summer of 2000, as part of a larger watershed management study. The objective of this survey was to map the major macrophyte growth areas in the lakes, and to characterize the vegetation in Long and Mickey Lakes. This survey established macrophyte baseline data, which will be an important resource to be used for future comparative monitoring efforts by the Long Lake Association. Plant species composition, average lakewide density, and the distribution of macrophyte growth areas were determined from transect data and from direct observation of the lake bottom during the peak growing periods. Sediment samples and plant tissue samples were also collected at a limited number of selected sites for phosphorus analyses.

A macrophyte survey can be particularly valuable in watershed management efforts because lake fertility is an important factor affecting aquatic plant growth, and the distribution of aquatic plants can be a reflection of the characteristics of the surrounding watershed. Watershed characteristics (size, land uses, soil types, and drainage patterns) influence the quantity of plant growth nutrients which enter a lake from the land.

Methods

The methods used to conduct this survey were based on previous macrophyte studies which GLEC has conducted locally, and on methods described in "A Citizen's Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes" (Michigan State University, 2000). To insure maximum visibility, the surveys were

conducted on sunny to partly sunny days with low wind, between the hours of 10:00 a.m and 3:00 p.m.

A preliminary survey of Long and Mickey Lakes was performed on June 30, 2000, to locate the major aquatic plant growth areas. On July 1, 2000, transects were established at 22 locations on Long and Mickey Lakes, and plant surveys were performed. The transects were established in association with a number of the aquatic growth areas identified in the preliminary survey, but transects were also established at public access sites (including boat launches and swimming beaches), which are common areas for exotic species introduction. In addition, because inlets can often be significant sources of nutrient introduction to lakes, a transect was established in the outlet pond area on the south end of Long Lake, and at a small inlet (Girl Scout Creek) on the east side of Long Lake. Surveys were also conducted in August and September to include the species that grow later in the season. During the late summer surveys some of the early summer transects were re-visited, and 16 new transects were established at macrophyte growth areas. Thus, for the entire program, transects were established at a total of 38 different locations (2 on Mickey Lake and 36 on Long Lake).

Each transect was identified by shoreline landmarks and/or GPS (Global Positioning System) coordinates. Each transect survey was performed by anchoring a boat perpendicular to the shore at three different water depths: 1, 4 and 8 feet, which were determined by using a weighted sounding line. At each anchoring site, a weighted rake with a retrieving line was used to obtain plants from all four sides of the boat (bow, stern, starboard and port). Each plant which was collected was identified to species either on-site, or at GLEC's laboratory. Relative densities were determined based on the quantity of plants obtained by each rake retrieval, by the number of retrievals for which a particular species was present, as well as by direct observation of the lake bottom when possible.

The GPS data were used to prepare macrophyte location maps and to measure the dimension of large macrophyte growth areas. The actual boundaries of the larger macrophyte growth areas were estimated using GPS coordinates from near-shore and mid-depth observations, and by extrapolating to the 20 foot depth contour. The individual macrophyte growth areas that were too small to measure using GPS and those that were very sparsely vegetated, were each

estimated to be one half acre for simplicity, although some were probably slightly larger or smaller.

Aquatic plant density ratings were assigned for each macrophyte area using the following criteria:

Dense (5)	Species fills the rake in all four casts.
Heavy (4)	Species found mixed with other plants in all four casts of the rake.
Moderate (3)	Species found in three of the four rake casts.
Sparse (2)	Species found in two of the four rake casts.
Found (1)	Species found in one of the four rake casts.

Each plant species identified was assigned a numerical value, or portrait number following the Michigan State University Citizen's Guide (MSU, 2000), that relates to the plant's growth characteristics. For example, floating leaved plants including water lilies and watershield were assigned a value of 12, while plants that are low growing (1 to 3 feet) were assigned numbers in the 20's. Plants that grow several feet high (2 to 5 feet) were assigned values in the 30's, and plants that grow up to 10 feet or more in height were assigned values in the 40's. Plants assigned a value of 50 or more are tall growing plants that can also form a dense canopy. Each plant species was assigned a corresponding color (Table 1A; Appendix II) that was used to prepare figures that summarize the transect data by species. The transect data were also used to calculate average lakewide density ratings, as well as the relative dominance of each species at a particular transect.

For comparison purposes, plant tissue samples and sediment samples were collected for total phosphorus analyses both in areas with dense and sparse macrophyte growth. A total of six surface sediment samples were collected using an Eckman stainless steel dredge in water less than 4 feet water deep, and analyzed at GLEC for total phosphorus. A total of 4 plant tissue samples were shipped to an outside laboratory for total phosphorus analysis.

Results (Long Lake)

A preliminary survey of Long Lake was performed on June 30, 2000, to locate the major aquatic plant growth areas, and to establish some of the transects. Significant macrophyte growth areas (larger than 100 square feet) were observed in the north and south end embayments of Long Lake, in bays near the Timbers Girl Scout Camp, in bays to the north of the peninsula, in the peninsula bay, in the bay just south of the peninsula, and north of the Crescent Shores boat launch. Macrophyte growth areas were also identified near Picnic Island, Long Island and South Island during the preliminary study (Table 1; Figures 1 and 2). Brush Island and Fox Island were not visited during the preliminary study. In addition, macrophyte growth areas where populations of Eurasian milfoil were observed during the June 30, 2000 survey are indicated in Figure 1.

Eurasian milfoil is the only non-native species identified during this survey. There were seven areas observed during the June survey where Eurasian milfoil was growing including the east shore of Long Lake, the bay just to the south of the peninsula, the bay on the south end of Long Lake, South Island and Long Island. The Eurasian milfoil plants were typically associated with stands of native aquatic plants, and were not the dominant vegetative cover (Figure 1).

At each transect, field data sheets were used to record the plant species and the density rating of each species at different water depths (Appendix I). The data sheets are summarized in bar graphs in Appendix II. Each different plant species is assigned a number and a unique color, and can be identified using Table 1A of Appendix II. For example, the figure representing Transect 1 in Appendix II (surveyed July 7, 2000), shows chara (portrait #20 - blue color code from Table 1A) present at a moderate density (3) at the 4 foot sampling site, with sparse to moderate populations of elodea (36), vallisneria (34), and clasping leaved pondweed (42). This figure is comparable to the transect data from the August 30, 2000 survey.

Near-shore sediment samples and plant tissue samples were collected as part of the macrophyte study to determine if there was a correlation between the phosphorus concentrations in the sediment, or in plant tissue, and the density of the corresponding macrophyte growth areas. High nutrient concentrations in plant tissue can be indicative of excessive nutrient availability. The phosphorus concentrations measured in the plant tissue samples collected during this survey

ranged from 0.11 to 0.16 percent dry weight. These plant phosphorus values are typical of concentrations reported in the literature for the phosphorus content of aquatic macrophytes. A range of 0.11 to 0.67 percent dry weight was reported by Adams 1974 for *Myriophyllum spicatum* shoots collected from Wisconsin lakes. The samples analyzed during this study are at the low end of the this reported range. The total phosphorus content of all four collected tissue samples were similar; there were no significant differences between the phosphorus tissue concentrations of Eurasian milfoil plants and native species of plants. Additionally, no differences were observed between plant tissue samples collected from dense and sparse growth areas.

A correlation between sediment phosphorus concentrations and dense macrophyte growth areas may exist, because some of the sediments with higher sediment phosphorus concentrations were associated with dense macrophyte growth areas (Table 2). However, dense growths of macrophytes were not always associated with high phosphorus sediment values, and some of the intermediate sediment phosphorus concentrations did not correlate with intermediate plant growth density. These results are somewhat difficult to interpret because macrophyte control efforts may have reduced the number of plants in the study areas, and because the limited number of samples analyzed did not provide enough data to draw any definite conclusions. There was enough information, however to suggest that further studies may be warranted.

There were 14 macrophyte growth areas that were sufficiently large to be mapped using GPS measurements. The observed macrophyte growth areas ranged in size from about a half acre, to over 12 acres (Figure 3). The GPS coordinates and a description of each of the macrophyte growth areas that are represented in Figure 3 are included in Table 3.

Results (Mickey Lake)

Surveys were conducted on July 7, August 30 and September 28, 2000 to characterize the vegetation of Mickey Lake. There were macrophyte growth areas observed throughout Mickey Lake, but there were also unvegetated areas that were visible over large portions of the lake, especially in the central and southern parts of the lake. Overall, the macrophyte growth areas in Mickey lake were located close to shore, with moderate to sparse plant densities, but the northern

lakeshore area of Mickey Lake had macrophyte growth areas with moderate to dense growth areas. Plants were also present on steep drop off areas near the east and west shores.

Two transects were established on Mickey Lake; one of the transects was established at the north end of the lake in a dense macrophyte growth area, and a second transect was established at the southern end of the lake in a sparse macrophyte growth area. A total of fourteen species of submerged aquatic plants were collected at the two transect sites on Mickey Lake (Table 4). The only non-native plant species collected was Eurasian milfoil, which was collected (and observed) growing only in the north end of the lake. There was a very sparse population of Eurasian milfoil observed during the initial survey in July (with a density rating of 1), and a density rating of 2 was assigned during the late summer survey at the same transect site. Chara, naja, vallisneria and fern leaved pondweed were the dominant species in the north end of Mickey Lake. The dominant species in the south end of the Mickey Lake was Illinois pondweed, with sparse to moderate densities observed throughout the summer.

The two sediment samples collected from near-shore areas on Mickey Lake (Figure 4) had sediment phosphorus concentrations of 46.5 and 95.8 mg/kg dry weight. Both of these sediment phosphorus values were higher than any of the four sediment samples collected on Long Lake. The sediment sample collected near the dense plant growth area at the north end of Mickey Lake had the highest phosphorus value, while the sediment sample collected on the east shore of Mickey Lake (where there was no plant growth), had the lower sediment phosphorus value.

Discussion (Long Lake)

It is important for the public to recognize that rooted aquatic plants are a natural and essential part of a healthy lake ecosystem. Aquatic plants stabilize the water temperature and moderate wave action, and the roots of aquatic plants stabilize sediments and in so doing reduce erosion. Aquatic plants also provide essential habitat for fish, and for the organisms that provide food for both young and adult fish (such as invertebrates, forage fish species, and plankton). Fish also depend on aquatic plants for cover to protect their young, as an area to obtain food and

for predator avoidance. Waterfowl, shorebirds, reptiles, amphibians and aquatic mammals also need aquatic plants as food sources, for cover and for nesting. Nutrient cycling and other ecological processes are also dependent on the existence of aquatic plants in lakes.

The rooted aquatic plants of lakes like Long Lake (like most clear northern Michigan Lakes) extend from the shore to water depths of 20 feet or greater (the littoral zone). Figure 3, shows the potential macrophyte growth area for Long and Mickey Lakes (0-20 foot lake bottom contour). This potential growth area represents 1,329 acres for Long Lake, and 61 acres for Mickey Lake (the entire lake). However, water depth is only one of the factors that influence the locations of aquatic plant growth. Protection from lake currents and wave action, nutrient availability, and the character of the lake bottom are important factors that also influence whether plants can grow in a particular location.

The macrophyte growth areas identified on Long Lake seem to be related to physical shoreline features that offer protection by reducing the movement of water. Bays, lagoons and points of land that project into the lake nearly always had associated macrophyte growth areas. Conversely, parts of the lake subject to wave action (for example, where residents erected break walls on the SE corner of the lake with prevailing westerly winds) had no significant associated macrophyte growth. A large area of lake bottom off the east shore of Long Lake at water depths of 10 feet or less is covered with wood planks (off-shore from an old sawmill site; the mill is no longer in existence). Significant macrophyte growth consisting of native plants are present on both the north and south sides of the wood planks, suggesting that the wood planks are inhibiting plant growth.

Generally, in the summer of 2000 the lakewide density of macrophytes in Long Lake was observed to be low. The average lakewide density rating for all of the species identified was 2 (sparse), or less during both the mid- and late-summer surveys, with an overall decline observed throughout the course of the summer (Figure 5). There was a healthy diversity of aquatic plants identified during the surveys, including 19 different species of submersed aquatic plants, and six different genera of algae (Table 4).

The three plant species with the highest lakewide density ratings were: Chara (portrait #20), Vallisneria (Portrait #34) and Illinois pondweed (portrait #46). All three of these plant

species, and all but one of the remainder of the species encountered during this study, are considered to be highly beneficial to lake ecosystems, with no associated negative characteristics. Chara (or stonewort) is actually a macroscopic green algae that is commonly identified in aquatic plant surveys. This low growing species can form dense mats (known as chara meadows) that rarely exceed one foot in height. Chara is extremely common and provides excellent habitat for aquatic invertebrates, and food for waterfowl and fish. Since chara derives its nutrition directly from the water column rather than from the sediment, it can enhance water clarity (because it removes nutrients such as phosphorus from the water column, which reduces the growth of microorganisms and phytoplankton that can increase the turbidity of the water). Stonewort is a beneficial species that should be encouraged wherever found (Michigan State University, 2000).

Vallisneria (or water celery) is another common species that is also relatively low growing. The plants rarely exceed four feet in height, and Vallisneria rarely forms large beds (except in lakes where the density of other plants has been reduced by control programs; non-vegetated sediments provide the substrate for the late blooming wild celery to expand, thus replacing the controlled plants). This species is one of the most important waterfowl foods, and it provides good habitat for young fish as well. Studies by the U.S. Army Corps of Engineers have shown that the only situation in which Vallisneria can be perceived to be a nuisance species is in lakes that have been repeatedly treated with herbicides (Westerdahl, 1988).

Illinois pondweed is also an extremely common aquatic plant, with only beneficial characteristics. Illinois pondweed is a member of the genus *Potamogeton*, growing up to eight feet tall, but rarely forming dense colonies. In general, Potamogeton species like Illinois pondweed offer good fish habitat, are an important waterfowl food, and the growth pattern characteristics of these species minimize conflict with most recreational activities. (Michigan State University,2000).

Although the macrophyte lakewide density ratings were generally low, there were a few isolated areas of dense plant growth. The majority of the large macrophyte growth areas were found to have a high diversity of plant species, with moderate, low or non-existent populations of Eurasian milfoil. Several of the areas found to have dense macrophyte growth correspond to

areas similarly identified in the three previous water quality studies performed in 1972, 1976 and 1983 on Long and Mickey Lakes. These previous studies focused on fecal bacterial indicators, nutrients, or algae (*Cladophora*), and were designed to help detect poorly performing septic systems associated with shoreline residences. Figure 6 shows the locations that the historical studies identified as having high bacterial or algal concentrations which correlated with dense macrophyte growth areas observed during the current macrophyte inventory. Because inadequate domestic wastewater treatment associated with poorly maintained or otherwise inappropriate septic systems can result in leaching of nutrients on a localized basis, it is reasonable to expect that there is the potential for significant growth of macrophytes in these areas. The three areas of concern which were identified in the historical studies which had correlated macrophyte growth areas found in the present study are:

1) Girl Scout Creek (small inlet from Fern Lake (Transect 23)
2) The bay at the south end of the lake near the outlet (Transects 11 and 9)
3) Peninsula bay (Transect 7)

Two of these areas (Girl Scout Creek and the south bay area) had significant populations of Eurasian milfoil.

Overall, the quantity of vegetation in Long Lake appears to be low, and typical of oligotrophic clear water lakes in our region. The inventoried macrophyte growth areas represented in Figure 3 account for about 4 percent of the lake bottom encompassed by the 0-20 foot contour (48 acres out of a possible 1,329) for Long Lake (Table 5). There is the possibility some macrophyte growth areas were overlooked in our survey. For example, macrophyte growth areas that are located in deep water where there were no plants growing near the shore could have been overlooked. Additionally, herbicide applications during July and August complicated our investigation by eliminating or reducing some of the macrophyte growth areas that otherwise would have been noted. Nevertheless, even though this study may have underestimated the total acreage of macrophytes present in Long Lake, it is clear that on a lakewide basis only a small percentage of existing macrophyte growth areas can be classified as dense growth areas. As previously discussed, it is important for a lake to have healthy populations of aquatic plants to maintain a stable ecosystem, it is critical to protect the existing native macrophytes in Long Lake.

The sources of nutrients in lake bottom sediments are both natural and anthropogenic (associated with human activity). The historical bacterial and algal studies indicate that nutrients have been leaching into the lake from septic systems, as has runoff from the developing shoreline. The phosphorus concentrations measured in the rainwater and in the sediments of Long Lake are high (Long Lake Watershed Management Plan). Therefore, nutrient inputs from the past (sequestered in the sediments), as well as current contributions, most likely combine to support the macrophyte growth areas identified in this investigation.

Precise determination of all the sources of nutrients responsible for the macrophyte growth areas on Long Lake is not possible. However, the three areas identified in previous studies as having high indicators of septic seepage are associated with areas found to have large macrophyte growths in our investigation. The nutrients appear also to collect in bays and downwind from points, which is demonstrated by the islands very well. There are no residences on any of the five islands, and yet each island had macrophyte growth areas associated with all of the points of land, and in some of the bays. The long flushing time of Long Lake, the characteristics of the surrounding soils in the watershed and the human activity in the watershed also influence the accumulation of nutrients.

Shoreline Vegetation

Shoreline vegetation, including emergent plants, is a very important feature of lake vegetation. The lack of natural shoreline vegetation on Long Lake is an important concern in most of the developed/developing lakeshore areas, because many of the lakeshore residents have replaced the native shrubs, trees and other vegetation, with landscaping grasses. These cultivated grasses have minuscule root systems compared to the native plants replaced, which results in reduced nutrient retention and filtering capability. Lakeshore owners often exacerbate the problem by adding fertilizers, pesticides and herbicides to the landscaped areas, and by creating artificial sand beaches and paved areas. Undeveloped shoreline areas are very desirable to the maintenance of healthy fish, reptile and amphibian populations in lakes like Long and Mickey Lakes, and are essential critical habitats for shorebirds. For example, during our survey Mickey Lake was home to a nesting pair of loons, and local residents maintained a vigilant watch

for motor boats that could upset the birds. The area where these birds were nesting was an area on the shore where the shoreline vegetation was relatively undisturbed. Because there was a sufficient quantity of native plants and shrubs that provided cover for the birds, the loons were able to nest in close proximity to area residents. Unfortunately, undeveloped shoreline areas account for a very small portion of the lakeshore of many northern Michigan lakes, including Long and Mickey Lakes. However, through educational programs, shoreline owners can learn to develop appropriate buffer zones with native vegetation, thereby providing substantial protection from surface runoff from their own residences, and from the surrounding watershed.

Eurasian milfoil

The only non-native plant species identified during the study was Eurasian milfoil (*Myriophyllum spicatum*), which was found growing in both Long and Mickey Lakes. Eurasian milfoil is an aggressive, tall-growing aquatic plant from Europe and Asia, which is commonly considered to have negative attributes. It can grow to the surface in 12-15 feet of water, and can form dense colonies that can cover much of the littoral zone of a lake. Eurasian milfoil is different from many native plants because it does not rely exclusively on seeds for reproduction. Eurasian milfoil seeds germinate poorly under natural conditions, but it reproduces very effectively by fragmentation. These fragments, which can be carried by currents or can be inadvertently picked up by boaters and transported in bilges, live wells or bait buckets, and can stay alive for weeks if kept moist. Once a population of Eurasian milfoil has become established in a lake, it reproduces from stolons (stems that grow horizontally on the sediment surface). The stolons, stems and roots persist over winter, and store the carbohydrates that help milfoil take advantage of the available habitat earlier in the spring than many native plants. The rapid and effective dispersal of Eurasian milfoil, and its ability to displace other macrophyte species through competition are major factors contributing to Eurasian milfoil's ability to dominate certain lakes.

Eurasian milfoil is not, however, invasive in every lake where this species is found (Grace, 1978). Eurasian milfoil does not spread rapidly into undisturbed areas where native plants are well established. It does, however, tend to invade disturbed areas where native plants cannot adapt as quickly to an alteration. Alterations to a lake bottom can include dredging,

motor boating in shallow water (or any similar activity that disturbs the sediment), pesticide/herbicide application, siltation and excessive nutrients (Engel 1990). These types of habitat disturbance favor colonization by Eurasian milfoil, because competitor plants are removed and macrophyte growth areas are accessible for milfoil rooting (Smith and Barko 1990). For example, Eurasian milfoil colonies are often found at boat landings because boats not only bring in new shoots, but also can uproot native competitor plants. Shoreline development also can provide areas for Eurasian milfoil colonization as can the improper use of herbicides and indiscriminate macrophyte harvesting, by removing native competitors (Engel 1990). As an example, dredged areas and marinas in Grand Traverse Bay were also observed to support dense growths of pure stands of Eurasian milfoil (GLEC, 1998).

There is no way to know if Eurasian milfoil will become dominant in a given lake; typically, Eurasian milfoil grows best in fertile, fine-textured, inorganic sediments. In less productive lakes (like Long Lake), it is typically restricted to areas of nutrient-rich sediments. Eurasian milfoil does have a history of becoming dominant in eutrophic, nutrient-rich lakes, although this is not always the case. Eurasian milfoil infestations are most often found in disturbed lake beds, lakes receiving large loads of nitrogen and phosphorous-laden run off, and in heavily used lakes. Optimal growth has been observed in alkaline systems with high concentrations of dissolved inorganic carbon and warmer water temperatures (Grace 1978). However, clear lakes with infertile water can support infestations of Eurasian milfoil if sufficient quantities of nutrients are stored in their sediments (Madsen 1998). Although these characteristics do not necessarily predominate on Long Lake, it is important to understand the types of conditions that can encourage excessive growth of Eurasian milfoil.

The members of the Long Lake Association have been aware of Eurasian milfoil growths in Long and Mikey Lakes for several years. Applications of an herbicide (granular 2,4-D), in combination with divers who physically remove Eurasian milfoil are the methods currently used by the Long Lake Association to control this exotic plant species. The lakewide density rating of Eurasian milfoil (portrait #50) based upon summer 2000 observations was sparse, with the density being slightly higher in the late summer survey than in the mid-summer survey (Figure 5). None of the areas where Eurasian milfoil was observed had any canopy formation, and the

plants did not reach the water surface. There were several areas where Eurasian milfoil was observed to be associated with native plants, and there were also isolated areas, many of them small (less than 10 X10 feet), where there were pure stands of Eurasian milfoil.

Eurasian Milfoil Control

The herbicide 2,4-D was applied during the survey; this study therefore is not an accurate representation of the vegetation of Long Lake. The initial survey of Long Lake was performed on June 30, and July 1, 2000, and the herbicide application dates were July 7, August 8, 10 and 24, 2000. All the herbicide treatments were performed between the initial survey (mid-summer) and the late summer survey. Typically, herbicide treatments are conducted in early spring or late fall, and we did not anticipate that herbicides would be applied during this survey.

The herbicide-treated areas and the areas where populations of Eurasian milfoil were observed during this study are represented in Figure 7. The locations indicated for the herbicide applications are approximate, since there were no application markers or buoys observed during this survey. In the absence of accurate location information, the locations of the application areas were determined based upon a generalized map provided by a member of the Long Lake Association. About half of the treated sites (7 out of the 13) correspond to areas where dense Eurasian milfoil populations were observed during the survey, while the remainder of the treated areas were observed to have sparse to moderate populations .

Some before and after herbicide application comparisons can be made based upon the transect data. However, because the actual application boundaries were rough estimates and no chemical measurements were performed the interpretation is subjective (Appendix II). Generally, the transects that were associated with herbicide treatment areas had reduced densities of Eurasian milfoil after treatment. However, at some of the transects there was also a corresponding reduction in native plants after the herbicide treatment. For example, for Transect 3A (south shore of Picnic Island), there was a decrease in the diversity of species observed, as well as a decrease in densities of some of the native plant species between the initial survey in July and the late summer surveys (post herbicide treatment). During the late summer survey at that transect, the native plants which were previously observed during the mid-summer survey at the 1 foot and 4 foot depths were not present. The Eurasian milfoil observed at the 4 foot depth

during the mid-summer survey was also not observed (eliminated), and the Eurasian milfoil at the 8 foot depth was reduced in density.

A reduction in the density of Eurasian milfoil is the goal of the herbicide application. A reduction in the number of native plants could be explained by the herbicide application since four of the native species that were reduced or eliminated are known to be killed by 2,4-D (Westerdahl, 1988). One of the recognized disadvantages of using herbicides is the potential for the material to drift (Engel,1990). Although 2,4-D is considered to be selective for Eurasian milfoil, it also has the potential to affect 6 of the species of native plants that were collected this summer in Long Lake at the use rate recommended by the manufacturer, and as many as 16 native plant species (Table 6) if the exposure concentration exceeds the recommended use rate (Robinette, 1998-1999; Westerdahl et al. 1988; Appendix III). Aquatic plant populations change over the course of the summer with plants that grow early in the spring dying, and other late growing species expanding their populations. The reason why the herbicide treatment is suspected in this instance, is because of the dramatic reduction in plant biomass that occurred between August 30 and September 28, 2000 (from heavy populations to no vegetation in 30 days during the herbicide treatment). The plant species that were not present at the 4 foot depth included plants species that were growing at the 8 foot depth on September 28, 2001. Vallisneria, Illinois pondweed, and Eurasian milfoil typically grow later in the season and were observed at other transects on September 28, 2001 at 4 foot depths. Some of the plants could have been removed by water currents especially in the 1 foot sampling area. However, this seems unlikely at the 4 foot anchoring depth (the boat is anchored in 4 feet of water but the rake could be bringing in plants growing in water deeper than 4 feet off the stern). All the vegetation was removed at the 4 foot transect sampling site and there was a reduction in native plants and Eurasian milfoil at 8 foot, therefore there is a reason to suspect the herbicide treatment.

Transect #9 data show a pattern similar to Transect 3A, with the absence of plants in the 1 foot and 4 foot depths in the late summer survey. At transect #10, moderate populations of milfoil initially observed at the 4 foot and 8 foot depths were not observed during the late summer survey, and there was a decrease in the density of native plants. In July, observations at transect #19 indicated sparse native plant growth in the 1, 4, and 8 foot depths, and Eurasian

milfoil was not observed. After the herbicide treatment no native plants were found growing at this transect site during the late summer survey. Transect 19A, located less than 50 feet to the south of Transect 19, had a very large variety of plant species (one of the most diverse transects), with sparse to moderate populations of Eurasian milfoil present in late summer. The transect on the north shore of Mickey Lake (#20), which was also associated with a treated area, showed no significant decrease in Eurasian milfoil abundance after treatment; Eurasian milfoil was very sparse prior to and after herbicide treatment.

Our survey was not designed to assess the efficacy of the herbicide treatments, but rather to characterize the vegetation in Long and Mickey Lakes. Nevertheless, we believe it is important for the public to clearly recognize that there is potential for impacts to the native vegetation of Long and Mickey Lakes from the use of the 2,4-D herbicide, even at labeled use rates. Diatoms and many sediment dwelling organisms are highly susceptible to 2,4-D at accepted application rates. Shifts in microbial populations can cause algal blooms and upset the ecological balance of a healthy ecosystem. Impacts to native vegetation and, therefore, the ecosystem of Long Lake, are possible when there are repeated applications, when applications are not performed at the proper time of year or when incorrect concentrations are applied (which is typically not monitored by the applicators or by DEQ). It is also important for the public to recognize that the certification process for applicators is not a guarantee an applicator will apply the herbicide correctly. Additionally, a number of environmental factors can affect how well a treatment works, including water depth, wave action, temperature, pH, dissolved oxygen concentration, microbial populations in the sediment and the sediment characteristics (SEIS, 2000).

Transects that were not associated with herbicide treated areas were generally found to have increases in species diversity and densities between the mid-summer and late summer surveys. Transect #'s 1, 2 and 3 all showed increases in growth, or in the number of different species observed. Eurasian milfoil was not noted in the July survey for transect #1, and was sparse in the August survey. For transects #2 and 3, only native plants were observed. Transect #7 was the an untreated site that showed a decrease in plant density between July and September survey dates in the 1 foot depth and a shift in species dominance in the 4 foot and 8 foot sampling depths.

Some of the transects were surveyed only in the late summer (post-treatment). Transect #21B was an area where we were told that herbicides were applied; the transect observations showed very dense populations of Eurasian milfoil at the 4 foot and 8 foot depths. Transect #23 (near the inlet from Fern Lake), and Transect F on the east side of Fox Island data showed moderate Eurasian milfoil populations at the 4 and 8 foot depths.

In summary, the transect data show that of the13 areas treated with herbicide, Eurasian milfoil was eliminated in two of the areas, and was reduced in abundance at four of the other areas. Six of the treated areas were observed to have moderate to dense growths of Eurasian milfoil after treatments. The native plant populations were also affected (reduced or eliminated) in the herbicide treatment areas. Since there was an observed impact on the native plants, it is possible that excessive concentrations of herbicide may have been applied to these areas, or perhaps the pellets or dissolved 2,4-D drifted to some near-shore areas, resulting in concentrations exceeding the recommended treatment dosages. Unfortunately, there is no way to document the actual concentrations of herbicide, since no measurements of residual 2,4-D were made. We suspect, however, that the concentration of the herbicide, especially in some near-shore areas, may have been much higher than the recommended treatment because all the plants observed earlier in the summer were gone (unvegetated). Aquatic plant populations change over the course of the summer with some species disappearing as part of the natural course. It is important to recognize that, according to the label description for 2,4-D, concentrations of this herbicide can accumulate to concentrations that are many times higher in the sediment than those found in the water column. Movement in the water of 2-4-D specifically, Aqua-Kleen® and Navigate® (forms of granular 2,4-D used on lakes for aquatic "weed" control), may injure susceptible plants: "Use of these products to control weeds not listed on the label is not recommended. However, other weeds may be controlled incidentally as a result of application of Aqua-Kleen® or Navigate® for the control of species listed on the label" (SEIS, vol.3 sec.1 pp.8-12).

The half life of 2,4-D in a lake is often listed as 7-days, but results published in the scientific literature indicate a considerable range in 2,4-D decay, because there are a number of environmental conditions that can have a considerable influence on the breakdown of this

chemical in lake sediment. Temperature, pH, microbial flora, sediment type, aerobic state, trophic level of the lake, dilution factors and application rates all affect the persistence of this herbicide in a lake. For example, a study on the half life of 2,4-D in an outdoor artificial pond was found to be 15 days (SEIS 2000).

Discussion - Mickey Lake

Mickey Lake, with a surface area of 61 acres (Meridian Geographics), is connected to Long Lake by a small opening at the northwest corner of Long Lake. Mickey Lake is very shallow (less than 20 feet deep), the bottom sediments are finely textured in the south end of the lake, with rocky, gravelly, sandy substrate in the north end of the lake. In spite of the fact that the entire lake is shallow and well protected, the quantity of macrophyte growth areas was lower than might be expected. Historical accounts indicate that aquatic plants were dense in Mickey Lake, which resulted in efforts to control Eurasian milfoil over three years ago by the Long Lake Association. Currently, the south and central portions of Mickey Lake have extensive areas of unvegetated sediment, with very sparse to moderate populations of Illinois pondweed in the south end of the lake. Small ribbons of native plant growth were observed near the east and west shores of Mickey Lake, as well as populations of water lilies near the south and eastern shoreline areas. The macrophyte growth areas were determined to be moderate to dense in the northern portion of Mickey Lake.

The area on the north shore of Mickey Lake was treated with herbicide during the current macrophyte survey period. The transect data from the July 7, 2000 survey show that the Eurasian milfoil density was low prior to treatment, and the transect data from the late summer (post herbicide treatment) survey also indicate a low density of Eurasian milfoil. Historically, Eurasian milfoil was found in Mickey Lake before any populations were reported to be growing in Long Lake, which has resulted in herbicide applications for multiple years to Mickey Lake. Unfortunately, there is no baseline information available on the original species composition of Mickey Lake. Currently, the Eurasian milfoil population is low, and the native vegetation is not excessive in Mickey Lake.

Mickey Lake is a small, shallow lake with significant lakeshore development, and it is

reasonable to expect that the phosphorus sediment concentrations would be greater than those measured in Long Lake. The near-shore sediment samples collected (in less than 4 feet of water) during this survey had phosphorus concentrations ranging from 13.6 to 95.8 mg/kg dry weight for the six samples analyzed; two samples were collected on Mickey Lake and four samples were collected on Long Lake (Table 2). The samples collected from Mickey Lake had the highest phosphorus concentrations (95.8 and 46.5 mg/kg dry weight). The sample with the lower phosphorus concentration was collected in an area where no plants were observed on the east shore of Mickey Lake, while the sediment sample with the highest concentration of sediment phosphorus was collected near a dense plant growth area. The highest sediment phosphorus concentration for the near-shore sediment samples collected on Long Lake was 36.5 mg/kg dry weight, which was collected near an area of dense plant growth. The sediment phosphorus values may reflect a correlation between high sediment phosphorus concentrations and the dense growth of macrophytes. However, based upon the data collected during this survey, it is unclear whether there is such a correlation, because a limited number of samples were collected, and because some of the areas were treated with herbicides, and the observed vegetation therefore probably does not reflect the sediment nutrient content.

Conclusions

The vegetation observed during this survey in Long Lake is indicative of a well balanced aquatic plant community, with a low overall abundance of plant growth, which is typical of oligotrophic lakes like Long Lake. The abundance of macrophyte growth areas in Mickey Lake was lower than might be expected, considering that the entire lake is shallow, and well protected. An exotic plant species, Eurasian milfoil was observed at a range of densities around Long Lake, and in the north end of Mickey Lake. Under current conditions, Eurasian milfoil did not pose a significant threat to the native plant community, or to recreational activities on either of these lakes in the summer of 2000. It is important to recognize, however, that there were herbicide applications to control aquatic plants throughout the summer months during the period of this survey. Therefore, the macrophyte study results presented in this report are not an accurate representation of the plant communities on Long and Mickey Lakes.

Nutrient and sediment loading from the watershed are most likely stimulating plant growth in some areas. There was a wide range of sediment phosphorus concentrations found in the near-shore samples collected during the survey, and it appears that sediments with higher phosphorus concentrations could be correlated with dense macrophyte growth areas. The presence of macrophyte growth areas also corresponded with physical features of the lake that resulted in sheltered environments

Eurasian milfoil control efforts are reducing the abundance of this species, as well as the abundance of native species (native milfoils). Mickey Lake historically had dense populations of Eurasian milfoil, which have been greatly reduced by earlier herbicide applications.

Recommendations

The plant community data provided from this macrophyte study can be used in conjunction with the information provided in the Watershed Management Plan to enable the Long Lake Association to formulate a long term management strategy for Long and Mickey Lakes, and to assess and evaluate changing lake conditions. Based on that objective, future monitoring of water quality and aquatic plant communities is essential. Watershed management controls are recommended to provide long-term control of nutrient and sediment loading.

We also recommend that the management strategy be in place before any additional macrophyte control efforts are re-initiated. The Michigan Department of Environmental Quality (MDEQ) has noted that chemical control is a temporary means of controlling aquatic plants and algae. When herbicides are part of an aquatic plant management program, special care must be taken to protect both the environment and individuals involved, since herbicides are toxic when used inappropriately. Because herbicides can affect all forms of plant life, beneficial aquatic plants may be killed along with the nuisance plants. However, it is difficult to control the drift of herbicides under certain conditions, resulting in the elimination of native plants outside of the target area. Additionally, herbicides provide only temporary control. In lakes where herbicides are used repeatedly on a large scale, native plant populations may change dramatically, thus seriously altering the ecology of a lake (MDEQ, 1999).

If a problem is perceived with Eurasian milfoil, a selective maintenance control plan is

recommended to carefully control nuisance plants without significant negative impacts on the rest of the plant community. Future goals should not include the eradication, but rather control of Eurasian milfoil in Long and Mickey Lakes. Since Eurasian water milfoil spreads by fragmentation, (and it was found in many areas around the lake and at depths of 20 feet or greater) there is a constant source of new fragments. Also, the two public boat launches and other points of boat entry provide potential new sources for Eurasian milfoil introduction. Since virtually every lake in 33 states has populations of Eurasian water milfoil, the potential will always exist for new introduction, even if somehow these plants were temporarily eradicated from Long and Mickey Lakes. Control efforts should target only those areas were there are recreational conflicts, or where control has been determined to be absolutely necessary for other well-defined reasons. The Long Lake Watershed Handbook (Reisig & Stone,1999) recommends that weed treatment is "a process that should be used only as a last resort and only after a community consensus." If, for example, Eurasian milfoil is identified growing in a mix of native plants, the milfoil should be monitored for at least one growing season to see if it could potentially become dominant.

If herbicide treatments are to be continued, it is imperative that the Long Lake Association monitor treated areas before and after treatment, and efforts be undertaken to ensure that applications are made at the time when the Eurasian milfoil plants are most susceptible, and there is the least chance of contact with recreational users. Establishing criteria for what constitutes the need for treatment is also essential. The State of Michigan is currently working on new administrative rules that pertain to the Aquatic Nuisance Control Act, that will establish such criteria. Pam Tining, a consultant with Lake Management in Grand Rapids, Michigan stated one of the criteria they use to determine whether to treat aquatic plants is if there is sufficiently dense plant material that boat traffic is inhibited (personal communication February 6, 2001). Howard Wandell, Department of Fisheries and Wildlife at Michigan State University stated (personal communication 03-09-01) that his approach is a control approach with long term goals. Mr. Wandell believes 2,4-D is the herbicide that is the most selective and least ecologically damaging of the alternatives but that herbicide treatments must be part of a monitoring program with an intergrated management approach. Herbicide treatments cannot be

the sole treatment. Each of the areas need to be evaluated individually and the lake association members have to decide their approach and goals. Mr. Wandell feels for Long Lake that limiting nutrient inputs through a good watershed management plan is the most significant step to protect Long Lake. He also warned that commercial herbicide applicators are not sensitive to lakes (they don't live there) and if possible it is better for the lake associations to make certain they have control if they use commercial herbicide applicators. Mr. Wandell also stated that the lake association needs to be sure that if chemical treatments are conducted, they must be done only where it is deemed absolutely necessary, treating the minimum area. He acknowledged one of the problems he has seen with the granular formulations of 2,4-D is that it can drift over wide areas and it has the potential to migrate into the groundwater. These are serious problems and it is really up to the lake associations to decide what they want to do. Mr. Wandell said studies from NewYork State that have compared treated and untreated Eurasian milfoil populations in lakes over a period of years are finding that there is not a difference in the milfoil populations between the untreated and treated lakes, (which is similar to the results from a similar study in Wisconsin). There is no cure, and there is no right answer to the Eurasian milfoil problem.

GLEC recommends that the Long Lake Association consider reducing or eliminating the use of 2,4-D or other aquatic herbicides for milfoil control and consider other alternatives for the following reasons:

- Chemical controls are a short term approach which do not address the cause for milfoil invasions. According to the Michigan State University Citizen's Guide "Excessive use of direct manipulation or short-term controls will not reduce lake fertility but will alter biological systems, usually with serious negative ecological and recreational impacts" (MSU 2000)
- Applications have already been made for multiple consecutive years on Long and Mickey Lakes
- Long term shifts in native plant distribution and density due to herbicide application may result in an increase in Eurasian milfoil densities due to a reduction in interspecies competition. This condition is advantageous to Eurasian milfoil, because milfoil begins to grow earlier in the spring than native species. Control of other aquatic plants reduces

competition and appears to allow Eurasian milfoil to maintain a greater coverage for a longer period. (MSU,2000).

- The potential for impacts to native vegetation exists because 2,4-D controls at least 6 different species of plants identified to be growing in Long and Mickey Lakes at the recommended use rate for the control of Eurasian milfoil (SEIS 1999). Some states (Vermont and Wisconsin, for example) do not use herbicides for Eurasian milfoil control. The State of Wisconsin Department of Natural Resources does not recommend chemical control for Eurasian water milfoil "because it is typically disruptive to aquatic ecosystems and not selective in the vegetation it affects, thus threatening native plants." (http://www.dnr.state.wi.us/org/land/er/invasive/milfoil.htm).
- Improper use of this herbicide can have significant ecological impacts, and proper dosing is dependent on a complex array of environmental conditions and judgements on the part of applicators
- Over application (too much chemical/ too large of an area treated) cannot be adequately monitored.
- 2,4-D accumulates and persists in sediment at much higher concentrations than those in the water column (SEIS 2000)
- Sediment organisms and soil microbes are adversely affected by 2,4-D, even at allowed dosing rates. Changes in micro-flora/fauna and dissolved oxygen concentrations have been observed at the sediment surface. (SEIS 2000). This can affect the entire ecological base of a lake community, since these organisms form part of the food chain in the lake.
- Concerns about mobility of 2,4-D and transport to groundwater exist because 2,4-D does not bind strongly to most soils or sediments, particularly in lakes with high pH and low organic content (like Long Lake), which are least likely to adsorb 2,4-D (SEIS 2000, Levato et al. 1999)
- The half life of 2,4-D in sediments is reported as 7 days, but it is actually quite variable (minutes to months) depending on the pH, sediment type, organic content, microbes present, trophic level, dissolved oxygen, amount of carbonate in the system, application rates, rate of dilution and temperature (SEIS 2000).

- Potential effects on fish and zooplankton are not easily quantified.
- Research suggests that once milfoil has arrived in a lake, the only lasting way to "control" it may be to allow time to take its course (Helsel, 1999).
- Biological control is currently recognized as a safe and long term option with a promising future for undesirable macrophyte management.

The previously discussed long-term management strategy for Long and Mickey Lakes should address the following objectives:

- Reduce nutrient load to the lake
- Implement procedures that could encourage sensitive areas (buffer zones and areas with native vegetation) to be left undisturbed.
- Continue management strategies for Eurasian water milfoil that would reduce or eliminate the use of chemicals
- Provide for a monitoring strategy
- Continue to provide information and educational programs for the public.

Each of these objectives is discussed below:

Reduce nutrient load to the lake

The reduction of the nutrient load is a reasonable goal for every watershed management plan, but it is one of the most difficult to achieve because there are many potential sources of nutrients to a lake. Providing information to lakeshore residents on maintenance of septic systems, as well as ordinances that encourage thoughtful development of the lakeshore to reduce runoff could help prevent or reduce some nutrient inputs.

Implement procedures that encourage no disturbances in sensitive areas

Many lake associations and townships are implementing ordinances recommending native vegetation buffer zones, specifying a certain percentage of lakeshore that must/should be maintained in it's natural state. Volunteer efforts could be effective in accomplishing this objective. Public education about buffer zones is essential if any implementation program is to work.

Develop a Management Strategy for Eurasian Milfoil that Reduces or Eliminates the Need for

Herbicide Applications.

Potential impacts to existing native aquatic plant species should be evaluated carefully before implementing any future management techniques. Some methods are more appropriate for well-established populations, while others are better suited for those that are recent introductions. Since there is no way to completely eradicate Eurasian milfoil from a lake once it has been introduced, control efforts must instead focus on: controlling newly introduced infestations, preventing further spread of the plant, or reducing the nuisance level of the problem using an integrated approach.

Diver operated suction harvesting or pulling milfoil plants by hand (when done properly) is highly effective for controlling small, newly introduced milfoil populations. Hand pulling is the preferred control method for colonies of under 0.75 acres, or fewer than 100 plants. The process is both thorough and selective, but it is also time consuming. Using this approach, special care must be taken to collect all roots and plant fragments during removal. With any technique than involves removing plants or disturbing the sediment there is always the potential to encourage the growth of Eurasian milfoil. Bottom barriers (screens) are most appropriate to control growth in localized areas such as in swimming areas and around docks, or to create boat access to deeper water. The screens need to be cleaned yearly and anchored properly at the appropriate time. Biological controls, such as insects, bacteria or fungi, are being evaluated experimentally. A native insect, the aquatic weevil *Euhrychiopsis lecontei,* could be used for milfoil control. Paradise Lake in Emmet and Cheboygan Counties, is a 1900 acre lake that was stocked in 1998 with the milfoil weevil. This was among the first lakes approved for a commercial release of the milfoil weevil. According to Marilyn Smith, a lake association member of Paradise Lake, after three years of treating 350 acres of dense Eurasian milfoil growth (which accounts for 17 percent of their 1900 acre lake), they are very pleased with the results. Ms. Smith said there was a dramatic visual reduction after the first eight weeks, and all the canopy formation was removed by the weevils. This summer, the populations of weevils in Paradise Lake have increased and they expect to have good control next summer (personal communication with Marilyn Smith, February 7, 2001). The native weevil control method may prove to be the Eurasian milfoil control of the future in this area. The focus in the future should

be on monitoring both Long and Mickey Lakes, formulating a strategy for determining when control actions should be re-initiated, and determining what constitutes the need for action. In some instances, a no action option should be considered.

Provide a monitoring strategy

Monitoring is an essential part of a good management strategy. Treatments need to be monitored for their effectiveness, and Eurasian milfoil populations need to be monitored as does the density and health of the native plant populations. Monitoring should be conducted during the next season in early spring in the areas where heavy or dense populations were observed during this study. Typically, a macrophyte survey is carried out once every three to five years. However, since a treatment program has been initiated and Eurasian milfoil has been identified on both Long and Mickey Lakes, monitoring should be carried out every year to monitor the success of the treatment program and survey populations of Eurasian milfoil.

Provide information and educational programs for the public

Public input and the willingness to help is essential in any watershed program where nutrient inputs need to be reduced. Although apathy is a problem, most riparians have an interest in the lake, and the majority of people want a healthy aquatic community with clean water and healthy fish populations. For example, the signage at public DNR boat launches regarding invasive species and how to prevent them from entering our lakes has been credited with slowing the introduction of zebra mussels and Eurasian milfoil to inland lakes. These signs are effective because they help people understand the consequences of their actions, and can be enhanced through additional educational efforts by the State and by the Long Lake Association.

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TABLE 1. G.P.S. COORDINATES AND LOCATION DESCRIPTIONS FOR TRANSECTS LOCATED ON LONG AND MICKEY LAKES, SUMMER, 2000

G.P.S. Coordinates	Transect ID	Location Description
44 44.390 85 46.564	Transect 1	Gilbert Park Public Boat Launch
44 44.802 85 46.129	Transect 1D	Northeast corner of Long Lake near Skiver Rd in front of a large red pine, the shoreline is undeveloped
44 44.789 85 45.835	Transect 2	Public Swimming Beach off Long Lake Rd
44 44.491 85 45.151	Transect 2A	Located between transects 2 and 3 near Gilbert Trail
44 44.434 85 45.156	Transect 3	Near the Timbers Girl Scout Camp, in front of a boathouse near the point
44 44.335 85 45.047	Transect 3C	In the middle of the next bay past transect 3 (in front of Brown Boathouse
44 44.120 85 44.805	Transect 3B	South end of the bay to the south of transect 3C near brown and blue boathouse
44 43.970 85 44.903	Transect 3A	Southeast tip of Picnic Island
44 43.992 85 44.886	Transect 24	Northeast tip of Picnic Island
44 44.053 85 44.340	Transect 23	Inlet near Fern Lake
NA	Transect 4	Just to the south of transect 23, just to the north of a line drawn from the north tip of Long Island
NA	Transect 5	Just to the south of Transect 4, around a little curve just to the south of a line drawn from the north tip of Long Island

TABLE 1. G.P.S. COORDINATES AND LOCATION DESCRIPTIONS FOR TRANSECTS LOCATED ON LONG AND MICKEY LAKES, SUMMER, 2000

44 42.949 85 43.783	Transect 6	Located on the south end of a large bay across from Fox Island (east shore of Long Lake)
44 42.814 85 43.916	Transect 7	Located on the south tip of little peninsula that sticks out at the entrance to the bay on the north side of the big peninsula
NA	Transect 8	Northwest tip of the peninsula
44 42.314 85 43.886	Transect 9	Just past the middle of the bay on the south side of the peninsula
44 41.528 85 44.635	Transect 10	Just inside little point of land in south bay on the east side
NA	Transect 11	Outlet pond at the south end of the lake
44 41.778 85 45.543	Transect 12	Near the connection to Ruth Lake
44 41.924 85 45.279	Transect 13	Point of land to the north of transect 12
44 42.795 85 45.454	Transect 14	Point of land across from South Isand, off the north side of the point
44 42.929 85 44.788	Transect 15	Northeast side of South Island
44 43.274 85 44.928	Transect 16	Northwest tip of Fox Island
44 43.166 85 44.698	Transect F	Northeast tip of Fox Island in the bay
44 43.433 85 45.088	Transect 17	Southwest tip of Long Island
44 43.455 85 45.836	Transect 18	Crescent Public Boat Launch

TABLE 1. G.P.S. COORDINATES AND LOCATION DESCRIPTIONS FOR TRANSECTS LOCATED ON LONG AND MICKEY LAKES, SUMMER, 2000

NA	Transect 19 Transect 19A	Located in the bay that has the connection to Mickey Lake in the middle of the bay arrow pointing to the Northeast (through the center of the bay)
44 43.988 85 45.913	Transect 20	Northeast side of Mickey Lake not to far from the entrance
44 43.641 85 45.778	Transect 21	South shore of Mickey Lake
44 43.916 85 45.391	Transect 21A	Point of land before transect 21 B - across from Picnic Island
44 43.970 85 45.527	Transect 21B	Point of land before bay with the connection to Mickey Lake just to the south of the point
44 43.988 85 45.781	Transect E	East side near the entrance to Mickey Lake
NA	Transect 22	Just around the point from Transect E
44 44.307 85 46.391	Transect A	South of Gilbert Park Boat Launch
44 44.239 85 46.206	Transect B	On the mainland just to the north of Brush Island
44 44.204 85 46.134	Transect C	Just a bit north of Transect B and still just a bit north of Brush Island
44 44.199 85 46.005	Transect D	On northwest side of Brush Island

Table 2. Sediment and Plant Tissue Total Phosphorus Measurements in Long and Mickey Lakes Collected Near the Shore (less than 3 feet deep), Summer 2,000

Map Location # (Sample ID #)	Site Description	Date Collected	Total Sediment Phosphorus mg/kg dry wt.	Total Plant Tissue Phosphorus % dry wt.
1 (LL 640)	North End of Mickey Lake near thick plant growth (Transect 20)	9/28/00	95.80	
2 (LL 641)	East shore of Mickey Lake no plants observed	9/28/00	46.50	
3 (LL 639)	North tip of the peninsula near sparse plant growth	9/28/00	30.51	
4 (LL 614)	Northeast tip of Fox Island near dense plant growth	9/13/00	20.5	0.12
5 (LL 599)	North shore of Long Lake near Transect 1D near sparse native plant growth	8/30/00	13.6	0.11 0.13
6 (LL 598)	Northeast tip of Picnic Island near dense plant growth	8/30/00	36.5	0.16

Table 3. G.P.S. Readings and Descriptions for Macrophyte Growth Areas on Long Lake, Summer 2000

Site # Acreage	**G.P.S. Reading Latitude/Longitude Min. Sec**	**Site Description**	**Field observations**
M 1 3.83 acres	44 44.390 85 46.564 START 44 44.307 85 46.391 END	Gilbert Boat Launch-Transect 1START Transect A END	Plants begin just to the south of Gilbert launch in 6-10 feet of water, thick native plants, good diversity, EM* is sparse
M 2 0.44 acres	44 44.204 85 46.134 START 44 44.146 85 46.073 END	Transect C START 500 feet further south END	Plants begin at 10 of feet water and approximately 50 feet from the shore, moderate growth of native plants
M 3 1.79 acres	44 42.056 85 45.249 START 44 41.928 85 45.266 END	Point of land just north of Ruth Lake START to Transect 13 END	Natives only during July survey, spots of thick EM noted in September
M 4 0.55 acres	44 42.796 85 45.451 START 44 42.832 85 45.451 END	Point of land (across from South Island) on western shore (near Transect 14)	Plants at steep drop off over 5 feet deep sparse growth, sparse EM
M 5 2.42 acres	44 42.318 85 44.135START 44 42.387 85 43.911END	South of peninsula near entrance to bay	Plants at 5+feet depth, moderate growth

Table 3. G.P.S. Readings and Descriptions for Macrophyte Growth Areas on Long Lake, Summer 2000

M 6 1.83 acres	44 42.314 85 43.886START 44 42.225 85 43.815END	Further south in south peninsula bay (Transect 9)	Plants in 5+ feet, large areas of dense EM past transect 9, moderate native plant growth
M 7 2.84 acres	44 41.528 85 44.635START 44 41.540 85 44.564END	Near Transect 10 (point of land near Eastwood Drive)	Plants start near shoreline, dense native plant growth
M 8 12.13 acres	44 43.085 85 43.555START 44 42.993 85 43.611END	Bay on the east side of Long Lake across from Fox Island, starts just past wood slabs	Plants start 4 feet deep close to shore, large area of dense native plant growth
M 9 3.32 acres	44 43.301 85 43.687START 44 43.237 85 43.637END	Starts before wood slabs, north of M 8	Plants at 4 ft deep, moderate to dense native plant growth
M 10 2.19 acres	44 44.491 85 45.151START 44 44.434 85 45.156END	Transect 2A START Transect 3, northeast side of lake past Gilbert Trail Road END	Plants in over 5 feet of water, dense native plants with areas of dense EM
M 11 2.90 acres	44 44.802 85 46.129START 44 44.811 85 46.070END	North east corner of the lake, just to the west of Church Rd	Plants start near the shoreline, dense native plant growth with sparse EM

Table 3. G.P.S. Readings and Descriptions for Macrophyte Growth Areas on Long Lake, Summer 2000

		ISLANDS:	
M 12 0.29 acres	44 43.970 85 44.903START 44 43.992 85 44.886END	East end of Picnic Island	Plants begin near the shore, dense natives with dense patches of EM
M 13 0.99 acres	44 42.929 85 44.788START 44 42.878 85 44.726 END	East side of South Island	Plants near shore, plant growth moderate with moderate EM
M 14 0.47 acres	44 42.869 85 45.158START 44 42.909 85 45.036END	West side of South Island	Plants near shore, moderate native plant growth

Macrophyte Growth Areas Approximately 0.5 Acres

Map ID#	**G.P.S. Coordinates**	**Site Description**	**Field Observations**
M 15	44 44.516 85 46.492	Just to the north of the Gilbert Park Boat Launch	Patches of EM present with native vegetation
M 16	44 44.750 85 46.222	Just to the north of M 15, near breakwall , Transect 1C	August 30 survey native plants at 1ft, September 28 no plants.
M 20	44 43.941 85 45.039	West side of Picnic Island	Native plants

Table 3. G.P.S. Readings and Descriptions for Macrophyte Growth Areas on Long Lake, Summer 2000

M 23	44 44.199 85 46.005	Transect D, west side of Brush Island	Native plants thick, sparse EM
M 24	44 43.274 85 44.928	West tip of Fox Island (Transect 16)	Plants in 6 feet deep, native plants
M 25	NA	East tip of Fox Island (Transect F)	Herbicide treatment area, sediment and plant tissue samples collected here, Moderate populations of native plants as well as moderate populations of EM-observations after treatment 9-13-00
M 26	44 44.053 85 44.340	Bay near timbers (Inlet)	Plants in 4 feet of water, moderate growth of native plants with moderate populations of EM
M 27	44 42.814 85 43.916	Macrophyte growth area near transect 7	July survey showed dense growth of native plants, September 6 no plants in the shallows and decreased growth at 8 feet-looks as if it was treated with herbicide
M 28	NA	Small embayment off the west side of the peninsula	Sparse to moderate growth of native plants

Table 3. G.P.S. Readings and Descriptions for Macrophyte Growth Areas on Long Lake, Summer 2000

M 29	44 42.494 85 44.707	Drop off near the southwest side of the peninsula near boat dock	Plants in 10+ feet of water, moderate growth of natives
M 31	44 43.295 85 45.847	South of the Crescent Street Public Boat Launch	Large area of dense EM growth
M 32	44 43.455 85 45.836	Crescent Street Public Boat Launch, Transect 18	Moderate growth of native species, EM found
M 33	44 43.916 85 45.391	Transect 21A, point of land across from Picnic Island	Moderate to dense growth of native plants with dense growth of EM in deeper water
M 34	44 43.970 85 45.527	Transect 21B, point of land before bay at Mickey Lake entrance	Herbicide treatment area, moderate to dense native plant growth, dense EM growth noted on August 30 post treatment
M 36	44 43.988 85 45.781	Near Transect E, east side entrance to Mickey Lake in the bay	Dense growth of Elodea, and sparse growth of mixed natives
M 37	NA	Between transects 2 and 2A	Small area of native plants
M 38	NA	Northeast tip of Long Island	The east side of the tip (near water ski markers) had dense to moderate areas of plant growth-no EM observed
M 39	NA	Northwest tip of Long Island	Moderate growth of native plants

Table 3. G.P.S. Readings and Descriptions for Macrophyte Growth Areas on Long Lake, Summer 2000

M 40	44 43.433 85 45.088	Southwest tip of Long Island (Transect 17)	Plants begin in 4+feet of water, July survey showed moderate growth of native plants, dense growth of EM, Observations in August-post herbicide treatment showed moderate growth of natives with sparse to moderate growth of EM
M 41	NA	Point of land between transects 13 and 14	Moderate growth of native plants
M 42	NA	Transects 19 and 19A, in the bay just to the south of the opening to Mickey Lake	Transect 19 was located near undeveloped shoreline, in July there was sparse growth of native plants noted at all depths, Transect 19A was established August 30 closer to a residence since there were no plants found at Transect 19 on August 30. Perhaps this area was affected by herbicide treatments. Transect 19A had a large diversity of native plants with moderate densities of EM mixed in with them.

Table 3. G.P.S. Readings and Descriptions for Macrophyte Growth Areas on Long Lake, Summer 2000

M 43	44 43.988 85 45.913	Mickey Lake, north shore near Transect 20	7 different species of native plants were found with density ratings of " found" to "dense" during the July survey with populations of EM very sparse prior to herbicide treatments, the August 30 survey found 6 different species of native plants ranging from found to moderate densities and EM was still present (sparse)

*EM = Eurasian watermilfoil

TABLE 4. PLANT SPECIES LIST FOR LONG AND MICKEY LAKES MACROPHYTE SURVEY, SUMMER 2000

Scientific Name	Common Name	Long Lake	Mickey Lake
Brasenia schreberi	Watershield	x	
Elodea canadensis	Common water weed	x	x
Elodea nutallii	Slender najad	x	
Myriophyllum exalbescens	Water milfoil	x	x
Myriophyllum spicatum	Eurasian water milfoil	x	x
Myriophyllum tenellum	Water milfoil	x	x
Naja flexilis	Bushy pondweed	x	x
Nuphar variegata	Yellow pond lily	x	x
Nuphar odorata	Fragrant water lily	x	x
Potamogeton amplifolius	Large leaved pondweed	x	
Potamogeton filiformis	Narrow leaved pondweed	x	x
Potamogeton graminieus	Pondweed	x	x
Potamogeton illinoensis	Illinois pondweed	x	x
Potamogeton natans	Floating leaved pondweed	x	
Potamogeton richardsonii	Clasping leaved pondweed	x	x
Potamogeton robbinsii	Fern leaved pondweed	x	x
Potamogeton zosterformis	Flat stemmed pondweed	x	
Scirpus americanus	Three-square bulrush	x	x
Vallisneria americana	Wild celery	x	x
	ALGAE		
Chara sp.	Stonewort	x	x
Cladophora sp.	Cladophora	x	
Zygnema sp.	Zygnema	x	
Spirogyra sp.	Spirogyra	x	
Mougeotia sp.	Mougeotia	x	
Nostoc sp.	Nostoc	x	

TABLE 5. Estimated Acreage of Macrophyte Growth Areas in Long and Mickey Lakes, Summer 2000

	Dense/Heavy Macrophyte Growth (Acres)	**Moderate** Macrophyte Growth (50% or less of the bottom sediment visible - Acres)	**Sparse** Macrophyte Growth Areas (more than 50% of the bottom sediment visible - Acres)
Size Range	< 0.5 to 12	< 0.5 - 3.3	0.55
Total Acreage	36.9	9.5	0.55

TABLE 6

COMMON AQUATIC DICOTS FOUND IN GRAND TRAVERSE COUNTY, MICHIGAN

Common Name	Latin Name
Watershield * ▣	*Brasenia schreberi*
White flowered crowfoot ▣	*Ranunculus longirostris*
Mare's-tail	*Hippuris vulgaris*
Mermaid-weed	*Proserpinaca palustris*
Coontail ▣	*Ceratophyllum demursum*
White water lily* ▣	*Nymphaea odorata*
Yellow pond lily* ▣	*Nuphar variegata*
Spiked watermilfoil* ▣	*Myriophyllum exalbescens*
Various leaved watermilfoil* ▣	*Myriophyllum heterophyllum*
Native watermilfoil* ▣	*Myriophyllum tenellum*
Water smartweed	*Polygonum amphibium*

COMMON AQUATIC MONOCOTS FOUND IN GRAND TRAVERSE COUNTY, MICHIGAN

Waterweed * ▣	*Elodea canadensis*
Pondweed * ▣	*Potamogeton spp. (8 species in Long Lake)*
Water Celery * ▣	*Vallisneria americana*
Hornworts ▣	*Utricularia spp.*

* Collected from Long and Mickey Lakes, Summer 2000

▣ Species controlled by 2,4-D, specifically Aqua-Kleen® or Navigate®

FIGURES 1-7

Figure 1. Preliminary Macrophtye Survey of Long and Mickey Lakes, June 2000

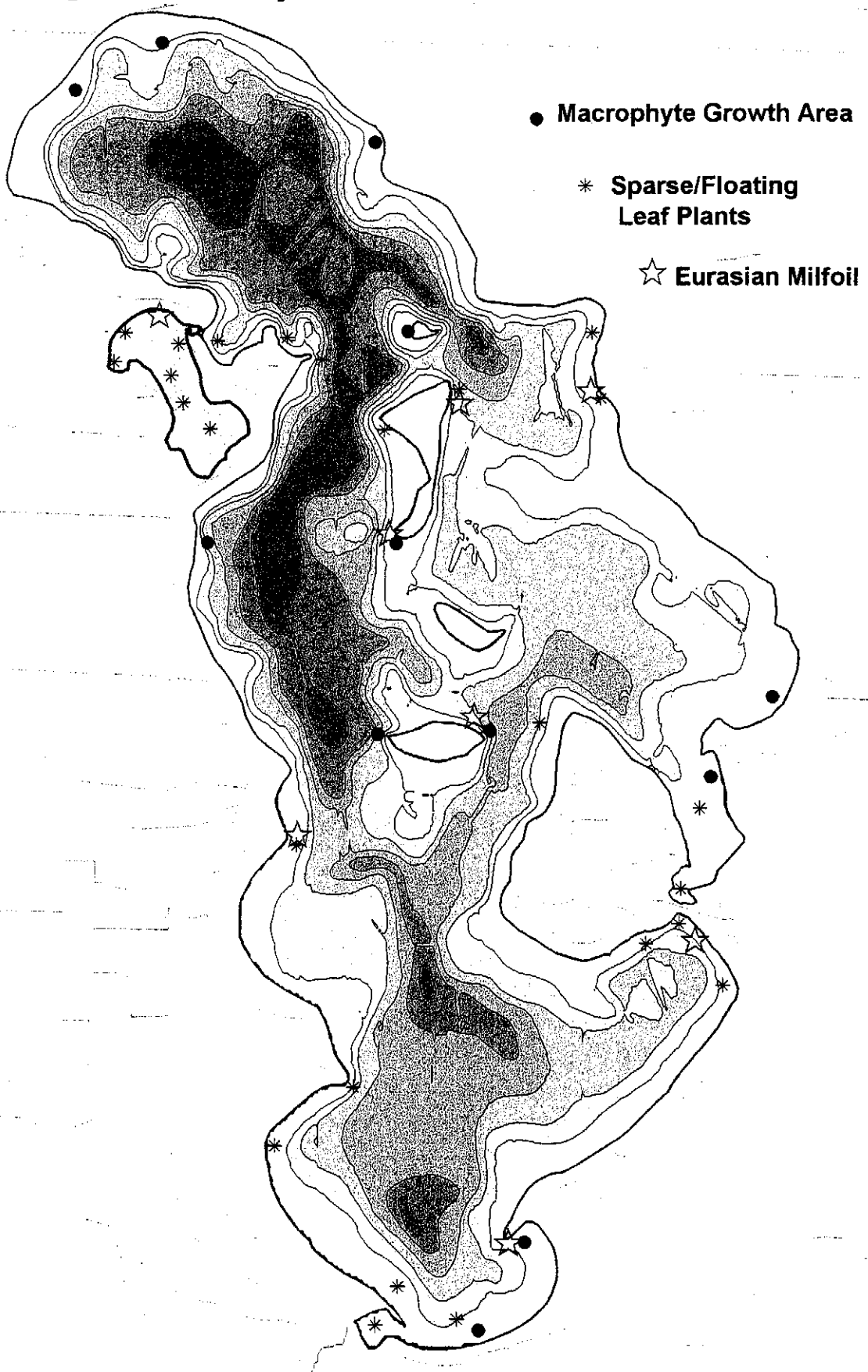


Figure 2. Transect Locations for the Macrophyte Survey Conducted on Long and Mickey Lakes, Summer 2000

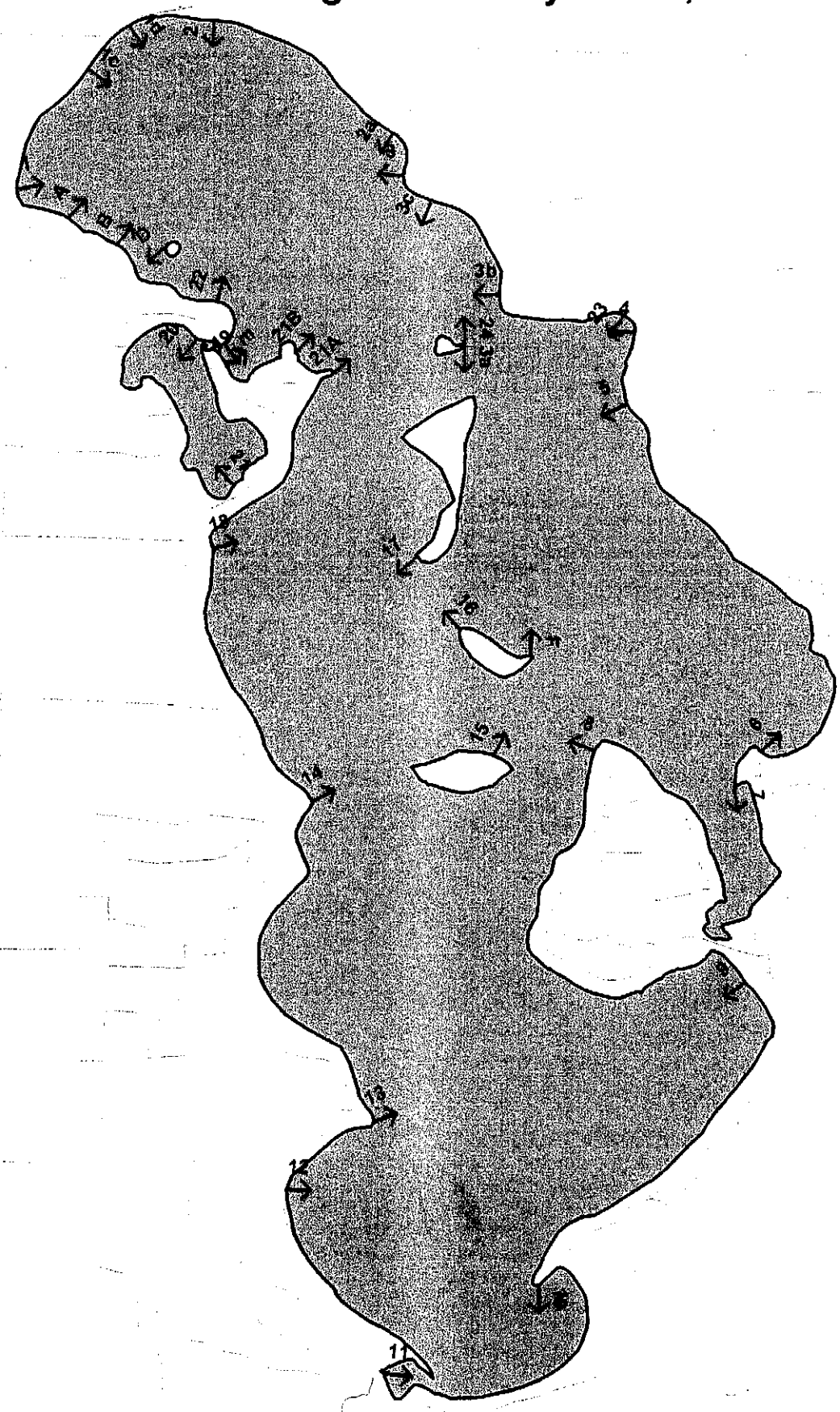


Figure 3. Macrophyte Growth Areas on Long and Mickey Lakes, Summer 2000

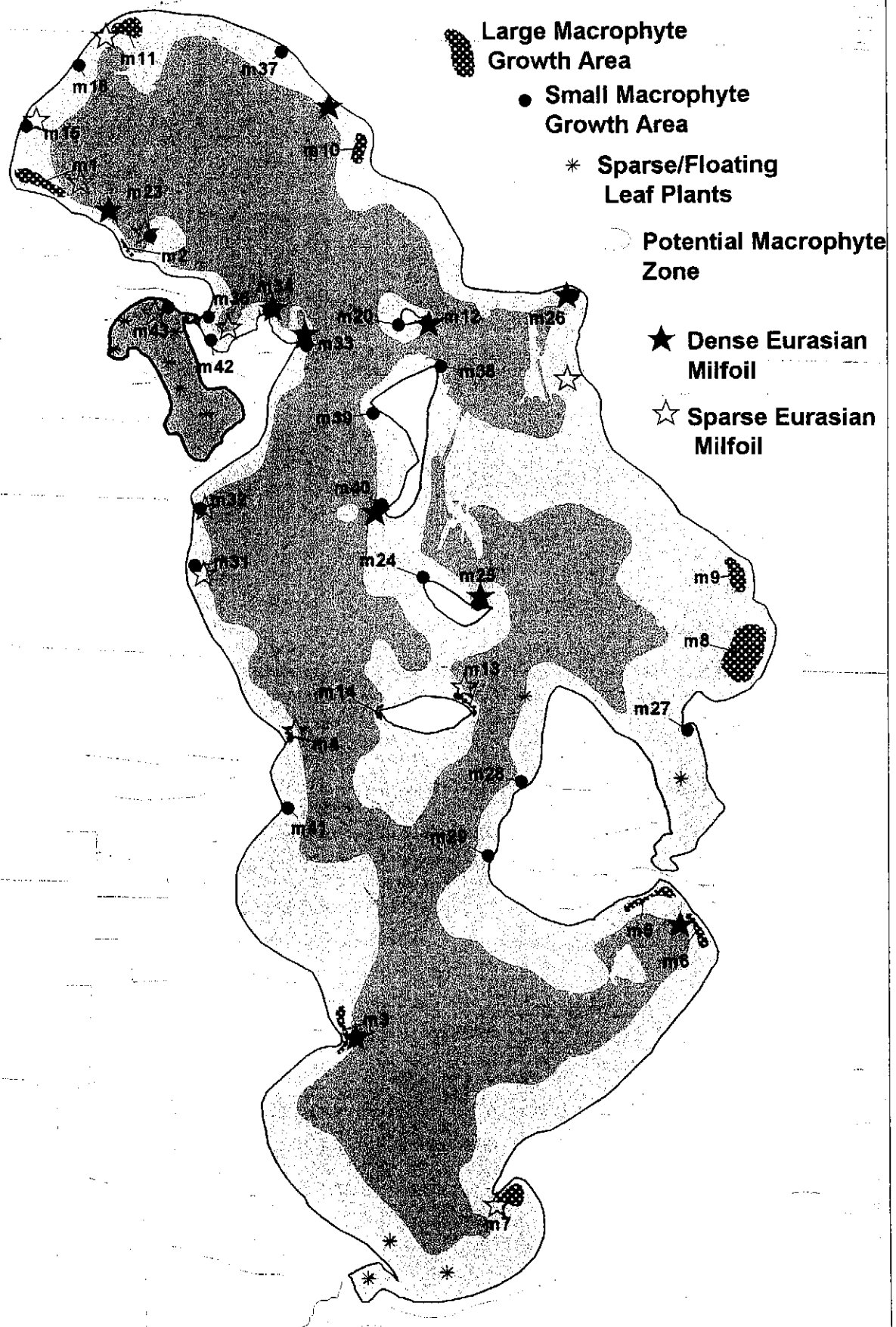


Figure 4. Sediment and Plant Tissue Collection Sites on Long and Mickey Lakes, Summer 2000

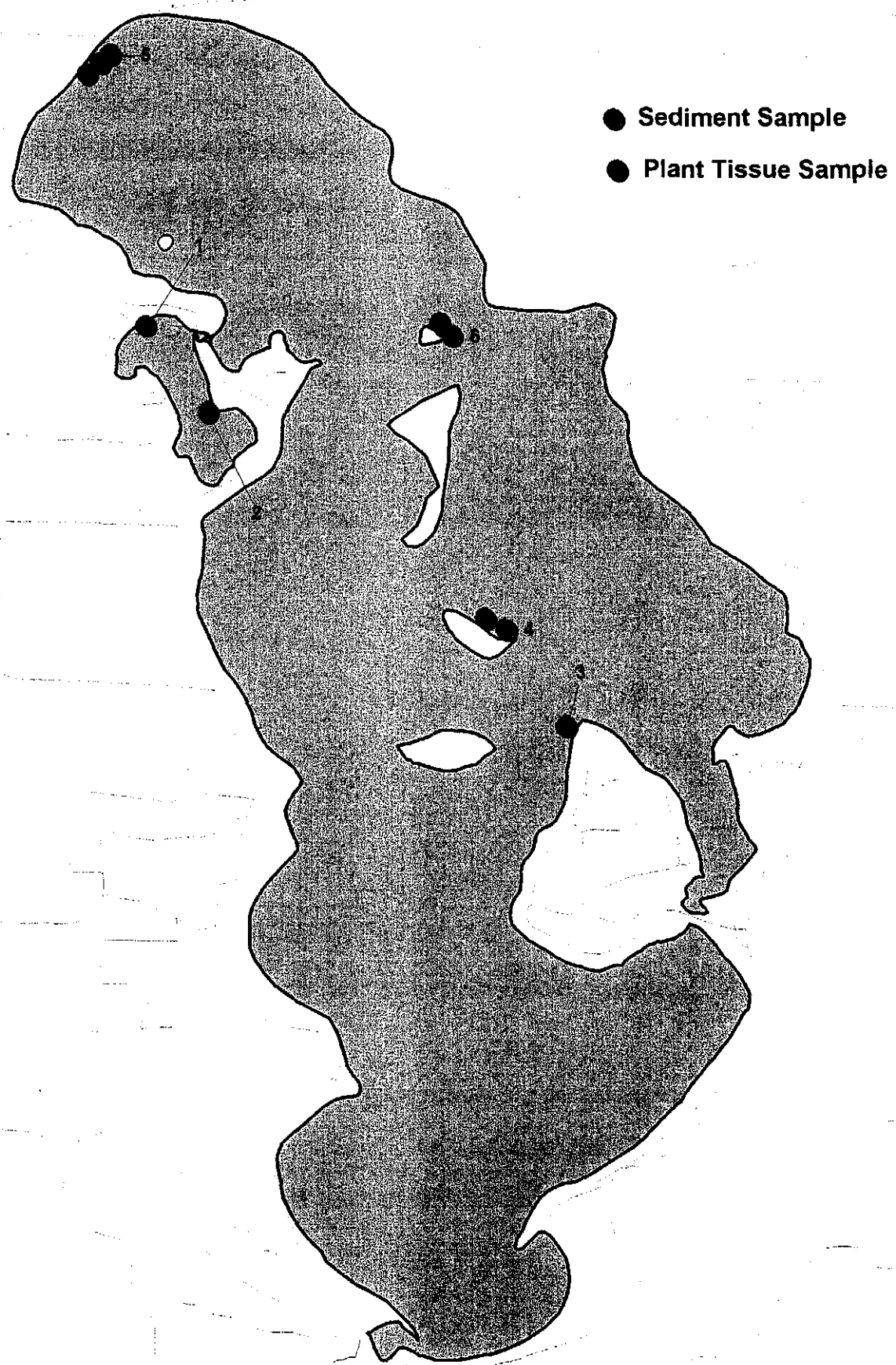


Figure 5. Average Lakewide Densities

in July and August Transects

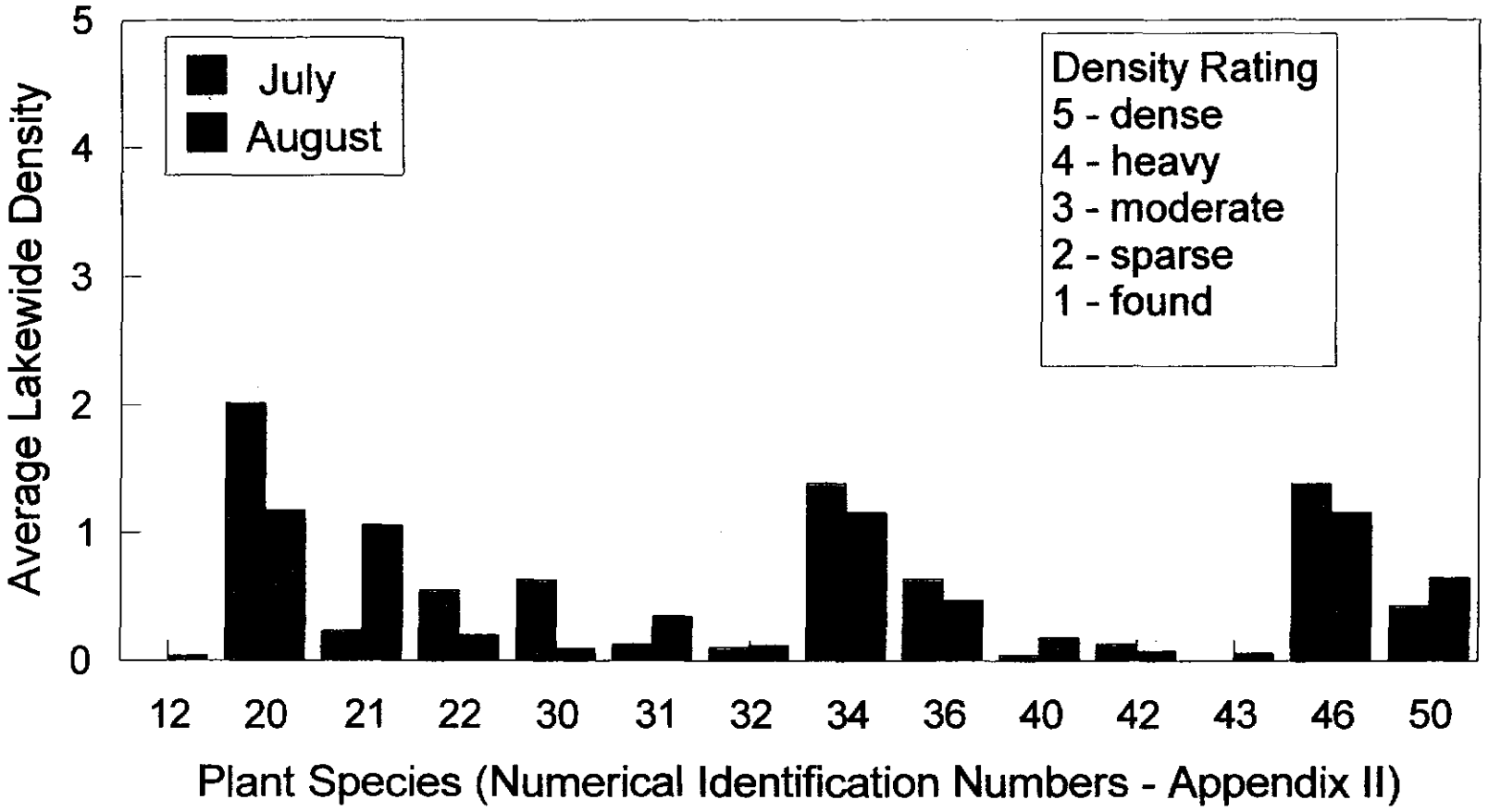


Figure 6. Areas Identified in Previous Water Quality Studies with Excessive Nutrient/Bacteria Concentrations on Long Lake

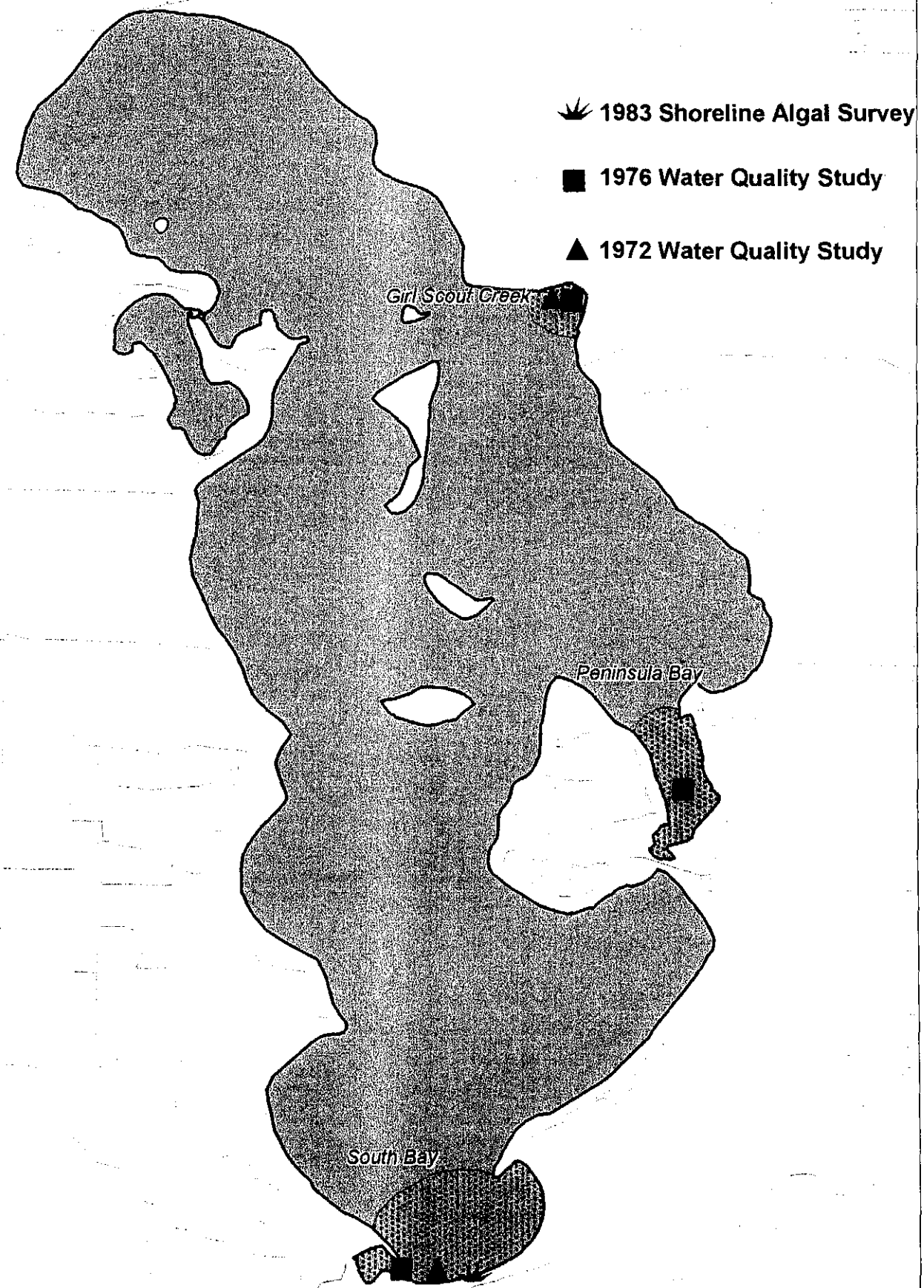
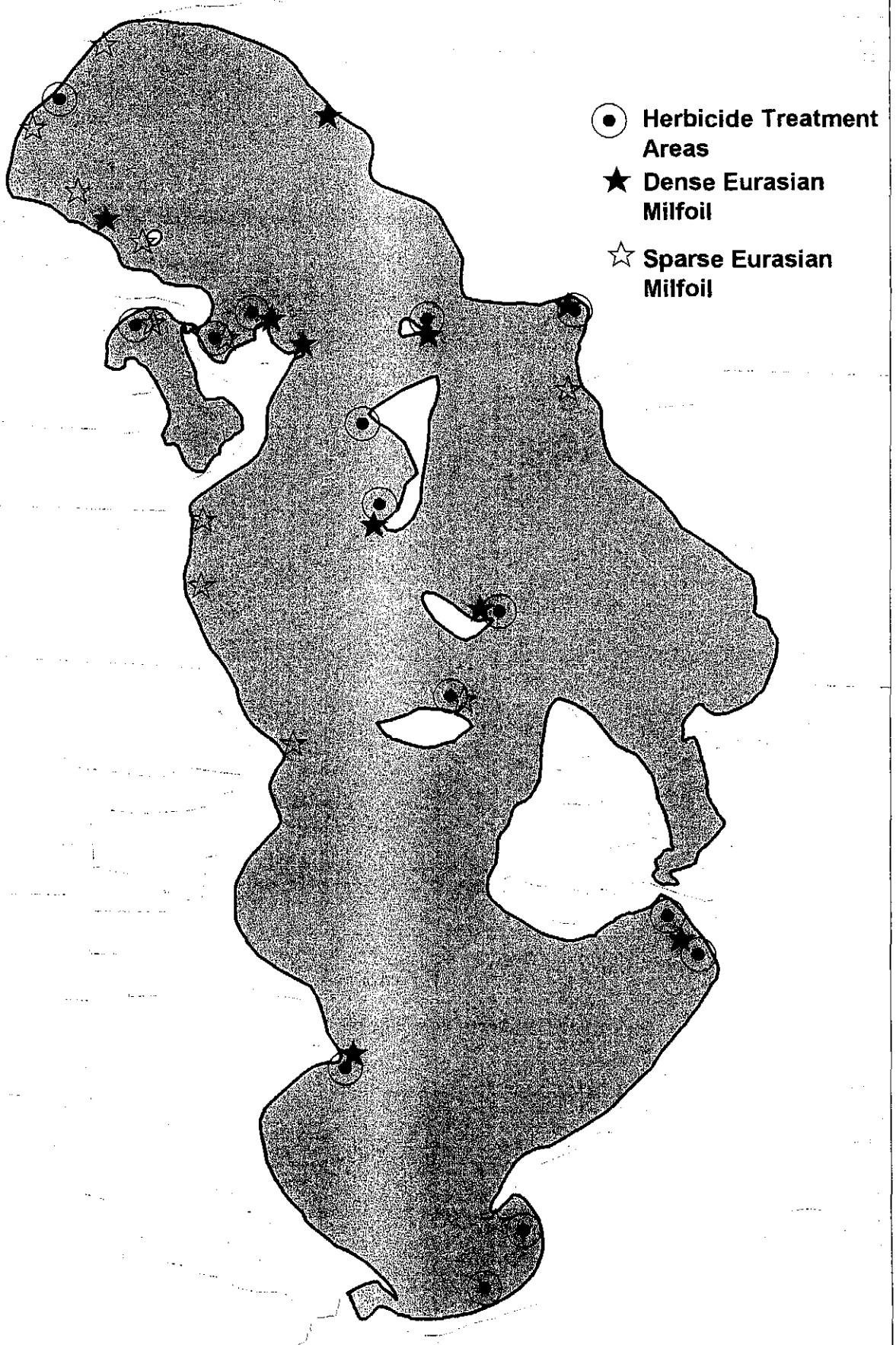


Figure 7. Locations of Herbicide Treatment Areas and Eurasian Watermilfoil on Long and Mickey Lakes, Summer 2000



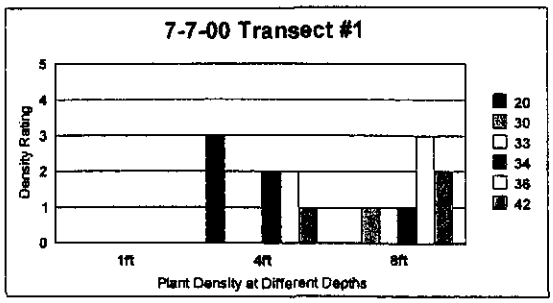
APPENDIX I
(Field Data Sheets)

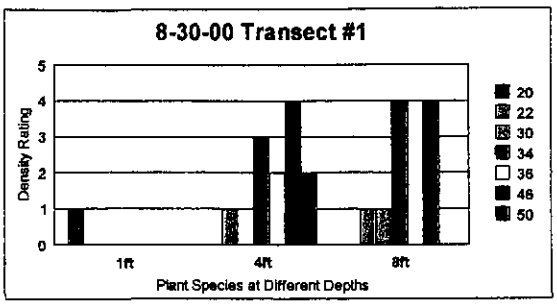
Data sheets on file at the
Grand Traverse County Drain Commissioner's Office

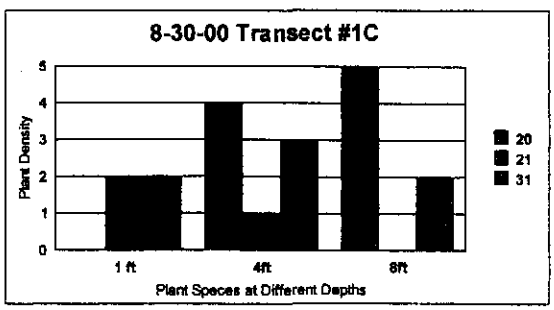
APPENDIX II
(Transect Data)

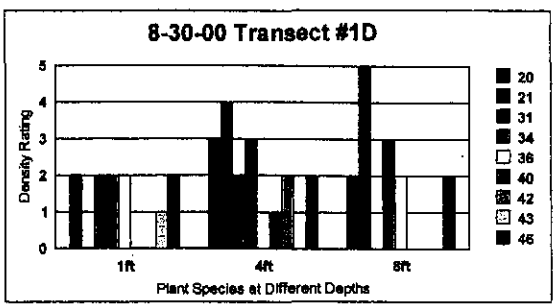
TABLE 1. PORTRAIT VALUES FOR ROOTED AQUATIC PLANTS IN LONG AND MICKEY LAKES, JUNE-SEPTEMBER, 2000

Portrait Value	Common Name	Scientific Name	Comments
12	White Water Lily	*Nymphaea spp.* *Brasenia spp.*	to 6 feet, important to aquatic mammals
20	Stonewort	*Chara spp.*	to 30 feet, enhances water clarity
21	Bushy Pondweed	*Naja spp.*	to 27 feet, (important duck food)
22	Fern Pondweed	*Potamogeton robbinsii*	to 20 feet
30	Large Leaved Pondweed	*Potamogeton amplifolius*	to 10 feet
31	Variable Pondweed	*Potamogeton gramineus*	to 10 feet
32	Thinleaf Pondweed	*Potamogeton spp.*	to 10 feet
33	Flat Stem Pondweed	*Potamogeton zosteriformis*	to 22 feet
34	Wild Celery	*Vallisnaria americana*	to 20 feet
36	Water Weed	*Elodea canadensis*	to 27 feet
40	Native Milfoils	*Myriophyllum spp.*	to 20 feet
42	Clasping Leaf Pondweed	*Potamogeton richardsonii*	to 20 feet, great fish habitat
43	Floating Leaved Pondweed	*Potamogeton natans*	to 5 feet
46	Illinois Pondweed	*Potamogeton illinoensis*	to 15 feet
50	Eurasian Watermilfoil	*Myriophyllum spicatim*	to 20+ feet, not native, can become invasive


7-7-00 Transect #1
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Density at Different Depths
20
30
33
34
36
42


8-30-00 Transect #1
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
22
30
34
36
46
50


8-30-00 Transect #1C
Plant Density
0
1
2
3
4
5
1 ft
4ft
8ft
Plant Species at Different Depths
20
21
31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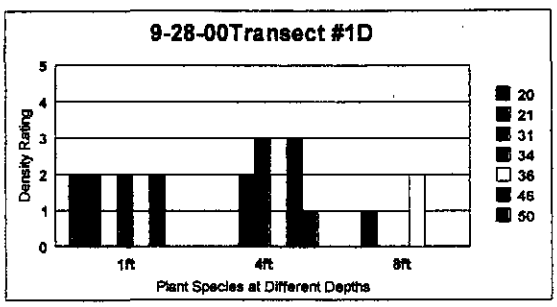
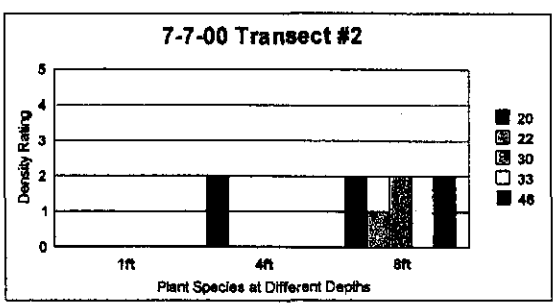
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
31
34
36
40
42
43
46


9-28-00Transect #1D
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
31
34
36
46
50


7-7-00 Transect #2
Density Rating
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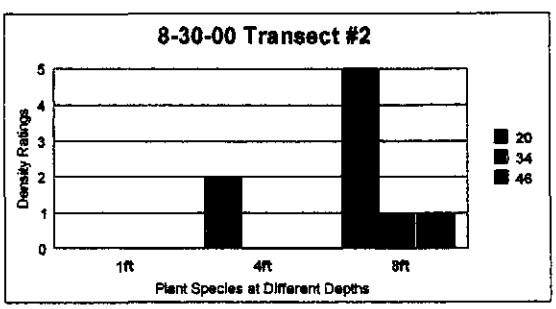
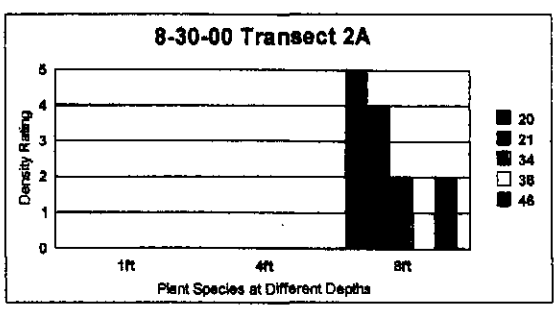
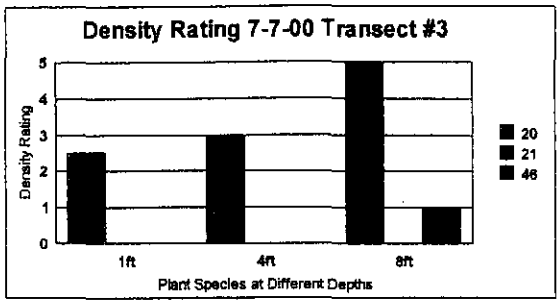
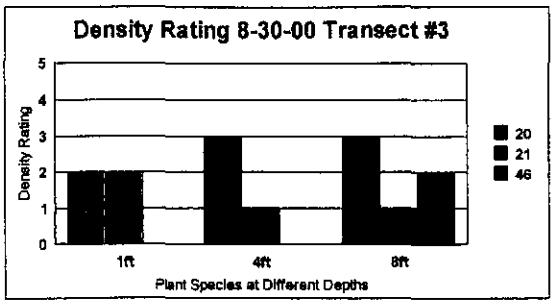
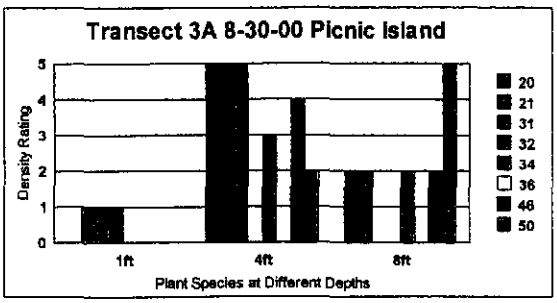
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
22
30
33
46

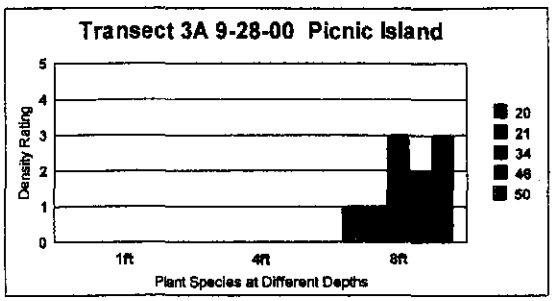

8-30-00 Transect #2
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
34
46

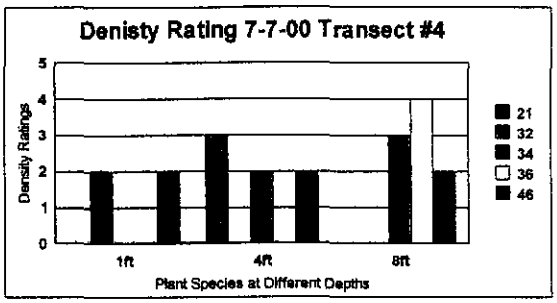

8-30-00 Transect 2A
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
34
36
46

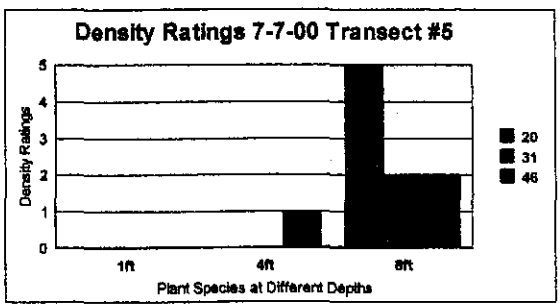

Density Rating 7-7-00 Transect #3
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
46

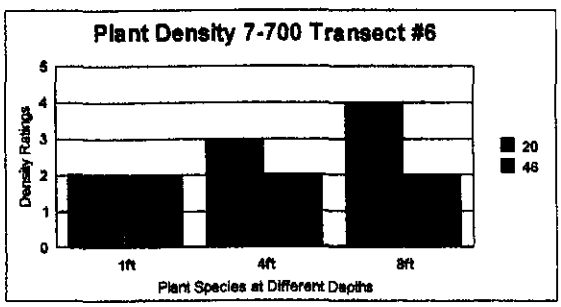

Density Rating 8-30-00 Transect #3
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
46

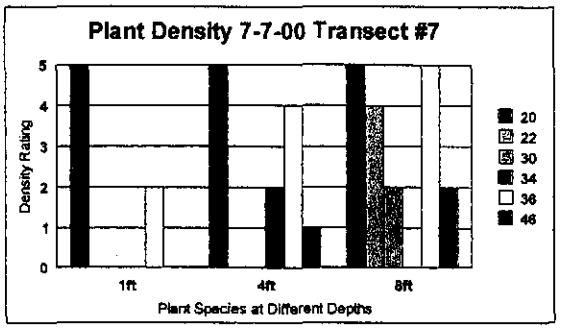

Transect 3A 8-30-00 Picnic Island
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
31
32
34
36
46
50

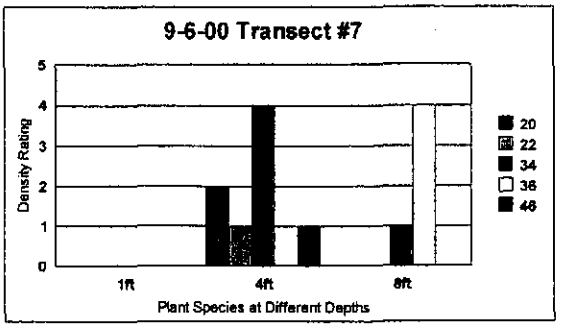

Transect 3A 9-28-00 Picnic Island
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
34
46
50

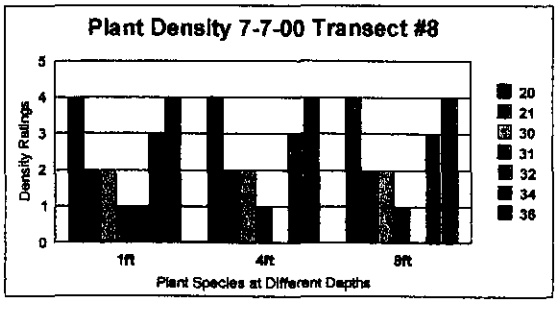

Denisty Rating 7-7-00 Transect #4
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
21
32
34
36
46

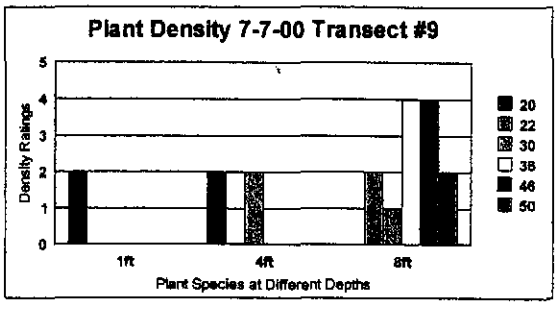

Density Ratings 7-7-00 Transect #5
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
31
46

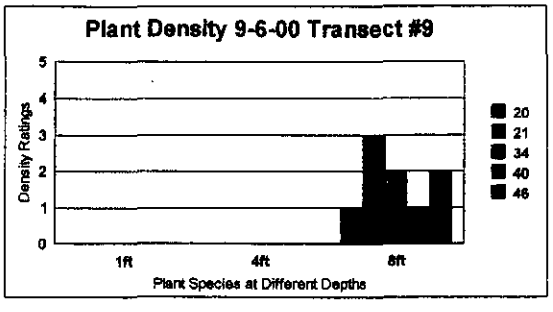

Plant Density 7-700 Transect #6
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
46

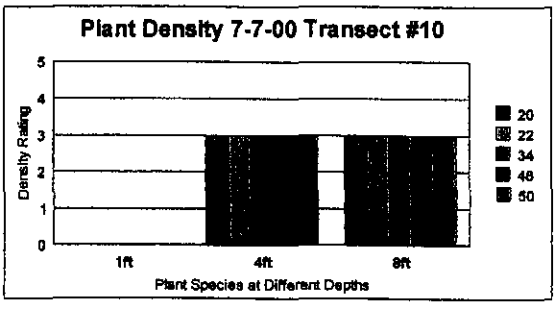

Plant Density 7-7-00 Transect #7
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
22
30
34
36
46

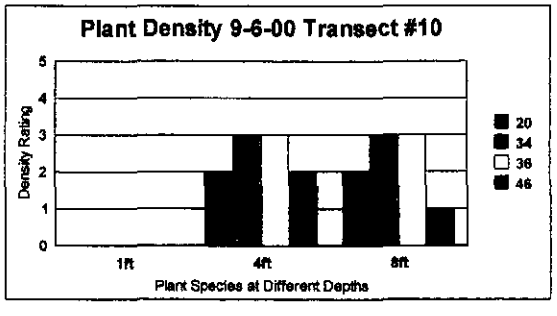

9-6-00 Transect #7
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
22
34
36
46

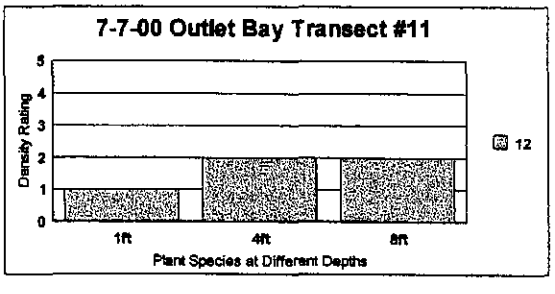

Plant Density 7-7-00 Transect #8
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
30
31
32
34
36

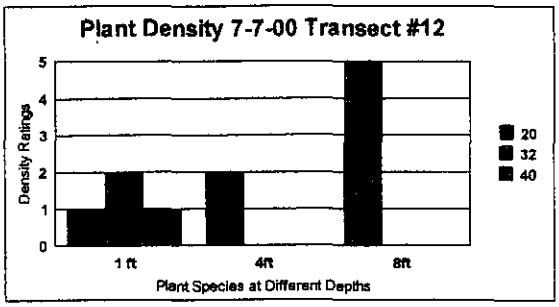

Plant Density 7-7-00 Transect #9
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
22
30
36
46
50

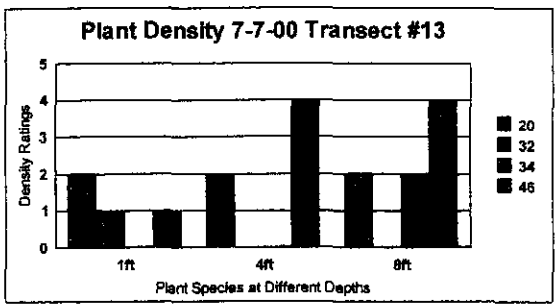

Plant Density 9-6-00 Transect #9
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
34
40
46

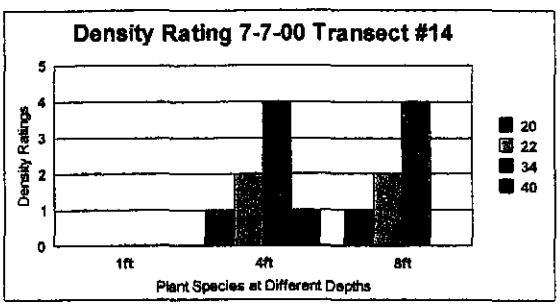

Plant Density 7-7-00 Transect #10
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
22
34
46
50


Plant Density 9-6-00 Transect #10
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
34
36
46


7-7-00 Outlet Bay Transect #11
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
12


Plant Density 7-7-00 Transect #12
Density Ratings
0
1
2
3
4
5
1 ft
4ft
8ft
Plant Species at Different Depths
20
32
40


Plant Density 7-7-00 Transect #13
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
32
34
46


Density Rating 7-7-00 Transect #14
Density Ratings
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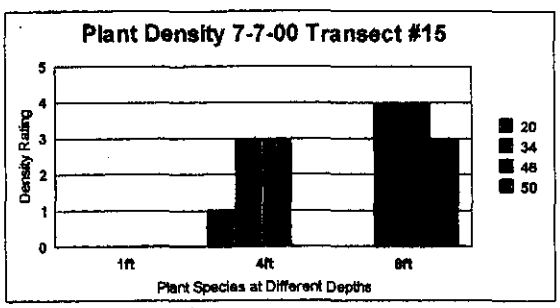
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
22
34
40


Plant Density 7-7-00 Transect #15
Density Rating
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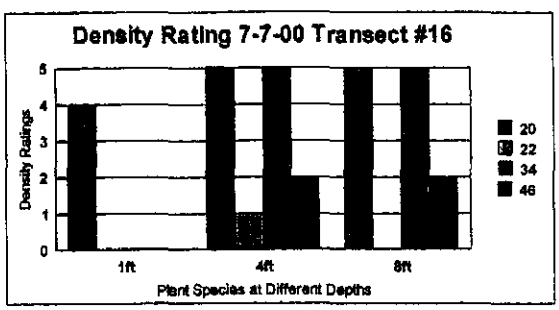
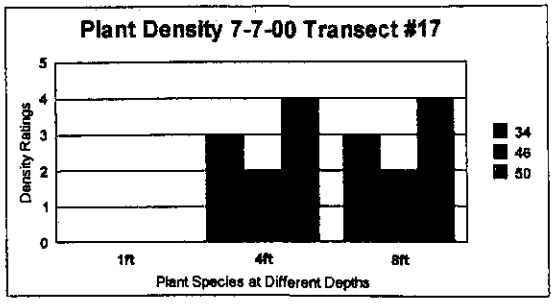
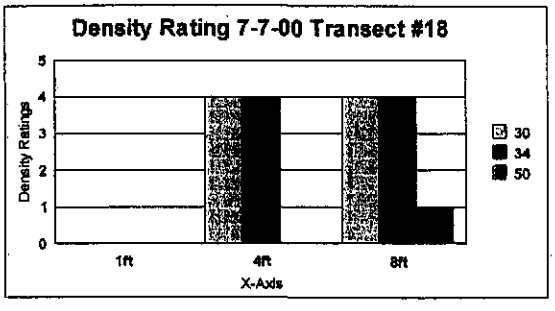
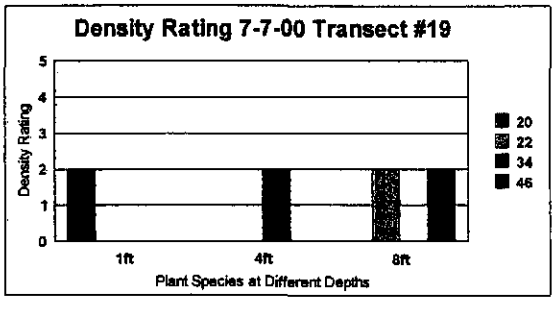
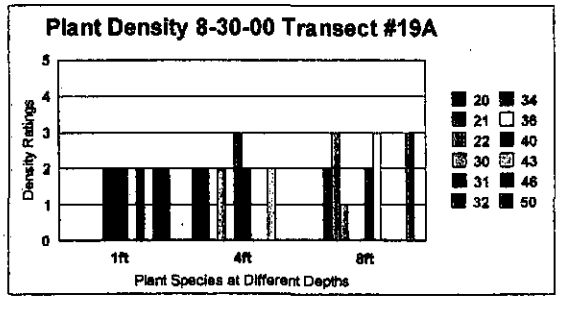
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
34
46
50

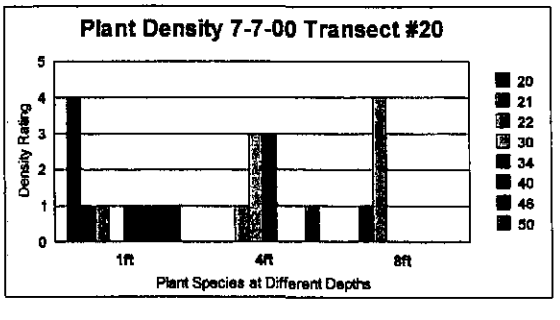

Density Rating 7-7-00 Transect #16
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
22
34
46

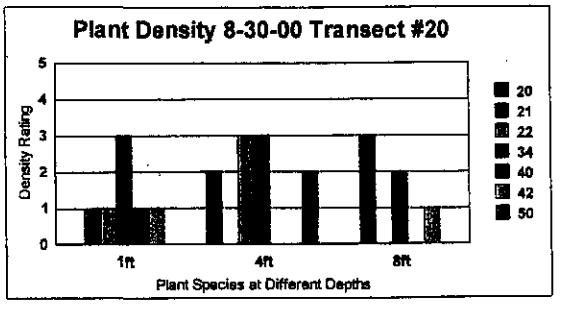

Plant Density 7-7-00 Transect #17
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
34
46
50

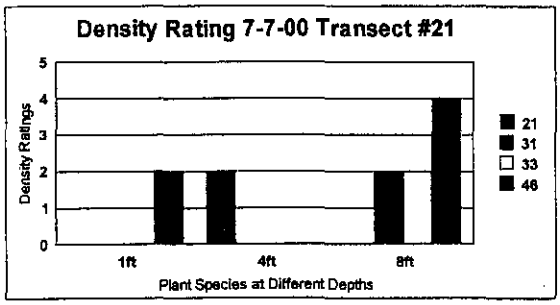

Density Rating 7-7-00 Transect #18
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
X-Axis
30
34
50

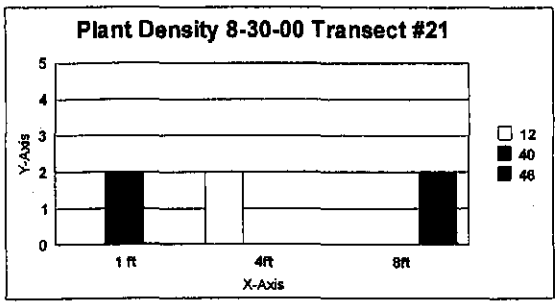

Density Rating 7-7-00 Transect #19
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
22
34
46

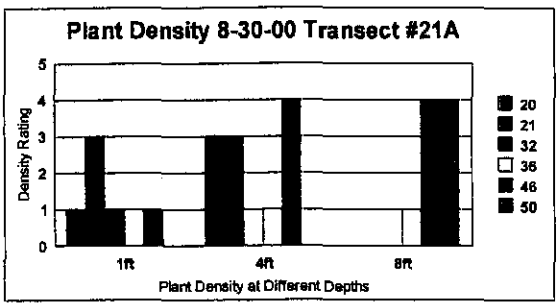

Plant Density 8-30-00 Transect #19A
Density Ratings
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
22
30
31
32
34
36
40
43
46
50

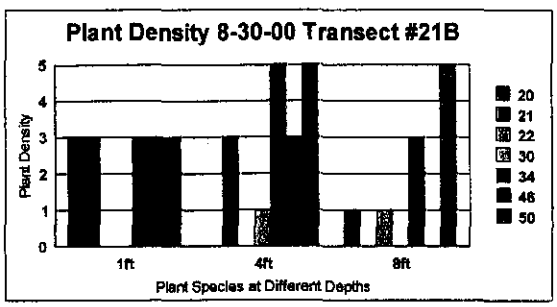

Plant Density 7-7-00 Transect #20
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
22
30
34
40
46
50

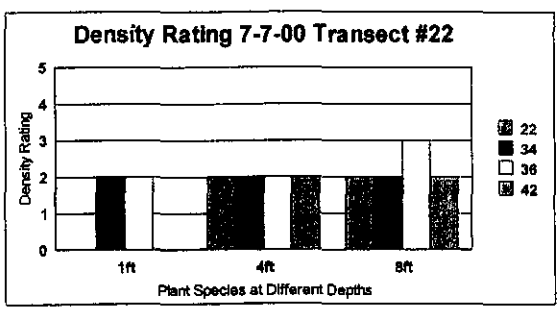

Plant Density 8-30-00 Transect #20
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
22
34
40
42
50

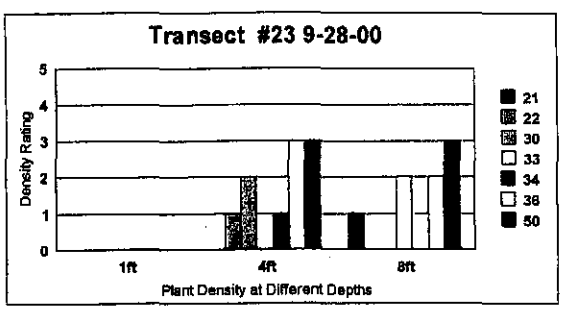

Density Rating 7-7-00 Transect #21
Density Ratings
5
4
3
2
1
0
1ft
4ft
8ft
Plant Species at Different Depths
21
31
33
46

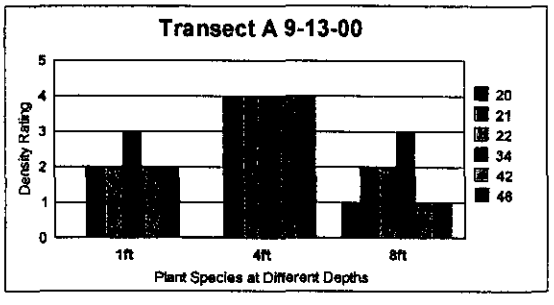

Plant Density 8-30-00 Transect #21
Y-Axis
5
4
3
2
1
0
1 ft
4ft
8ft
X-Axis
12
40
46


Plant Density 8-30-00 Transect #21A
Density Rating
5
4
3
2
1
0
1ft
4ft
8ft
Plant Density at Different Depths
20
21
32
36
46
50


Plant Density 8-30-00 Transect #21B
Plant Density
5
4
3
2
1
0
1ft
4ft
8ft
Plant Species at Different Depths
20
21
22
30
34
46
50


Density Rating 7-7-00 Transect #22
Density Rating
5
4
3
2
1
0
1ft
4ft
8ft
Plant Species at Different Depths
22
34
36
42


Transect #23 9-28-00
Density Rating
5
4
3
2
1
0
1ft
4ft
8ft
Plant Density at Different Depths
21
22
30
33
34
36
50


Transect A 9-13-00
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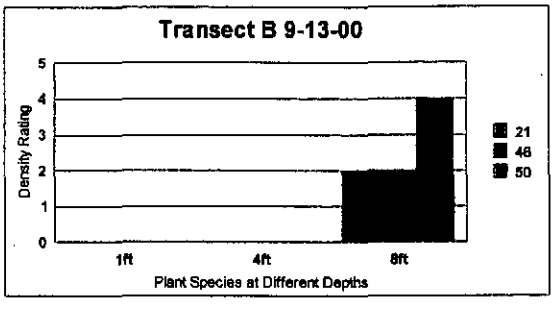
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
22
34
42
46


Transect B 9-13-00
Density Rating
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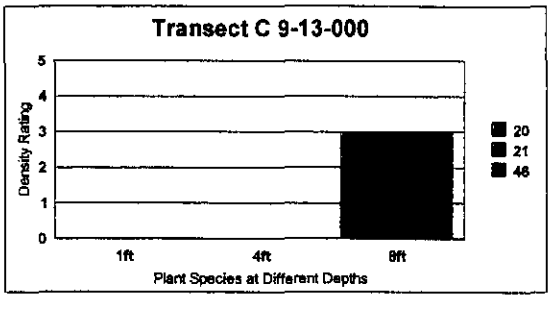
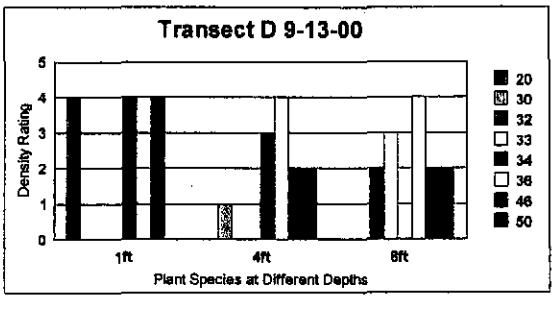
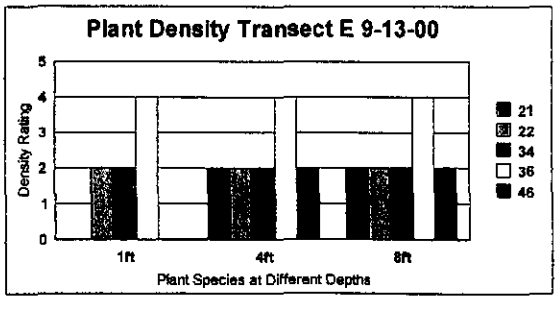
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
21
46
50


Transect C 9-13-000
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
21
46


Transect D 9-13-00
Density Rating
0
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
20
30
32
33
34
36
46
50


Plant Density Transect E 9-13-00
Density Rating
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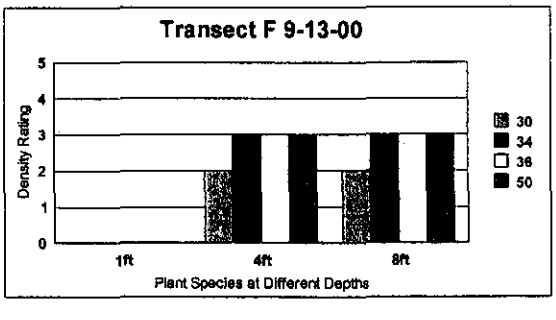
1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
21
22
34
36
46


Transect F 9-13-00
Density Rating
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1
2
3
4
5
1ft
4ft
8ft
Plant Species at Different Depths
30
34
36
50

APPENDIX III
(SEIS: Volume 3-2,4-D, Section 1p.17 Table 2.)

Table 2: Species Controlled with Aqua-Kleen® and Navigate®, Effectiveness of Control and Registration Status for Control of Listed Species

Species Controlled	Effectiveness of Control or Labeled Use	
	Aqua-Kleen®	Navigate®
Potamogeton spp. Pondweed	No Efficacy Claimed[7]	No Efficacy Claimed
Ceratophyllum spp. Coontail	Labeled Use Fair Control[2]	Labeled Use Fair Control[2]
Hydrilla verticillata Hydrilla	No Efficacy Claimed	No Efficacy Claimed
Myriophyllum spicatum Eurasian watermilfoil	Labeled Use Excellent Control[2]	Labeled Use Excellent Control[2]
Myriophyllum spp. Milfoil	Labeled Use Excellent Control[1]	Labeled Use Excellent Control[1]
Myriophyllum hetrophyllum Variable leaf milfoil	Labeled Use Excellent Control[1]	Labeled Use Excellent Control[1]
Brasenia spp. Watershield	Labeled Use Excellent Control[2]	Labeled Use Excellent Control[2]
Uricularia spp. Bladderwort	Labeled Use Fair Control[6] Good Control[3]	Labeled Use Fair Control[6] Good Control[3]
Heteranthera spp. Water stargrass	Labeled Use	Labeled Use
Sparganium spp. Bur reed	No Efficacy Claimed	No Efficacy Claimed
Hygrophila polysperma Hygrophila	No Efficacy Claimed	No Efficacy Claimed
Lythrum salicaria Purple loosestrife	No Efficacy Claimed	No Efficacy Claimed
Egeria densa Brazilian elodea	No Efficacy Claimed	No Efficacy Claimed
Myriophyllum aquaticum Parrotsfeather	Labeled Use Excellent Control[1,2]	Labeled Use Excellent Control[1,2]
Cabomba caroliniana Fanwort	Fair Control[4] No Efficacy Claimed	Fair Control[4] No Efficacy claimed
Tamarix ramosissima Saltcedar	No Efficacy Claimed	No Efficacy Claimed
Amorpha fruitcosa Indigobush	No Efficacy Claimed	No Efficacy Claimed
Polygonum sacalinense Giant knotweed	No Efficacy Claimed	No Efficacy Claimed
Polygonum cuspidatum Japanese knotweed	No Efficacy Claimed	No Efficacy Claimed

Table 2: Species Controlled, Effectiveness of Control and Registration Status for Control of Listed Species (Continued)

Species Controlled	Effectiveness of Control or Labeled Use	
	Aqua-Kleen®	Navigate®
Lysimachia vulgaris Garden loosestrife	No Efficacy Claimed	No Efficacy Claimed
Phalaris arundinacea Reed canarygrass	No Efficacy Claimed	No Efficacy Claimed Labeled Use
Typha Spp. Cattail	Labeled Use Fair Control[5] Good Control[4]	Fair Control[5] Good Control[4]
Elodea canadensis American waterweed	No Efficacy Claimed	No Efficacy Claimed
Nuphar spp. Spadderdock	Labeled Use Fair Control[5] Excellent Control[2]	Labeled Use Fair Control[5] Excellent Control[2]
Nymphaea spp. Fragrant water lilies	Labeled Use Good Control[3] Excellent Control[2]	Labeled Use Good Control[3] Excellent Control[2]
Hydrilla	No Efficacy Claimed	No Efficacy Claimed
Spartina Smooth cordgrass	No Efficacy Claimed	No Efficacy Claimed
Phragmites australis. Common reed	No Efficacy Claimed	No Efficacy Claimed
Trapa natans Water chestnut	Labeled Use Good Control[4]	Labeled Use Good Control[4]
Algae species	No Efficacy Claimed	No Efficacy Claimed

1 (Robinette, 1998-1999)
2 (Westerdahl et al., 1988)
3 (Robinette, 1998-1999)
4 (Westerdahl et al., 1988)
5 (Robinette, 1998-1999)
6 (Westerdahl et al., 1988)
7 No Efficacy Claimed = The indicated formulation has not been shown to control this species. Not listed as a controlled species on the label.

Appendix D1

2005 Long Lake Macrophyte Study

2005 MACROPHYTE (ROOTED AQUATIC PLANT) SURVEY

Background

A survey of the rooted aquatic plants in Long and Mickey Lakes was conducted by Great Lakes Environmental Center (GLEC) June through September, 2005, as part of a larger ongoing watershed management study. The objective of this survey was to map and characterize the major macrophyte growth areas in the lakes. The survey took special note of areas of Eurasian water milfoil. An estimation will be made as to whether the macrophyte growth area has increased or decreased, in comparison with a survey done in the summer of 2000. The same estimation will be done for Eurasian water milfoil. Plant species composition, average lake wide density, and the distribution of macrophyte growth areas was determined from transect data and from direct observation of the lake bottom.

Methods. The methods used to conduct this survey were the same as used in the previous survey in 2000, based on methods described in "A Citizen's Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes" (Michigan State University, 2000). To insure maximum visibility, the surveys were conducted on sunny to partly sunny days with low wind, between the hours of 9:00 a.m. and 3:00 p.m.

Most of the transects established during the previous survey were sampled again, and some new transects were added, for a total of 35 transects surveyed (Table 4). Each transect was identified by shoreline landmarks and/or GPS (Global Positioning System) coordinates. Each transect survey was performed by anchoring a boat perpendicular to the shore at three different water depths: 1, 4 and 8 feet, which were determined by using a weighted sounding line. At each anchoring site, a weighted rake with a retrieving line was used to obtain plants from all four sides of the boat (bow, stern, starboard and port). Each plant which was collected was identified to species either on-site, or at GLEC's laboratory. Relative densities were determined based on the quantity of plants obtained by each rake's retrieval, by the number of retrievals for which a particular species was

present, as well as by direct observation of the lake bottom when possible.

Aquatic plant density ratings were assigned for each macrophyte using the following criteria:

Dense (5)	Species fills the rake in all four casts.
Heavy (4)	Species found mixed with other plants in all four casts of the rake.
Moderate (3)	Species found in three of the four rake casts.
Sparse (2)	Species found in two of the four rake casts.
Found (1)	Species found in one of the four rake casts.

Additionally, a visual survey and GPS data were used to prepare a macrophyte area location map; additionally noting Eurasian water milfoil locations and densities.

Transect Sampling Results (Long Lake)

During the macrophyte sampling survey, nineteen different aquatic plants were found in Long Lake (Table 5). Of 35 transect sites, Eurasian water milfoil was found at 22 of the sites. Eurasian milfoil is the only non-native species identified during this survey, as was the case during the survey in 2000.

Transect Sampling Results (Mickey Lake)

During the macrophyte sampling survey, 10 different aquatic plants were found in the samples from two transects in Mickey Lake (Table 5). Eurasian water milfoil was found at only one of the two transect sites, but was prevalent on the northern side of the lake.

Macrophyte Visual Survey (Overall-Both Lakes)

The macrophyte growth areas identified in 2000 were resurveyed and compared as to larger or smaller than sited in 2000. Three new growth areas were observed and added to the macrophyte map (Figure 3). Of the macrophyte visual survey sites, 32 sites out of 46 had at least some amount of Eurasian water milfoil (varying from one stem to dense

patches). Comparison with data from the 2000 survey showed that in 16 sites, Eurasian water milfoil either increased in density or was sited in an area where it was not sited before. At five macrophyte areas, Eurasian water milfoil decreased in density. General macrophyte growth, in area amount, increased at five sites and decreased at two sites.

Figure 3. Macrophyte Growth Areas on Long and Mickey Lakes, Summer 2005

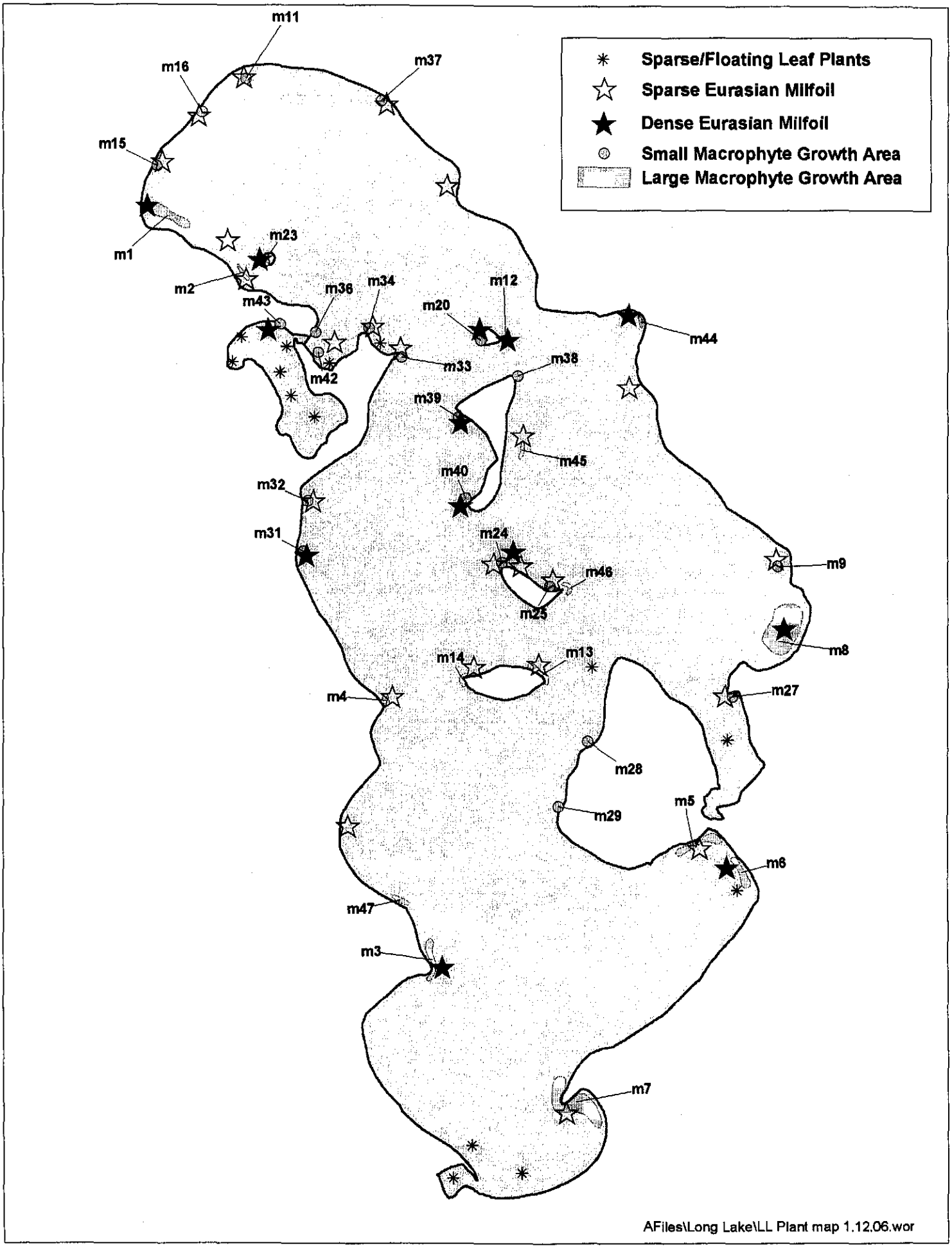


Table 4. GPS coordinates and location of macrophyte transects on Long Lake.

G.P.S. Coordinates	Transect ID	Location Description
44 44.390 85 46.564	Transect 1	Gilbert Park Public Boat Launch
44 44.802 85 46.129	Transect 1D	Northeast corner of Long Lake near Skiver Rd in front of a large red pine, the shoreline is undeveloped
44 44.789 85 45.835	Transect 2	Public Swimming Beach off Long Lake Rd
44 44.491 85 45.151	Transect 2A	Located between transects 2 and 3 near Gilbert Trail
44 44.434 85 45.156	Transect 3	Near the Timbers Girl Scout Camp, in front of a boathouse near the point
44 44.335 85 45.047	Transect 3C	In the middle of the next bay past transect 3 (in front of Brown Boathouse
44 44.120 85 44.805	Transect 3B	South end of the bay to the south of transect 3C near brown and blue boathouse
44 43.970 85 44.903	Transect 3A	Southeast tip of Picnic Island
44 43.992 85 44.886	Transect 24	Northeast tip of Picnic Island
44 44.053 85 44.340	Transect 23	Inlet near Fern Lake
NA	Transect 4	Just to the south of transect 23, just to the north of a line drawn from the north tip of Long Isle
NA	Transect 5	Just to the south of Transect 4, around a little curve just to the south of a line drawn from the north tip of Long Isle
44 42.949 85 43.783	Transect 6	Located on the south end of a large bay across from Fox Isle (east shore of Long Lake)
44 42.814 85 43.916	Transect 7	Located on the south tip of little peninsula that sticks out at the entrance to the bay on the north side of the big peninsula
NA	Transect 8	Northwest tip of the peninsula
44 42.314	Transect 9	Just past the middle of the bay on the south side of the

85 43.886		peninsula
44 41.528 85 44.635	Transect 10	Just inside little point of land in south bay on the east side
NA	Transect 11	Outlet pond at the south end of the Lake
44 41.778 85 45.543	Transect 12	Near the connection to Ruth Lake
44 41.924 85 45.279	Transect 13	Point of land to the north of transect 12
44 42.795 85 45.454	Transect 14	Point of Land across from South Isle, off the north side of the point
44 42.929 85 44.788	Transect 15	Northeast side of South Isle
44 43.274 85 44.928	Transect 16	Northwest tip of Fox Isle
44 43.166 85 44.698	Transect F	Northeast tip of Fox Island in the bay
44 43.433 85 45.088	Transect 17	Southwest tip of Long Isle
44 43.455 85 45.836	Transect 18	Crescent Public Boat Launch
NA	Transect 19 Transect 19A	Located in the Bay that has the connection to Mickey Lake in the middle of the bay arrow pointing to the North east (through the center of the bay
44 43.988 85 45.913	Transect 20	Northeast side of Mickey Lake not to far from the entrance
44 43.641 85 45.778	Transect 21	South shore of Mickey Lake
44 43.916 85 45.391	Transect 21A	Point of land before transect 21 B - across from Picnic Isle
44 43.970 85 45.527	Transect 21B	Point of land before bay with the connection to Mickey Lake just to the south of the point
44 43.988 85 45.781	Transect E	East side near the Entrance to Mickey Lake
NA	Transect 22	Just around the point from Transect E

44 44.307 85 46.391	Transect A	South of Gilbert Park Boat Launch
44 44.239 85 46.206	Transect B	On the mainland just to the north of Brush Isle
44 44.204 85 46.134	Transect C	Just a bit north of Transect B and still just a bit north of Brush Isle
44 44.199 85 46.005	Transect D	On northwest side of Brush Isle
44 43.703 85 44.909	Transect X-1	On the east side of Long Island; about midway.
44 43.272 85 43.655	Transect X-2	In the cove northeast of transect 6. (M8)
44.42.744 85 45.485	Transect X-3	In the cove just south of transect 14.
N/A	Transect X-4	Between transect 18 and transect 14. Western shore even with Fox Island.
44 42.369 85 45.604	Transect X-5	In the large cove south of X3; between transect 14 and 13.
N/A	Transect X-6	Between transects 12 and 13, algal site
N/A	Transect X-7	On the southeastern shore of Peninsula Bay.

Table 5. Plant species list for Long and Mickey Lakes Macrophyte Survey, Summer 2005.

Scientific Name	Common Name	Long Lake	Mickey Lake
Ceratophyllum demersum	Coontail	*	
Elodea canadensis	Common water weed	*	
Juncus pelocarpus forma submersus	Rush	*	
Myriophyllum exalbescens	Water milfoil	*	
Myriophyllum spicatum	Eurasian water milfoil	*	
Myriophyllum tenellum	Water milfoil		*
Naja flexilis	Bushy pondweed	*	*
Nuphar ovariegatum	Yellow pond lily	*	*
Nymphaea odorata	Fragrant white water lily	*	*
Potamogeton americanus	American pondweed	*	
Potamogeton amplifolius	Large leaved pondweed	*	
Potamogeton gramineus	Pondweed	*	*
Potamogeton illinoensis	Illinois pondweed	*	*
Potamogeton pectinatus	Sago pondweed	*	*
Potomogeton Richardsonii	Clasping leaved pondweed	*	
Potamogeton Robbinsii	Fern leaved pondweed	*	
Potamogeton zosterformis	Flat stemmed pondweed	*	*
Typha sp.	Cattail	*	
Utricularia sp.	Bladderwort		*
Vallisneria americana	Wild celery	*	*
Chara sp.	Stonewort (algae)	*	

Appendix E

Soil Erosion Inventory/BMP Implementation
Long Lake Watershed

Road /Stream Crossing Erosion Sites
Fischer Creek/Platte River, Grand Traverse County

INTRODUCTION

Typical of many Northern Michigan Lakes, Long Lake, located in Long Lake Township of Grand Traverse County, is a mix of past "cabin" type development and, more recently, large-home residential development. Throughout the years, properties that easily accommodated a dwelling were developed first and the more difficult, steeper properties remained undeveloped. As lake front property became scarcer and more valuable, development began occurring on the steeper and more erosion-prone properties. It follows that these properties may contribute a significant amount of sediment and nutrients through overland run-off to Long Lake, causing more rapid eutrophication and negatively impacting fish habitat and the overall quality of the lake.

In addition, plants such as live trees, shrubs, and fallen (in-lake) woody debris were cleared to make way for dwellings, views, beaches, and docks. The root systems from the live trees and shrubs provide critical shoreline stabilization, while the fallen trees break up wave action and provide important near-shore fish habitat.

Finally, an increase in the number and size of boats using the lake has also significantly increased wave action and the potential for erosion.

The purpose of this inventory was to document the sources of erosion around Long Lake and suggest Best Management Practices to stabilize these areas.

METHOD

Aerial photos (1998) were obtained for the entire lake. The photos were enlarged enough to allow a preliminary review of the shoreline. Seven 8½x11 photos covered the entire lake. The photos were placed in plastic inserts for inventory purposes. The plastic inserts kept the photos dry and allowed inventory identification notes to be written on the inserts without ruining the photos.

The inventory required two days to complete. One day on the lake and one day by vehicle around the watershed. A special thank you is extended to Bob Flannery for allowing us to use his boat and motor to conduct the lakeshore inventory.

RESULTS

Sixteen shoreline erosion sites were documented on Long Lake (Addendum "A"). Most of these sites were relatively minor with the exception of the three islands, Long (Site # 31), Fox (Site # 32), & South (Site #33), where moderate to severe erosion occurs. Several potential erosion sites were also documented because of high fragile banks or failing retaining walls and access steps. Erosion control measures have already been implemented on Picnic Island.

Large areas of undeveloped lakeshore were documented for potential conservation easement consideration.

One erosion site was recorded on Dyer Lake resulting from human activity along Boone Road. Long Lake was the only lake in the watershed to have a specific shoreline survey.

DISCUSSION

In our opinion, erosion/sedimentation is currently not a major problem on Long Lake. Over the years people have effectively stabilized their shoreline using a variety of methods including broken concrete, breakwalls, rocks, etc. In addition, homeowners have constructed access steps, decks, and docks to facilitate use of their property without continued aggravation of the banks. In many cases, the steepness and length of the upper bank has necessitated the measures taken.

The material estimates provided in Addendum "A" to repair the three island sites do not include permits, labor, or transportation (barging) of the material from the mainland to the islands. Furthermore, the Lake Association may want to consider additional practices if access/ use is desired (i.e. more access steps, access control fencing, etc..).

Though it was beyond the scope of this inventory, past and present removal of fallen trees (woody debris) from the water was also observed in many places. Fallen trees provide critical fish habitat. Removal of these fallen trees, and standing dead trees from the shoreline, by landowners "improving" their property has greatly reduced the amount of near-shore habitat over the years. In addition, turtles were noted sunning themselves on a high concrete dock possibly due to the lack of suitable logs.

The removal of woody debris is a common occurrence on many developing inland lakes around Northern Michigan.

RECOMMENDATION

Though shoreline erosion/sedimentation does not appear to be a major problem on Long Lake, landowners should be informed of Best Management Practices that will help reduce the amount of sediment and nutrients entering the lake.

The "Long Lake Watershed - A Landowner's Handbook" is an excellent resource to help landowners better understand and begin proper stewardship of their lakefront property. The Long Lake Association should consider preparing a more detailed publication which focuses specifically on Best Management Practices. The handbook could serve as an education tool which informs the landowner about proper stewardship and provides them with detailed descriptions of Best Management Practices. The word "handbook" is included with the recommended BMP on sites where education may have helped prevent a certain problem. To assist property owners in the future, a detailed Best Management Practice handbook should be considered by the Lake Association.

Finally, this inventory only looked at the shoreline's current condition. Historic inputs of sediment were not considered. A greater more in-depth study of Long Lake may be necessary to determine historic, present, and possible future land use impacts on Long Lake.

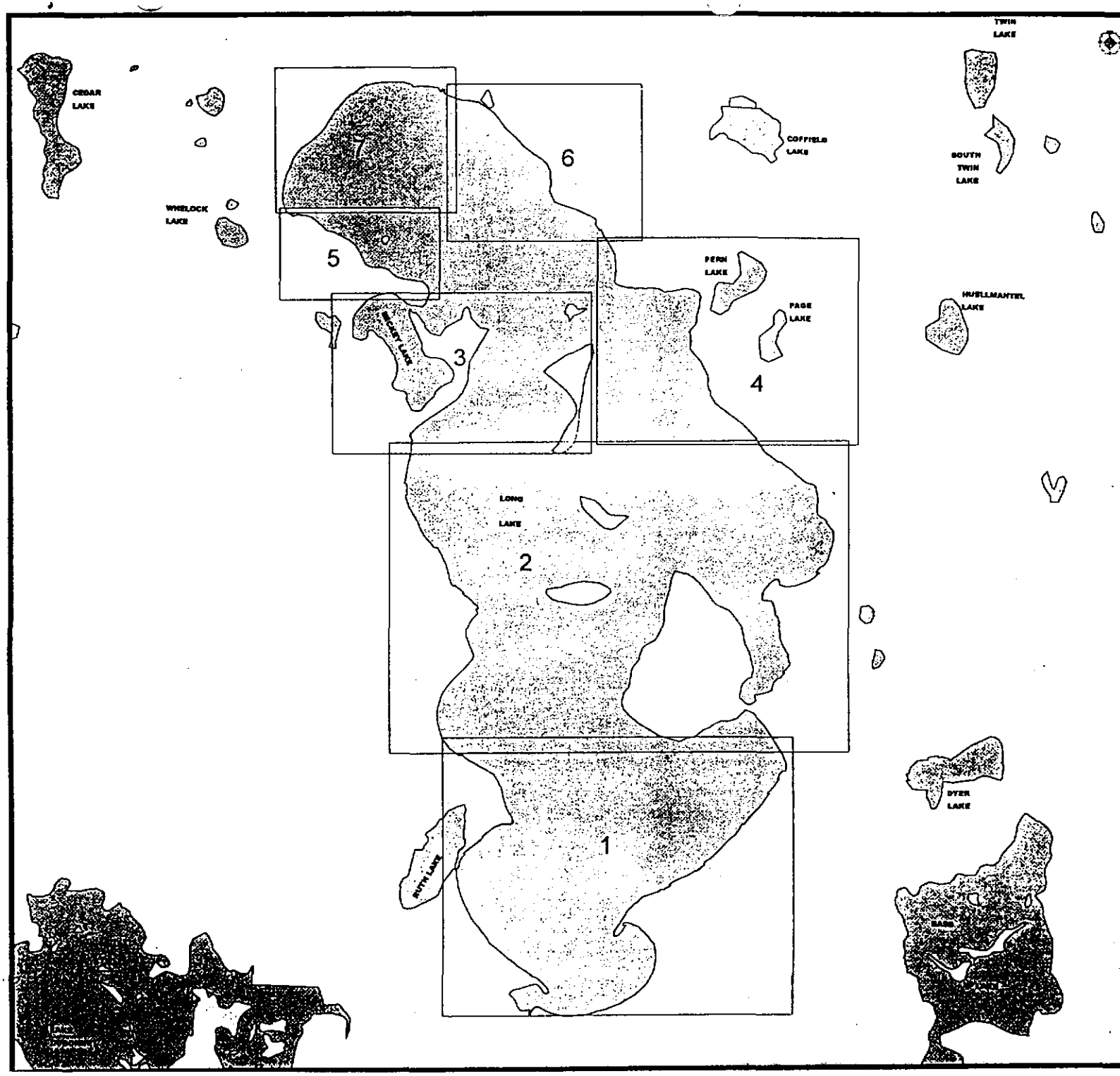
LONG LAKE WATERSHED

NON-POINT SOURCE POLLUTION
INVENTORY
Summer 1999

E	=	Erosion
PE	=	Potential Erosion
PCE	=	Potential Conservation Easement
0	=	Other

Site #	Description/Severity	BMP
1-E	Sheet Erosion/Minor	Plantings
2-E	Beach Erosion/Minor	Education/BMP Handbook
3-E	New Construction/Minor	Education/BMP Handbook
4-E	Point Erosion/Minor	Rock rip-rap, Plantings, Handbook
5-PE	Cement Blocks/Minor	Replace Cement Blocks w/rip-rap, Handbook
6-PE	Broken Cement/Minor	Replace Broken Cement w/rip-rap, Plantings
7-E	High Bank Erosion/Moderate	Replace Access Steps, Rip-rap, Top soil, Plantings , Bulkhead, Handbook
8-E	Sheet Erosion/Minor	Plantings
9-E	High Bank Erosion/Minor	Rock Rip-Rap, Top Soil, Plantings
10-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
11-PE	High Bank/Minor	Plantings
12-PE	High Bank/Minor	Plantings
13-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
14-PCE	Large Undeveloped Parcel on Point	Work w/ G.T. Regional Land Conservancy
15-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
16-0	Landowner used Coco Fiber Rolls in an attempt to protect/reclaim point	Education/Handbook

17-PE	Piles of sand near water/Minor	Education/Handbook
18-E	Sheet Erosion/Minor	Ground Cover/Handbook
19-PE	High Bank/Minor	Plantings
20-PE	New Construction/Minor	Education/Handbook
21-E	Sheet Erosion/Minor	Ground Cover/Handbook
22-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
23-E	High Bank Erosion/Moderate	Rock Rip-Rap, Plantings, Eductaion/ Handbook
24-E	High Bank Erosion/Minor	Rock Rip-Rap, Plantings,
25-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
26-E	Toe & High Bank/Moderate	Rock Rip-Rap, Plantings, Handbook
27-PE	Failing Bulkhead/Minor	Replace/Repair Bulkhead
28-E	High Bank Erosion/Minor	Plantings
30-PCE	Large Undeveloped Parcel	Work w/ G.T. Regional Land Conservancy
31-E	Bank Erosion/Severe	Rock Rip-Rap (10 yds^3), Top Soil (15 yds^3), Plantings (2000 ft^2) Est. Material Cost: $1,500
32-E	Bank Erosion/Severe	Rock Rip-Rap (20 yds^3), Access Steps (30 ft.), Top Soil (25 yds^3), Plantings (3,000 ft^2), Est. Material Cost: $3,000
33-E	Upper Bank Erosion/Severe	Rock Rip-Rap (20 yds^3), Top Soil (20 yds^3), Log Cribbing (75 ft.), Plantings (3000 ft^2); Est. Material Cost: $2,500
Dyer Lake:		
34-E	Road Run-off/ Public Access/ Fire Tanker Watering Point/ Moderate	Work with Road Commission to stop road run-off, Access Steps, Dry Hydrant; Est. Project Cost: $12,000
35-0	Potential Nutrient Loading Cedar Hills Golf Course	Work with golf course on nutrient management if determined a problem



GTC G I S

GRAND TRAVERSE COUNTY
GEOGRAPHICAL INFORMATION SYSTEM

Long Lake Index

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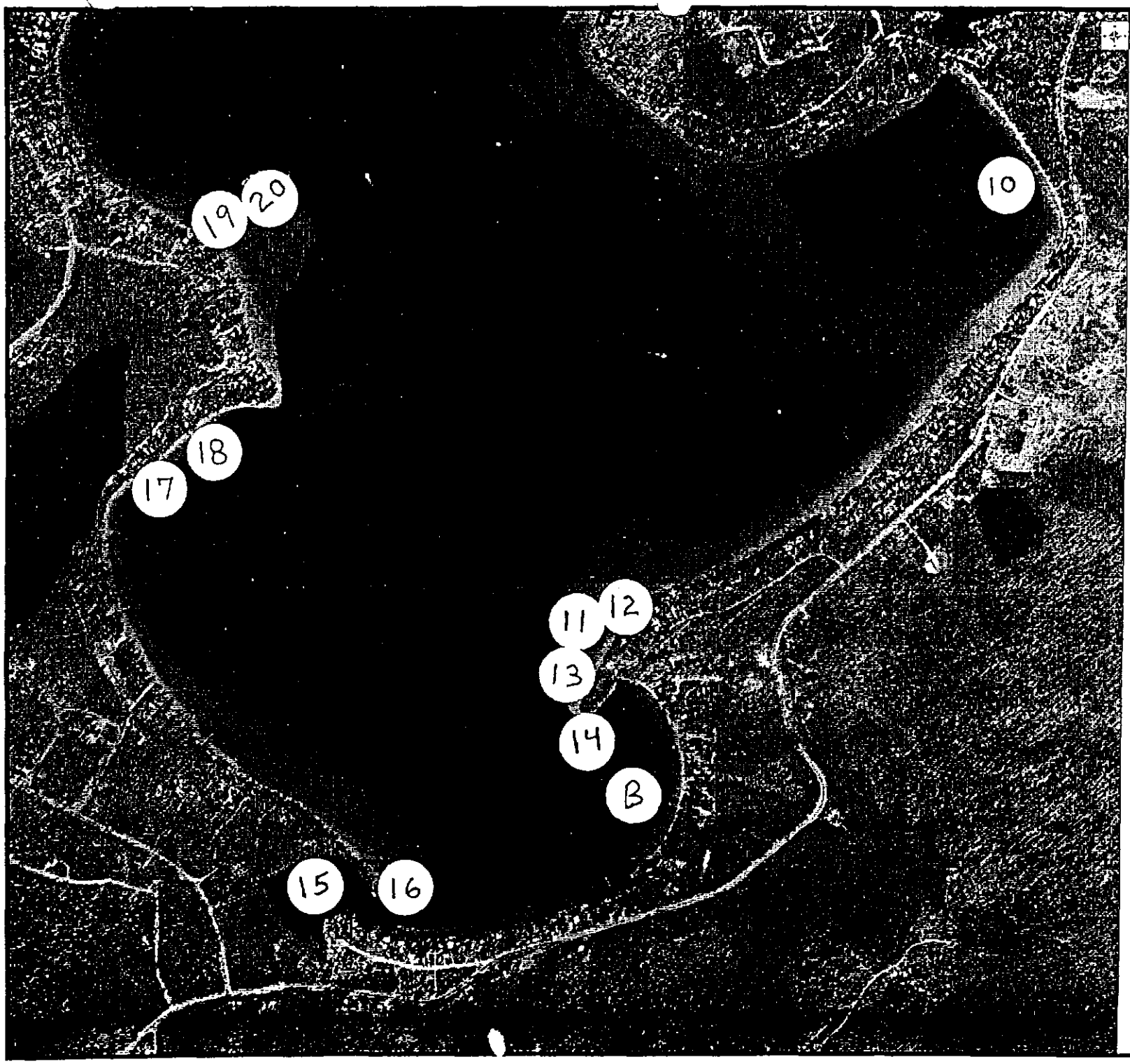
Plot date: May 25, 1999; c:\temp\long lake erosion sites.apr



GTC

GRAND TRAVERSE COUNTY
GEOGRAPHICAL INFORMATION SYSTEM

Long Lake #1

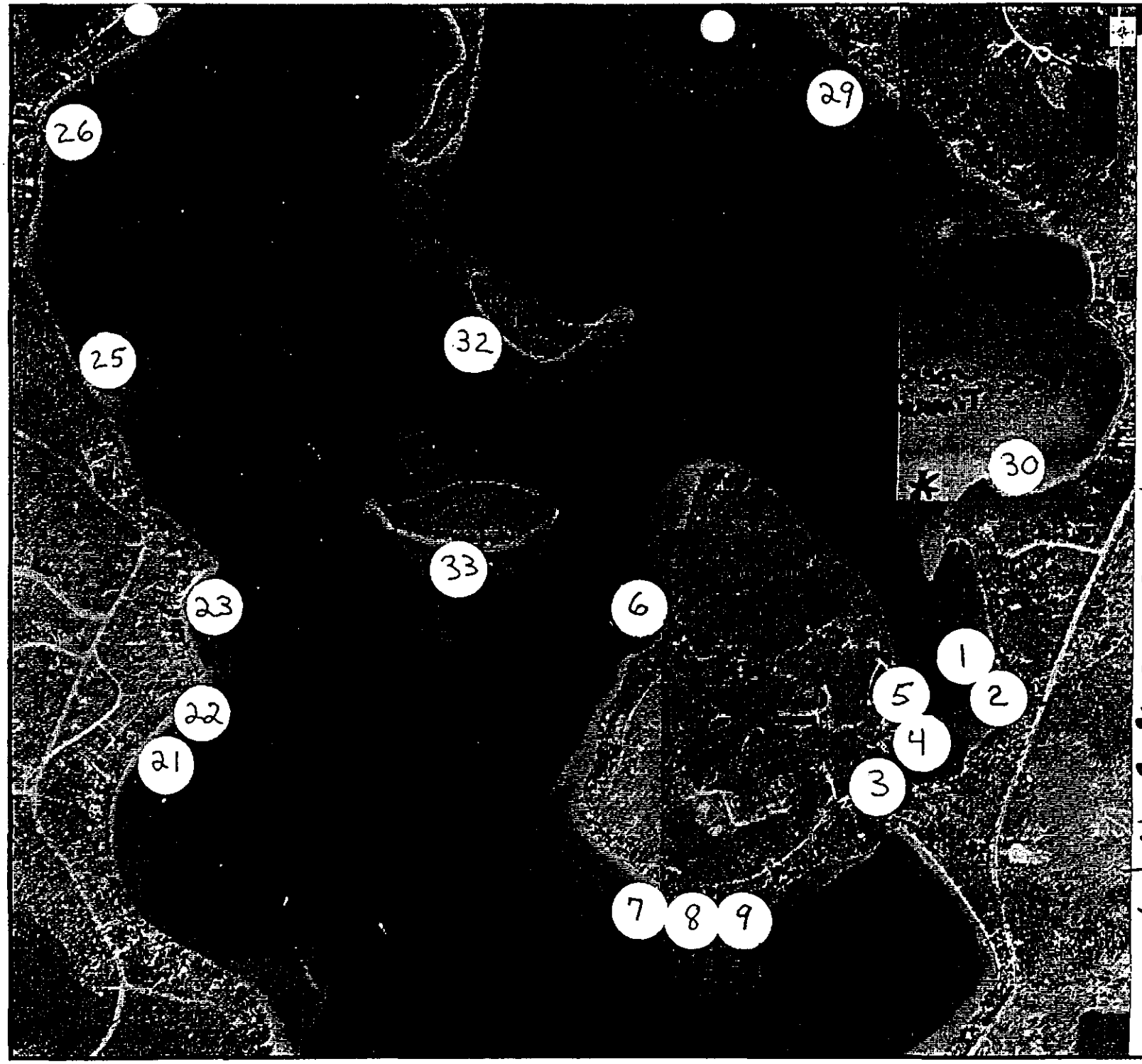
10. Potential Easement
11. PE
12. PE
13. Potential Easement
14 Potential Easement
B. Area of older Homes
15. Potential Easement
16. STABILIZED - ATTEMPTED
17. Beach Sand
18. E
19. E
20. E

0 500 1000 1500 Feet
1" = 1100 feet

Grand Traverse County

This map is based on digital databases from Grand Traverse County. GTC cannot accept any responsibility for errors, omissions, or positional accuracy. There are no warranties, expressed or implied.

Date Printed: May 20, 1999



GTC G I

GRAND TRAVERSE CO
GEOGRAPHICAL INFORMATION SYSTEM

Long Lake
#2

1. E
2. E
3. B. SAND
4. E
5 PE
6. PE
7. E
8. E (high PE)
9. E

21. ME
22. POTENTIAL EASEMENT
23. E - ATTEMPTED STABIL.
24. E
25. Potential easement
26. E

30. EASEMENT POTENTIAL

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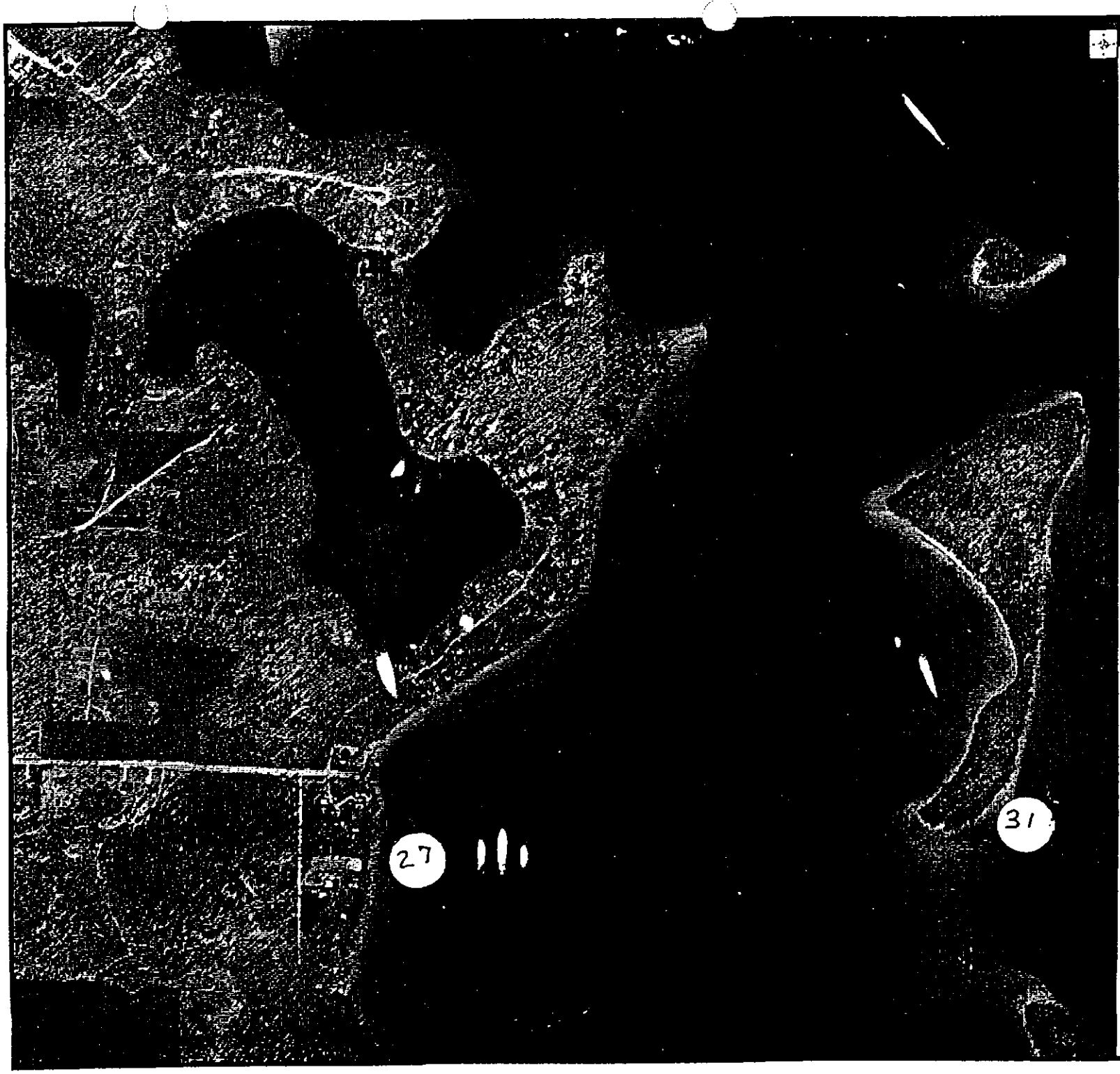
Plot date: May 25, 1999, n



GTC G I S

GRAND TRAVERSE COUNTY
GEOGRAPHICAL INFORMATION SYSTEM

Long Lake
3

27. E. Failing retaining wall

~~31.~~

31. E

32. E SEE PG #2

"

33. E

0 400 800 1200 Feet

1" = 810 feet

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GTC G S

GRAND TRAVERSE COUNTY
GEOGRAPHICAL INFORMATION SYSTEM

Long Lake
4

29. E

Nothing
INVENTORIED

0 400 800 1200 Feet

1"= 810 feet

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Plot date: May 25, 1999; nl

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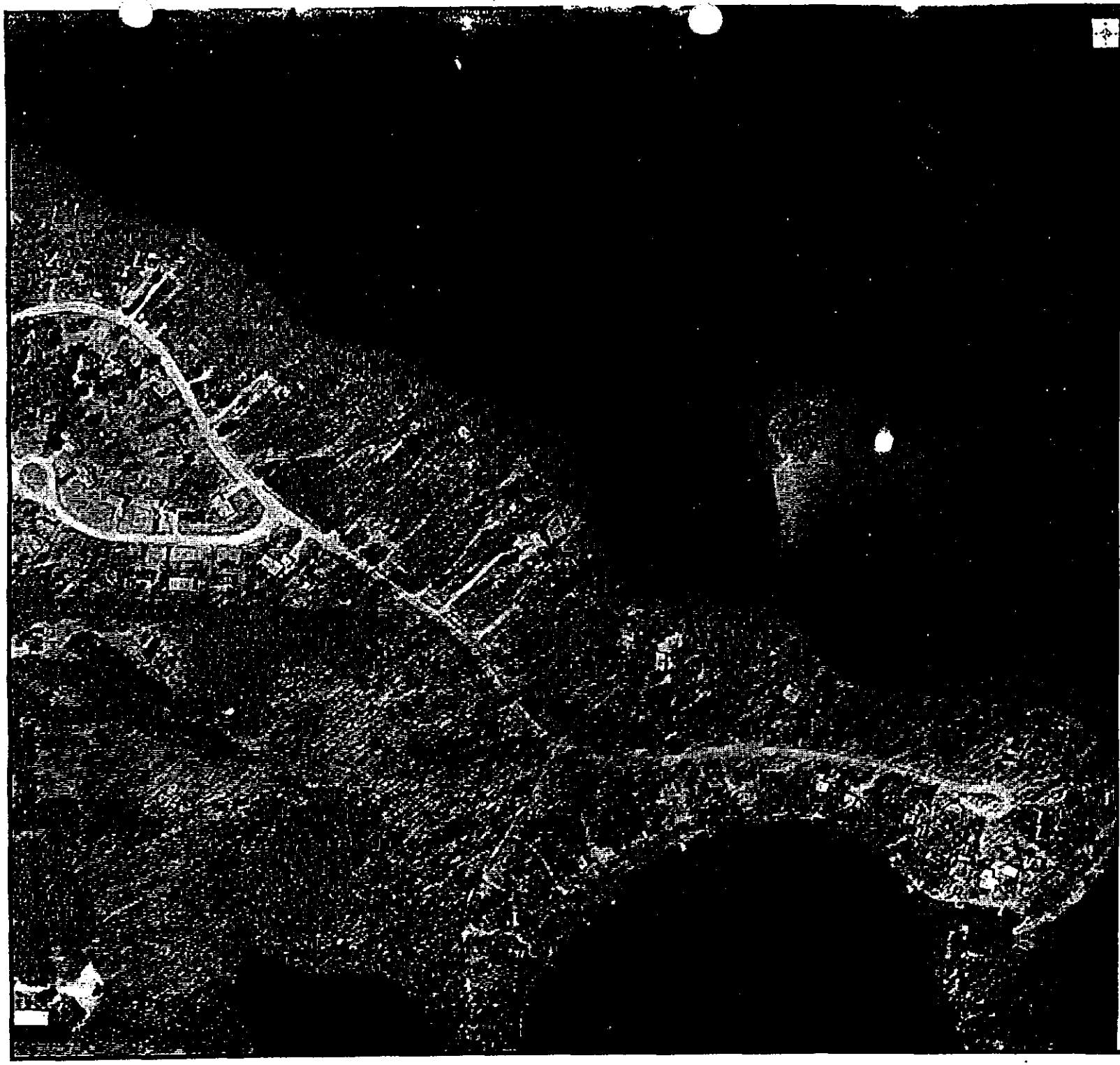

GTC G 1 S

GRAND TRAVERSE COUNTY
GEOGRAPHICAL INFORMATION SYSTEM

Long Lake
5

Nothing Inventoried

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GTC G I S

GRAND TRAVERSE COUNTY
GEOGRAPHICAL INFORMATION SYSTEM

Long Lake
6

R E

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Plot date: May 25, 1999; nl

Please recycle with office grade paper

Benzie Conservation District
207 S. Benzie Blvd., P.O. Box 428
Beulah, MI 49617

(616) 882-4391 • Fax: (616) 882-9767

RECEIVED
JAN - 9 2001
DRAIN COMMISSIONER OFFICE

January 8, 2000

Maureen K. Templeton
Grand Traverse County Drain Commissioner
2325 Garfield Road
Traverse City, MI. 49686

Maureen,

Enclosed are inventory sheets for four (4) road/stream crossing sites on the Platte River system that are within Grand Traverse County. This information should meet the MDEQ's requirement for implementation funding to correct these problems. Additional site plans and cost share information is needed as well.

If you choose not to seek implementation funding for the Long Lake watershed then it may be possible to cover these sites under future Platte River Project funding. Because of the severity of three of the sites, I feel that restoration plans should be made by either or both of our offices.

I look forward to your comments.

Sincerely,

Ron

Ron Harrison
Platte River Watershed Project Coordinator

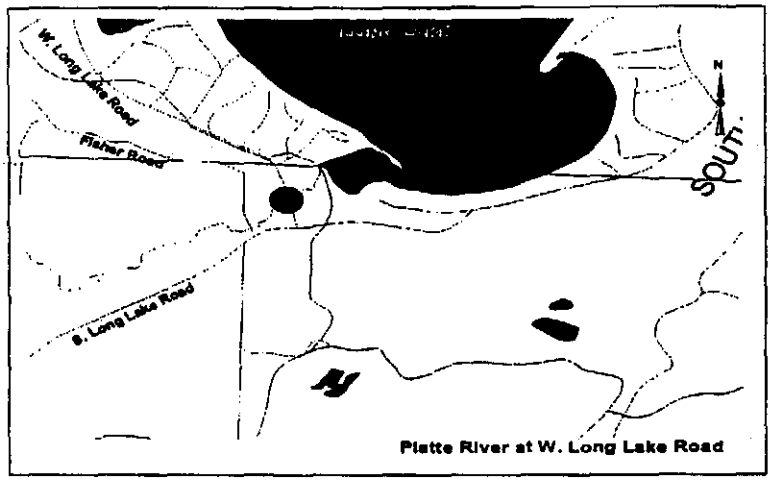
Platte River Watershed
Road/Stream Crossing
Field Data Form

LOCATION

Stream Name **Fisher Creek** Road Name **West Long Lake Road**

County **Grand Traverse** Township **Green Lake** Range _____ Section **3**

Map:



Crossing Type

___bridge
X metal culvert: ___single X twin ___triple ___quad
___box culvert

ROAD INFORMATION

Width at crossing 24 feet)
Average width of grade, including shoulders and ditches: 30 feet
Road Surface X paved
___ gravel
___ sand

Maintenance X year-round
___ seasonal

Location of low point: X crossing
___ other _____

Existing runoff control features:
___ swale/basin: ___ grassed ___ stone
___ check dam
___ curbing
X none
___ other _____
___ Functioning ___ Repairs needed

Crossing Approaches (looking downstream):

	Left		Right
Length:	___ ft		___ ft
Slope:	___	0%	___
	___	1-5%	___
	X	6-10%	X
	___	+10%	___

Ditch/shoulder vegetation:

Above		Below
___	None	___
___	Partial	___
X	Heavy	X

Dominant Veg. Grass Grass

Other Road Information: **Road runoff is discharged over vegetated shoulders and embankments.**

(Over)

CULVERT DESCRIPTION

Length 54ft
Shape Round
Diameter 24in

Construction: X galvanized
___ concrete
___ other _____

Flow through culvert: X clear
___ obstructed

Fish passage problem: ___ yes X no

Upstream ponding ___ yes X no
Downstream pool ___ yes X no

	Inlet		Outlet
Fill Depth:	____ ft		____ ft
Embankment:	____	vertical	____
	____	1:1	____
	____	1.5:1	____
	X	2:1	X
	____	+2:1	____

Other information: _____

STREAM CHARACTERISTICS

	Upstream		Downstream
Ave. Width	12 ft		12 ft
Ave. Depth	____ ft		____ ft
Channel substrate:	X	sand	X
	____	gravel	____
	____	snd/ grav	____
	____	silt	____

Est flow: -1 ft/sec
Adjacent wetland: X yes ___ no

Additional Stream Info: _____

CONCLUSIONS/COMMENTS

Extent of erosion:
X Minor ___ Moderate ___ Severe

Recommended for BMP Implementation:
___ Yes ___ No

Reason: **Repair minor rill erosion. Re-evaluate runoff controls.**

Photo1 **Downstream**

Photo 2 _____

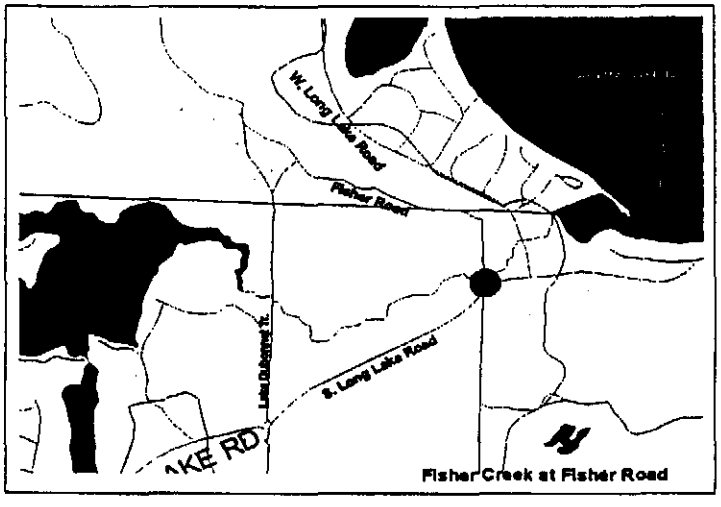
rsinven2.wpd (6/00)

Platte River Watershed
Road/Stream Crossing
Field Data Form

LOCATION

Stream Name **Fisher Creek** Road Name **Fisher Road**
County **Grand Traverse** Township **Green Lake** Range _____ Section **4**

Map:



Crossing Type
___bridge
X metal culvert: ___single X twin ___triple ___quad
___box culvert

ROAD INFORMATION

Width at crossing 24 feet)
Average width of grade, including shoulders and ditches: 32 feet
Road Surface ___ paved
X gravel
___ sand

Maintenance ___ year-round
X seasonal

Location of low point: X crossing
___ other _____

Existing runoff control features:
___ swale/basin: ___ grassed ___ stone
___ check dam
___ curbing
___ none
X other **Geo-text fabric over embankment**
___ Functioning X Repairs needed
No vegetation over fabric. Fabric is exposed.

Crossing Approaches (looking downstream):

	Left	Right
Length:	___ ft	___ ft
Slope:	___ 0%	___
	X 1-5%	X
	___ 6-10%	___
	___ +10%	___

Ditch/shoulder vegetation:

Above		Below
___	None	___
X	Partial	X
___	Heavy	___

Dominant Veg. **Grasses** **Grasses**

Other Road Information: _____

(Over)

CULVERT DESCRIPTION

Length 44 ft
Shape Arch
Diameter ___ in

Construction: X galvanized
___ concrete
___ other _____

Flow through culvert: ___ clear
X obstructed
Fish passage problem: X yes ___ no

Upstream ponding ___ yes X no
Downstream pool ___ yes X no

	Inlet		Outlet
Fill Depth:	3 ft		3 ft
Embankment:	___	vertical	___
	___	1:1	___
	X	1.5:1	X
	___	2:1	___
	___	+2:1	___

Other information: _____

STREAM CHARACTERISTICS

	Upstream		Downstream
Ave. Width	8 ft		8-10 ft
Ave. Depth	___ ft		___ ft
Channel substrate:	X	sand	___
	___	gravel	___
	___	snd/ grav	X
	X	silt	X

Est flow: -1 ft/sec
Adjacent wetland: X yes ___ no

Additional Stream Info: No Flow (7/00)

CONCLUSIONS/COMMENTS

Extent of erosion:
___ Minor ___ Moderate X Severe

Recommended for BMP Implementation:
X Yes ___ No

Reason: Severe road washouts above and below.

Photo1 Upstream

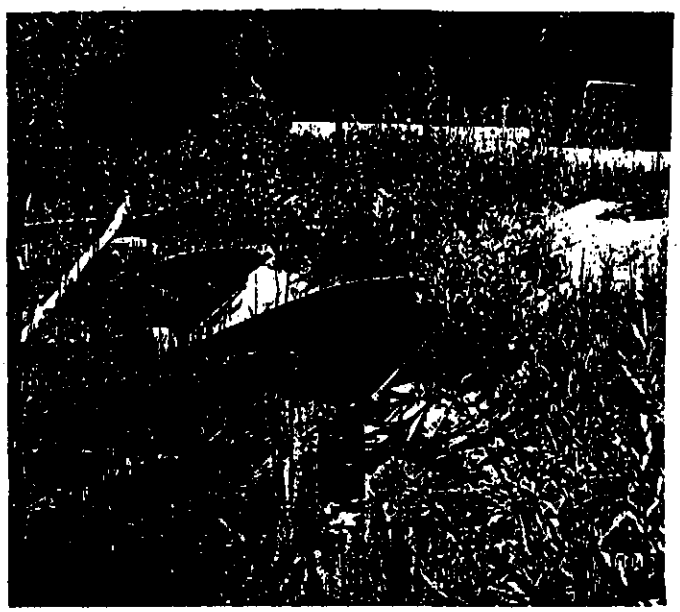
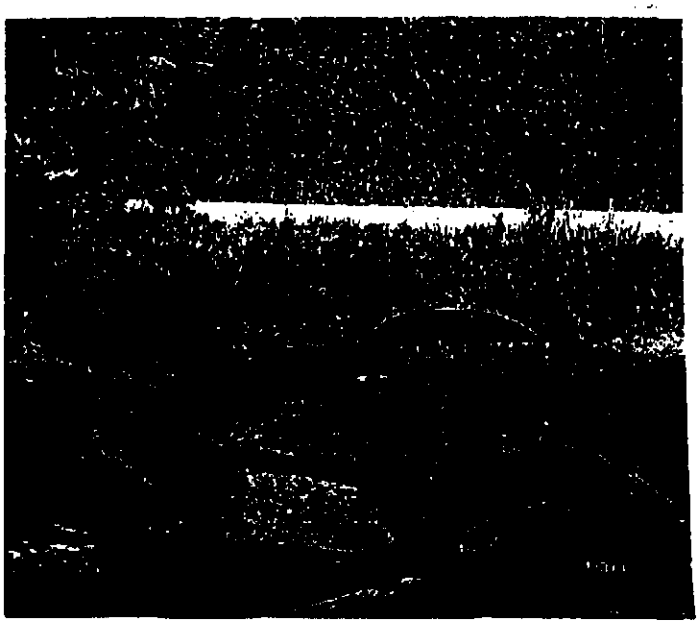


Photo 2 Downstream



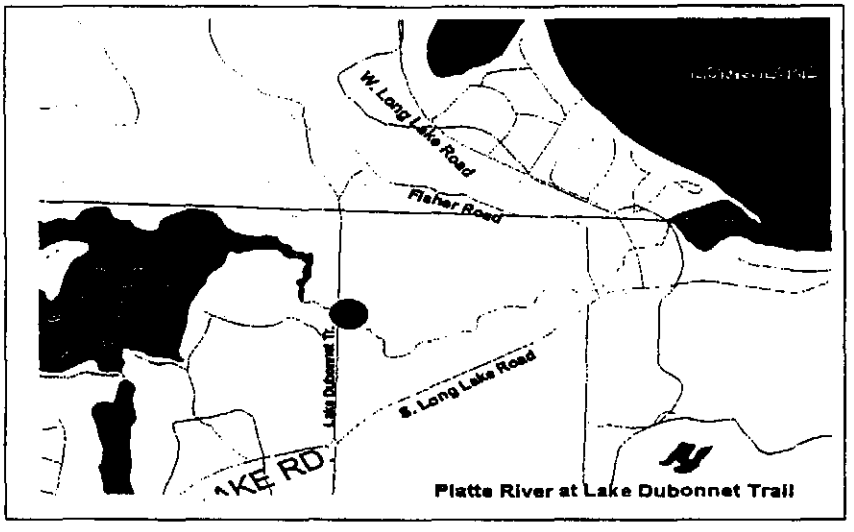
Platte River Watershed
Road/Stream Crossing
Field Data Form

LOCATION

Stream Name Fisher Creek Road Name Lake Dubonnet Trail

County Grand Traverse Township Green Lake Range _____ Section 4

Map:



Crossing Type
___bridge
X metal culvert: X single ___twin ___triple ___quad
___box culvert

ROAD INFORMATION

Width at crossing 15 feet)
Average width of grade, including shoulders and ditches: 20 feet
Road Surface ___ paved
X gravel
___ sand

Maintenance X year-round
___ seasonal

Location of low point: X crossing
___ other _____

Existing runoff control features:
___ swale/basin: ___ grassed ___ stone
___ check dam
___ curbing
___ none
X other Fabric/rock rip-rap at inlet
___ Functioning X Repairs needed ___
Fabric is exposed. Erosion at sides of wooden access steps.

Crossing Approaches (looking downstream):

	Left	Right
Length:	___ ft	___ ft
Slope:	___ 0%	___
	___ 1-5%	___
	X 6-10%	X
	___ +10%	___

Ditch/shoulder vegetation:

Above		Below
___	None	___
X	Partial	___
___	Heavy	X

Dominant Veg. _____ _____

Other Road Information: _____

(Over)

CULVERT DESCRIPTION

Length 40 ft
Shape Arch
Diameter 12 feet

Construction: X galvanized
___ concrete
___ other _____

Flow through culvert: X clear
___ obstructed
Fish passage problem: ___ yes X no

Upstream ponding X yes ___ no
Downstream pool ___ yes X no

	Inlet		Outlet
Fill Depth:	3 ft		3 ft
Embankment:	___	vertical	___
	X	1:1	X
	___	1.5:1	___
	___	2:1	___
	___	+2:1	___

Other information: _____

STREAM CHARACTERISTICS

	Upstream		Downstream
Ave. Width	30 ft		15 ft
Ave. Depth	1 ft		1 ft
Channel substrate:	X	sand	___
	___	gravel	___
	___	snd/ grav	X
	X	silt	X

Est flow: -1 ft/sec
Adjacent wetland: X yes ___ no

Additional Stream Info: _____

CONCLUSIONS/COMMENTS

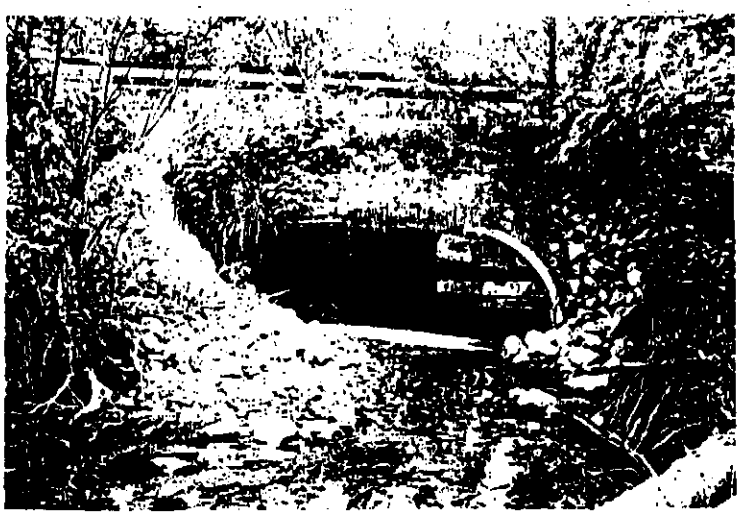
Extent of erosion:
___ Minor ___ Moderate X Severe

Recommended for BMP Implementation:
X Yes ___ No

Reason: **Active erosion from road runoff and foot traffic**

Photo1 **Upstream**

Photo 2 **Downstream**



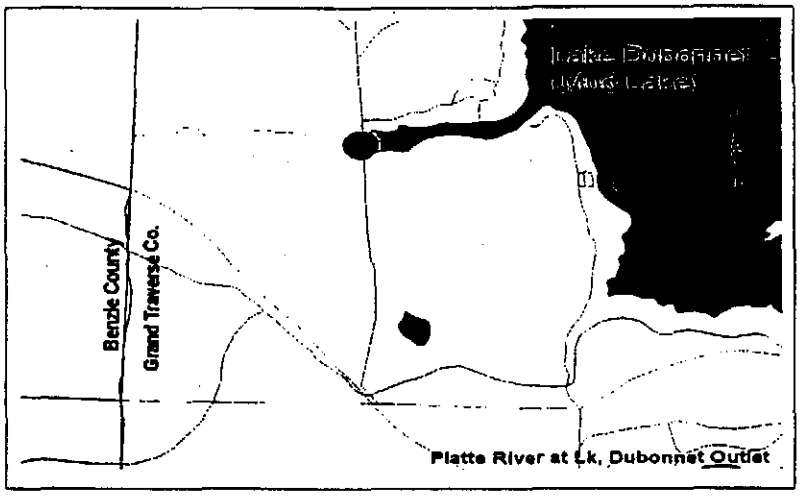
Platte River Watershed
Road/Stream Crossing
Field Data Form

LOCATION

Stream Name Platte River Road Name Unnamed-outlet at Lake Dubonnet

County Grand Traverse Township Green Lake Range _____ Section 6

Map:



Crossing Type

___bridge
X metal culvert: ___single X twin ___triple ___quad
___box culvert

ROAD INFORMATION

Width at crossing 18 feet)
Average width of grade, including shoulders and ditches: 30 feet
Road Surface ___ paved
X gravel
X sand

Maintenance ___ year-round
X seasonal

Location of low point: X crossing
___ other _____

Existing runoff control features:
___ swale/basin: ___ grassed ___ stone
___ check dam
___ curbing
X none
___ other _____
___ Functioning ___ Repairs needed

Crossing Approaches (looking downstream):

	Left	Right
Length:	+200 ft	+200 ft
Slope:	___ 0%	___
	X 1-5%	X
	___ 6-10%	___
	___ +10%	___

Ditch/shoulder vegetation:

Above		Below
___	None	___
X	Partial	X
___	Heavy	___

Dominant Veg. Grass/shrub Grass/shrub

Other Road Information: _____

(Over)

CULVERT DESCRIPTION

Length 80 ft
Shape Box w/tubes
Diameter 36 in

Construction: X galvanized
X concrete
____ other _____

Flow through culvert: ___ clear
X obstructed (dam)
Fish passage problem: X yes ___ no

Upstream ponding X yes ___ no
Downstream pool ___ yes X no

	Inlet		Outlet
Fill Depth:	____ ft		____ ft
Embankment:	____	vertical	____
	____	1:1	____
	____	1.5:1	____
	____	2:1	____
	X	+2:1	X

Other information: _____

STREAM CHARACTERISTICS

	Upstream		Downstream
Ave. Width	Pond ft		5 ft
Ave. Depth	____ ft		1 ft
Channel substrate:	____	sand	X
	____	gravel	____
	____	snd/ grav	____
	____	silt	____

Est flow: 1 ft/sec
Adjacent wetland: X yes ___ no

Additional Stream Info: Small pool below right-downstream culvert. Stream regains normal pattern below.

CONCLUSIONS/COMMENTS

Extent of erosion:
____ Minor ___ Moderate X Severe

Recommended for BMP Implementation:
X Yes ___ No

Reason: Active erosion from road runoff and foot traffic

Photo1 Upstream

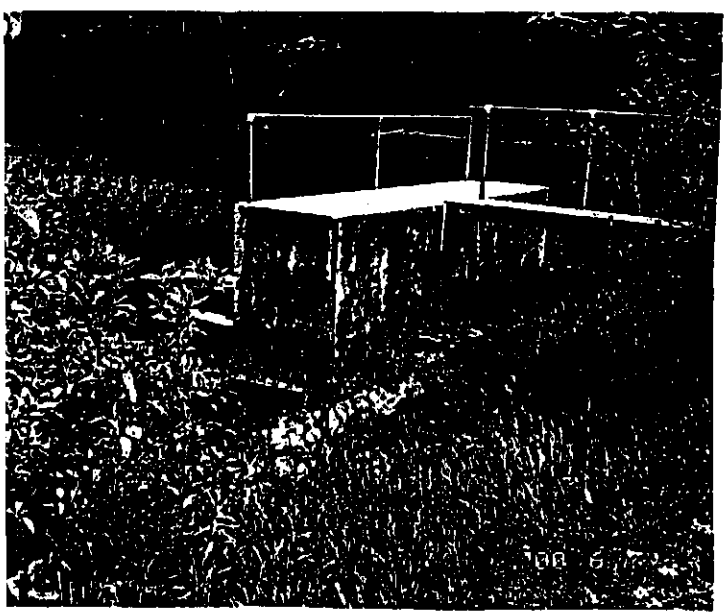


Photo 2 Downstream

Appendix E1

2006 Shoreline Survey of Long and Mickey Lakes

2006 SHORELINE SURVEY OF LONG AND MICKEY LAKES

In addition to water quality monitoring of Long Lake, the four year monitoring plan included the visual observation of the lake nearshore areas to determine instances of erosion, sedimentation, possible nutrient enrichment and well as observation of lakeside residences which might have outdated septic systems contributing nutrients or bacterial contamination to the lake.

The shoreline survey was conducted by Great Lakes Environmental Center (GLEC) along with members of the Long Lake Association over several days in August, 2006. The survey was completed using a pontoon boat which was able to move close to shore to enhance the visual observations. Global Positioning System (GPS) readings were taken at designated sites (See Figure 1) and relevant observations regarding shoreline characteristics (aquatic vegetation, erosion, homeowner landscaping, age of structures) was recorded for each site. The summary of these observations is presented in Table 1. These observations were used as a basis for determining sediment sampling sites and bacterial monitoring sites which were conducted later in the summer by GLEC.

Examination of the data collected by GLEC and the Long Lake Association in the shoreline survey did not show any new significant areas of concern that were not already identified in the 2001 Long Lake Watershed Management Plan and under observation by Lake Association members. A number of older residential structures were noted as possible sources of leaking septic systems, and will possibly be used to obtain any available septic system records from the Grand Traverse County Department of Environmental Health. The occurrence of high aquatic plant density in various spots on Long and Mickey Lakes was observed. In addition, lakeside residences with landscaping to the waters edge (e.g., lawn) or sites without a buffer area of native vegetation were noted. Continuing education of riparians is necessary, in the absence of specific zoning, to address the lack of buffer areas and to elucidate the importance of vegetation buffers in maintaining lake water quality.

Overall, Long and Mickey Lake shorelines appeared to be stable with no significant problem areas. Although a few erosion sites were noted, these sites did not seem problematic. The relatively high lakeside population continues to pose a challenge in terms of nutrient runoff from landscaping.

Figure 1. 2006 Shoreline survey sampling sites. Numbered sites indicate sediment sampling selections.

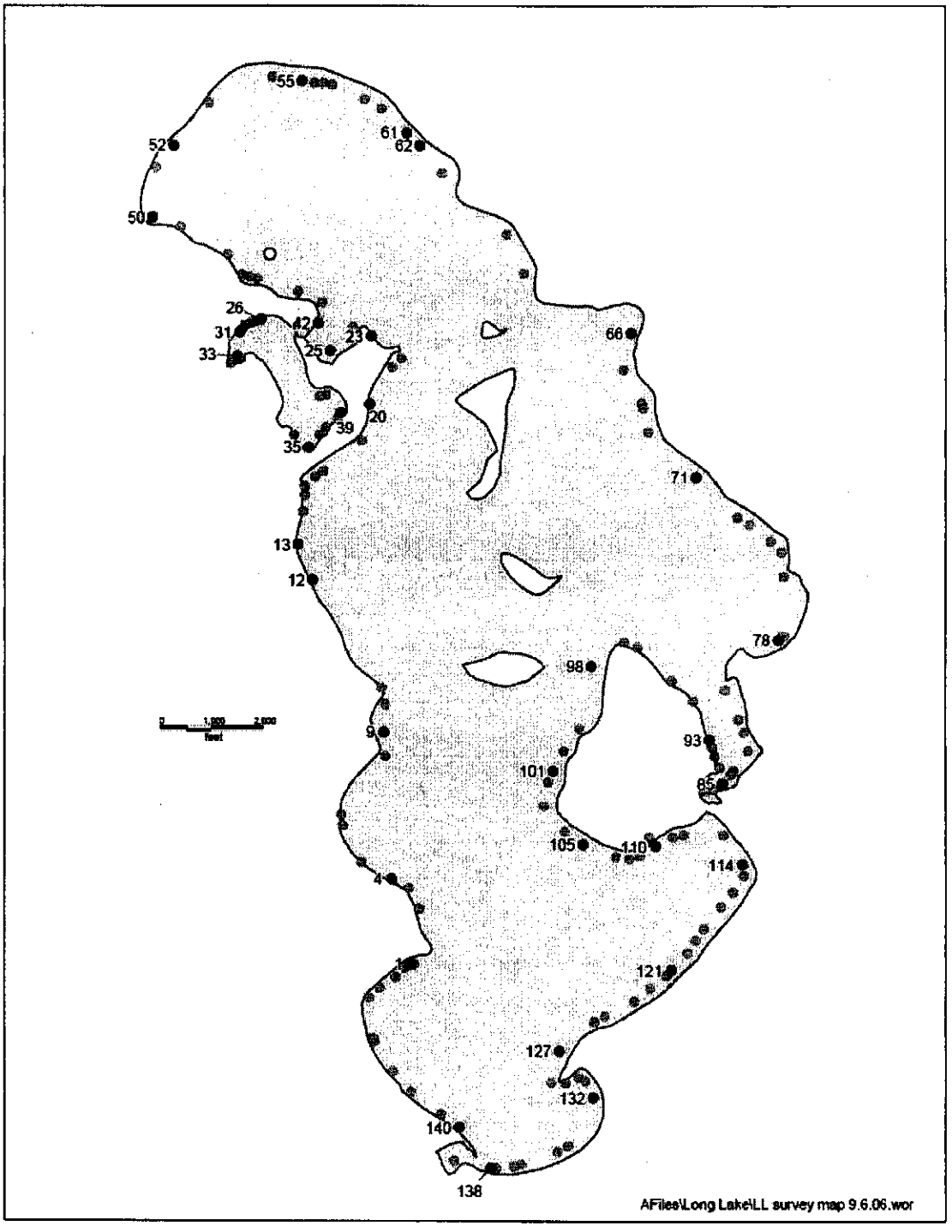


Table 1. Shoreline survey for Long and Mickey Lakes, July 2006

Long Lake Shoreline Survey 7-25-06 and 7-27-06

Bob Doerr, Ron Albers, Lois Feichtenbiner, Jennifer Hansen (GLEC)

Site #	GPS	GPS	Shoreline Observations	Structure/Septic concerns	Erosion Concerns	Observed Algae
2	N44.70146	W085.75502	Grass to shore or wall; little to no buffer area.			
3	N44.70257	W085.75581	Grass to shore or wall; little to no buffer area.			
5	N44.70402	W085.75936	Grass to shore or wall; little to no buffer area.			
6	N44.70604	W085.76080	Grass to shore or wall; little to no buffer area.			
7	N44.70662	W085.76086	Grass to shore or wall; little to no buffer area.			
8	N44.70978	W085.75761	Grass to shore or wall; little to no buffer area.			
10	N44.71265	W085.75760	Grass to shore or wall; little to no buffer area.		No buffer at end of road.	
11	N44.71347	W085.75795	Grass to shore or wall; little to no buffer area.			
14	N44.72299	W085.76376			Erosion area.	
15	N44.72394	W085.76373			Erosion area.	
16	N44.72438	W085.76370	Grass to shore or wall; little to no buffer area.			
17	N44.72493	W085.76291	Grass to shore or wall; little to no buffer area.			
18	N44.72519	W085.76235	Grass to shore or wall; little to no buffer area.			
19	N44.72690	W085.75936	Grass to shore or wall; little to no buffer area.			
21	N44.73087	W085.75707	New plantings. (fertilizer?)		Erosion. Newer house, patchy dirt.	
22	N44.73143	W085.75642	Grass to shore or wall; little to no buffer area.			
24	N44.73309	W085.76007	Little to no buffer area for most new lots in this area.		Erosion area. Several new builds.	
27	N44.73345	W085.76736	Grass to shore or wall; little to no buffer area.			
28	N44.73332	W085.76784	Grass to shore or wall; little to no buffer area.			
29	N44.73316	W085.76822	Grass to shore or wall; little to no buffer area.			
30	N44.73302	W085.76837	Grass to shore or wall; little to no buffer area.			
32	N44.73105	W085.76927				
34	N44.72724	W085.76446	Grass to shore or wall; some buffer area.			
36	N44.72720	W085.76255	Grass to shore or wall; little to no buffer area.			
37	N44.72762	W085.76206	Grass to shore or wall; little to no buffer area.			
38	N44.72813	W085.76118	Grass to shore or wall; little to no buffer area.			

Table 1. Shoreline survey for Long and Mickey Lakes, July 2006

Site #	GPS	GPS	Shoreline Observations	Structure/Septic concerns	Erosion Concerns	Observed Algae
40	N44.72940	W085.76213	Grass to shore or wall; little to no buffer area.	Suspect septic, cabin close to water.		
41	N44.72935	W085.76265	Grass to shore or wall; little to no buffer area.			
43	N44.73437	W085.76243	Grass to shore or wall; little to no buffer area.			
44	N44.73496	W085.76420			Erosion area, little plant cover, dirt to shore.	
45	N44.73565	W085.76727			Potential erosion area.	
46	N44.73575	W085.76789	Grass to shore or wall; little to no buffer area.			
47	N44.73588	W085.76843			Erosion area.	
48	N44.73702	W085.76945			Potential erosion, new construction, but with buffer.	
49	N44.73850	W085.77311			Sm. Erosion area.	
			Grass to beach to water. No buffer area.			
			Grass to shore or wall; little to no buffer area.			
51	N44.74172	W085.77491	Grass to shore or wall; little to no buffer area.			
53	N44.74517	W085.77090	Grass to shore or wall; little to no buffer area.			
54	N44.74660	W085.76615	Grass to shore or wall; little to no buffer area.			
56	N44.74634	W085.76299	Grass to shore or wall; little to no buffer area.			
57	N44.74630	W085.76229	Grass to shore or wall; little to no buffer area.			
58	N44.74616	W085.76155			Potenial erosion area.	
59	N44.74539	W085.75919	Grass to shore or wall; little to no buffer area.			
60	N44.74490	W085.75791	Sand to shore; little to no buffer.			
63	N44.74137	W085.75327	Grass to shore or wall; little to no buffer area.			
64	N44.73809	W085.74837	Sand to shore; little to no buffer.			
65	N44.73600	W085.74705			Erosion site, patchy dirt.	
67	N44.73080	W085.73946	Grass to shore or wall; little to no buffer area.			
68	N44.72900	W085.73807	Grass to shore or wall; little to no buffer area.			
69	N44.72868	W085.73802			Erosion area, new home.	
70	N44.72740	W085.73762			Erosion area.	
72	N44.72271	W085.73092			Erosion down bank.	
73	N44.72230	W085.73000	Grass to shore or wall; little to no buffer area.			
74	N44.72141	W085.72835	Grass to shore or wall; little to no buffer area.			
75	N44.72077	W085.72759	Grass to shore or wall; little to no buffer area.			
76	N44.71949	W085.72739	Grass to shore or wall; little to no buffer area.			
77	N44.71634	W085.72736	Grass to shore or wall; little to no buffer area.			
79	N44.71341	W085.73180	Grass to shore or wall; little to no buffer area.			

Table 1. Shoreline survey for Long and Mickey Lakes, July 2006

Site #	GPS	GPS	Shoreline Observations	Structure/Septic concerns	Erosion Concerns	Observed Algae
80	N44.71183	W085.73078	Grass to shore or wall; little to no buffer area.			
81	N44.71105	W085.73044		Close to water; newer or remodeled.		
82	N44.71006	W085.73006	Grass to shore or wall; little to no buffer area.			
83	N44.70905	W085.73119	Grass to shore or wall; little to no buffer area.			
84	N44.70879	W085.73145		Suspect septic, cabin/house close to water.		
86	N44.70827	W085.73201	Grass to shore or wall; little to no buffer area.			
87	N44.70797	W085.73270	Grass to shore or wall; little to no buffer area, continued.			
88	N44.70786	W085.73326	Grass to shore or wall; little to no buffer area.			
89	N44.70798	W085.73346	Grass to shore or wall; little to no buffer area, continued.			
90	N44.70915	W085.73224	Grass to shore or wall; little to no buffer area.			
91	N44.70981	W085.73259	Grass to shore or wall; little to no buffer area, continued.			
92	N44.71027	W085.73280		Suspect septic, cabin/house close to water.		
94	N44.71278	W085.73419	Grass to shore or wall; little to no buffer area, continued.	Suspect septic, cabin/house close to water; continued from last coord.		
95	N44.71391	W085.73576	Grass to shore or wall; little to no buffer area.			
96	N44.71568	W085.73841		Suspect septic, cabin/house close to water.		
97	N44.71603	W085.73943	Grass to shore or wall; little to no buffer area.			
99	N44.71127	W085.74280			Potential Erosion/runoff area. No ground cover.	
100	N44.71005	W085.74404		Suspect septic, cabin/house close to water.		
102	N44.70838	W085.74525		Suspect septic, cabin/house close to water.		
103	N44.70711	W085.74552	Grass to shore or wall; little to no buffer area.			
104	N44.70566	W085.74389		Suspect septic, cabin/house close to water.		
106	N44.70433	W085.73997	Grass to shore or wall; little to no buffer area.			
107	N44.70424	W085.73901	Grass to shore or wall; little to no buffer area.			
108	N44.70444	W085.73824	Grass to shore or wall; little to no buffer area.			
109	N44.70541	W085.73751		Suspect septic, cabin/house close to water.		
111	N44.70541	W085.73566	Grass to shore or wall; little to no buffer area, continued.			
112	N44.70551	W085.73489	Grass to shore or wall; little to no buffer area.	Suspect septic, cabin/house close to water.		
113	N44.70549	W085.73195	Grass to shore or wall; little to no buffer area, continued.	Suspect septic, cabin/house close to water; continued from last coord.		
115	N44.70333	W085.73035	Grass to shore or wall; little to no buffer area.			
116	N44.70235	W085.73115	Grass to shore or wall; little to no buffer area, continued.			

Table 1. Shoreline survey for Long and Mickey Lakes, July 2006

Site #	GPS	GPS	Shoreline Observations	Structure/Septic concerns	Erosion Concerns	Observed Algae
117	N44.70158	W085.73210	Grass to shore or wall; little to no buffer area.			
118	N44.70037	W085.73340	Grass to shore or wall; little to no buffer area.			
119	N44.69977	W085.73401	Grass to shore or wall; little to no buffer area.			
120	N44.69912	W085.73460	Grass to shore or wall; little to no buffer area, continued.			
122	N44.69788	W085.73618		Suspect septic, cabin/house close to water.		
123	N44.69719	W085.73735	Grass to shore or wall; little to no buffer area.			
124	N44.69651	W085.73863	Grass to shore or wall; little to no buffer area.			
125	N44.69565	W085.74076	Grass to shore or wall; little to no buffer area.			
126	N44.69543	W085.74160	Grass to shore or wall; little to no buffer area, continued.			
128	N44.69210	W085.74487				
129	N44.69212	W085.74381				Algae globs in weeds. (2)
130	N44.69243	W085.74279	Grass to shore or wall; little to no buffer area.			
131	N44.69223	W085.74233	Grass to shore or wall; little to no buffer area, continued.			
133	N44.68867	W085.74359	Grass to shore or wall; little to no buffer area, continued.	Suspect septic, cabin/house close to water; continued from last coord.		
134	N44.68837	W085.74443	Grass to shore or wall; little to no buffer area.	Suspect septic, cabin/house close to water.		
135	N44.68767	W085.74715	Grass to shore or wall; little to no buffer area, continued.	Suspect septic, cabin/house close to water; continued from last coord.		
136	N44.68761	W085.74770	Grass to shore or wall; little to no buffer area.	Suspect septic, cabin/house close to water.		
137	N44.68753	W085.74912	Grass to shore or wall; little to no buffer area, continued.	Suspect septic, cabin/house close to water; continued from last coord.		
139	N44.68787	W085.75230	Grass to shore or wall; little to no buffer area, continued.	Suspect septic, cabin/house close to water; continued from last coord.		
141	N44.69037	W085.75331	Grass to shore or wall; little to no buffer area.			
142	N44.69157	W085.75557	Grass to shore or wall; little to no buffer area.			
143	N44.69271	W085.75704	Grass to shore or wall; little to no buffer area.			
144	N44.69429	W085.75841	Grass to beach to shore; little to no buffer area.			
145	N44.69448	W085.75854	Grass to shore or wall; little to no buffer area.			
146	N44.69673	W085.75875		Suspect septic, cabin/house close to water.		
147	N44.69720	W085.75799	Grass to shore or wall; little to no buffer area.	Suspect septic, cabin/house close to water.		
148	N44.69781	W085.75684	Grass to shore or wall; little to no buffer area, continued.	Suspect septic, cabin/house close to water; continued from last coord.		
149	N44.69828	W085.75607		Suspect septic, cabin/house close to water.		
150	N44.69854	W085.75535	Grass to shore or wall; little to no buffer area.			Near seagull roosting area.
	N	W				Algal bloom. (1)
	NOTES: (1) Algal bloom identified as *Gleotrichia echinulata* (2) Globs or clouds of algae tentatively identified as Metaphyton (several different					

Appendix E2

2006 Sediment Sampling Long and Mickey Lakes

2006 SEDIMENT SAMPLING ON LONG AND MICKEY LAKES

The overall monitoring project developed by GLEC indicated that a comprehensive sediment sampling of nearshore areas could be useful in relating observed characteristics of the Lake, such as sparse or dense areas of aquatic vegetation, with sites of likely nutrient enrichment from groundwater runoff. By examining the sediment reservoir of one of the primary plant nutrients, total phosphorus, it was hoped that some insight could be gained to explain the distribution of aquatic plants, as well as identify problem areas which should be addressed through the Long Lake Watershed Management Plan or through an aquatic plant management plan (to be developed as part of this four year project).

Sampling sites for sediment sampling were determined by examining the data from the Shoreline Survey, conducted in August, 2006. Sites were chosen based on visual observation notes (possible areas of concern) and were also chosen to provide a geographical balance by distributing the sites around the lake. Sites chosen for sediment sampling are highlighted on the shoreline survey data table (Table 1) and are also indicated on Figure 1 as the black circles. Sediment was obtained nearshore by a the use of a dredge and samples were placed in a 1 liter glass bottle and analyzed by the chemistry laboratory at GLEC for total phosphorus and percent solids. The value for percent solids is an indication of the organic content of the sample. The higher the percent solids (e.g., sand), the less organic matter in the sample. As the proportion of organic matter in the sample increases (lower % solids), the greater the ability of the sediment to capture phosphorus.

In general, sediment phosphorus levels were low, usually less than 30 mg/kg dry weight. This may be due in part to a lower organic content in many of the samples.
Ten sampling sites which had concentrations greater than 40 mg/kg dry weight were identified (Table 2), and checked against the observations in the shoreline survey. In many cases, Eurasian milfoil was present near the site, particularly in the northern extent of the lake, as well as the southeast corner below the peninsula, and in some areas near Mickey Lake (see aquatic macrophyte map, Figure 2). In a majority of the cases, there

were also suspected septic problems, erosion noted, or closely spaced cabins near the water. Five of these ten sites (#'s 25,33,29,61 and 85) had phosphorus concentrations in excess of 100 mg/kg dry weight, and should be watched to see if they become problem areas for aquatic vegetation or algal blooms. For reference, two randomly selected sites which were deemed "Clear sites", with no aquatic vegetation and no observed algal problems, exhibited phosphorus concentrations of 27 and 11 mg/kg dry weight. Additionally, the sediment phosphorus concentrations determined in the deep sampling spots (2005 interim report) were 33 mg/kg (Deep site #2), 322 mg/kg (Deep site #1) and 654 mg/kg (Deep site #3). Phosphorus appears to be accumulating in these deeper areas as opposed to the shallow nearshore areas.

Figure 1. 2006 Shoreline survey sampling sites. Numbered sites indicate sediment sampling selections.

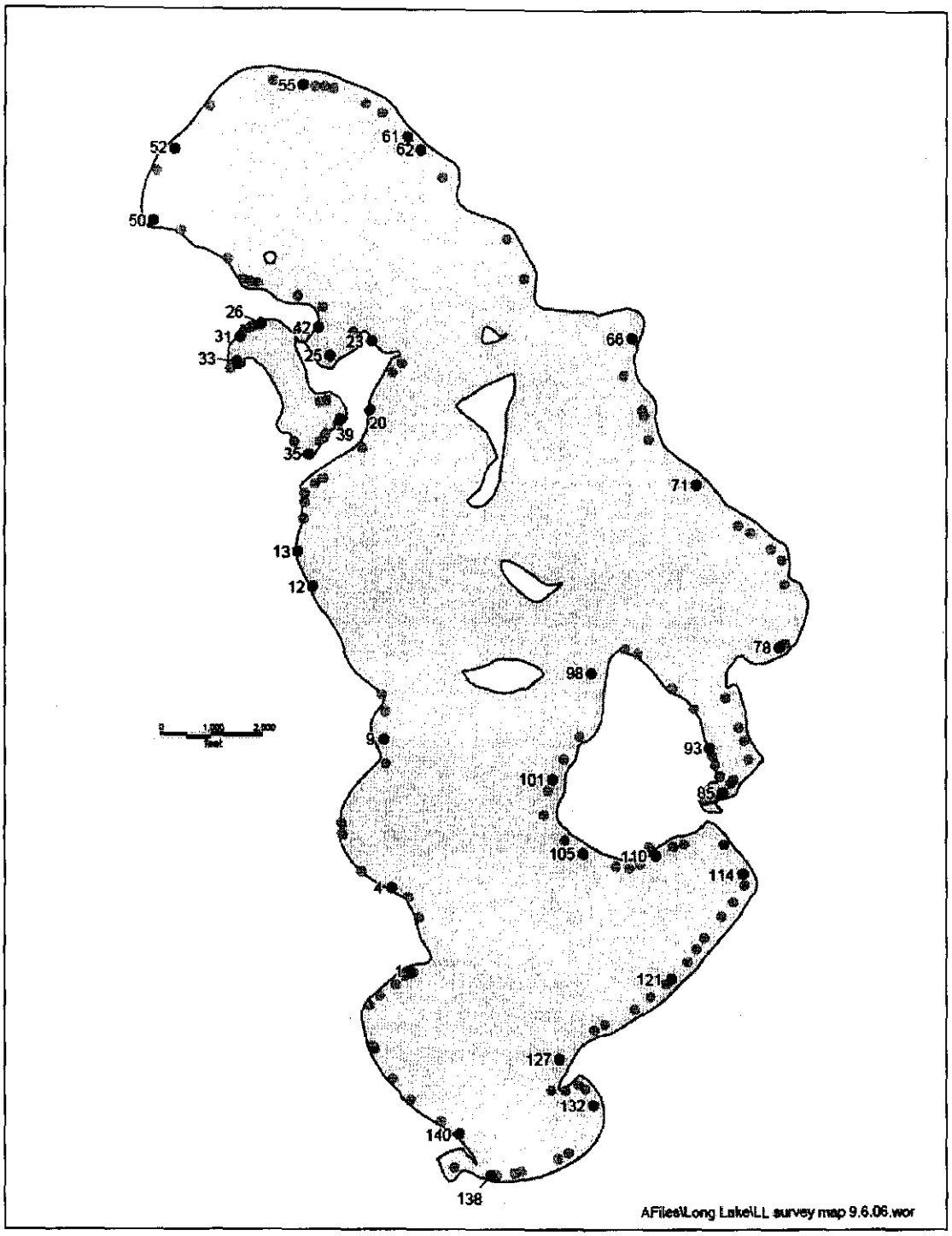


Table 2. Total Phosphorus (kg/mg dry weight) and Percent Solids of Nearshore Sediment Samples taken from Long and Mickey Lakes

Sampling Site #	Total Phosphorus (mg/kg dry wt)	Percent Solids
1	21.49	63.16
4	15.48	73.91
9	7.37	70.81
12	11.79	63.39
13	**44.31**	66.87
20	14.33	72.38
23	20.67	72.22
25	**101.9**	71.58
26	25.86	61.86
31	22.04	35.41
31 (duplicate)	23.15	36.46
33	**168.4**	3.84
35	**80.6**	2.61
39	**189.5**	3.7
42	14.2	59.44
50	10.96	69.08
52	**52.15**	54.57
55	**58.87**	68.75
61	**179.8**	64.99
62	29.08	67.08
66	16.83	65.29
66 (duplicate)	15.4	37.01
71	10.52	69.68
71 (duplicate)	10.99	67.15
78	17.57	64.94
85	**278.7**	5.25
85 (duplicate)	**272.1**	5.09
93	3.65	74.61
98	7..95	70.19
101	**47.21**	57.42
105	26.04	69.2
110	15.58	74.34
114	237	22.01
121	13.54	61.25
127	8.23	75.83
132	12.18	73.65
138	12.95	70.64
140	7.64	73.99

Random Clear 1	27.26	64.82
Random Clear 2	11.29	73.49

Samples in Boldface exceed 40 mg/kg dry weight

Appendix E3

2006 Bacterial Sampling Long and Mickey Lakes

2006 BACTERIAL MONITORING ON LONG AND MICKEY LAKES

Bacterial monitoring on Long and Mickey Lakes was completed in summer of 2006. Samples were chosen based on observations from the shoreline survey completed earlier in the summer. Shoreline survey sites which identified older structures with probable original septic systems, older structures with little lakeside setback, and closely spaced groups of cabins or cottages were chosen as some of the bacterial monitoring sites. Twelve sites, geographically spread around Long and Mickey Lakes, were chosen for monitoring (Figure 1, site numbers listed at right). Samples were collected and analyzed at GLEC within 6 hours of collection. Samples were all analyzed for *E. coli* using EPA Method 1603. An indicator organism, such as *E. coli*, is used to determine fecal contamination. The presence of *E. coli*, a normally non-pathogenic intestinal organism of warm-blooded animals, is easy to test for and is relatively more abundant than the human enteric pathogens, thus leaving a safety margin for the detection of disease-causing organisms. *E. coli* is considered a more specific indicator of fecal contamination than fecal coliforms since the more general test for fecal coliforms also detects non-fecal coliform bacteria. Currently, the State of Michigan single day standard for *E. coli* is 300 CFU (colony forming unit) per 100 mL sample, based on triplicate samples. It was decided that bacterial monitoring on Long Lake would preliminarily use single samples (rather than triplicates) in order to find any potential "hot" spots. These hot spots could then be resampled, as necessary, in triplicate to determine whether or not they exceed the State of Michigan standards.

The results of the bacterial testing did not indicate high numbers of *E. coli*, suggesting that fecal contamination in Long Lake at these suspected sites was not a problem. The data (Table 3) show that only two sites of the twelve monitored had bacterial counts greater than 1 CFU per 100 mL sample, and these sites had counts of 4 and 6 CFU/100 mL. These concentrations are extremely low. It should be noted that bacterial concentrations can be quite transient, and therefore any sample collection may miss a potential septic discharge if it isn't collected within 48 – 72 hours of a discharge. In addition, the dilution effect of the lake water can also reduce concentrations. However,

the consistently low bacterial concentrations observed in Long Lake do not suggest that this is would be an ongoing concern. Periodic reexamination of *E. coli* concentrations at those sites identified as possible contamination spots would be easy and cost effective.

Table 3. Levels of *E. coli* bacteria at selected nearshore monitoring sites On Long and Mickey Lakes, August, 2006.
Sampling site numbers correspond to shoreline survey sites (see Appendix E1)

Sampling Site	Concentration (CFU/100 mL)*
1	0**
13	1
20	0
26	1
35	6
61	0
66	4
78	1
114	1
121	1
138	1
140	1

*CFU = Colony forming Unit

** State Standard for singe event sample
(based on geometric mean of 3 replicates) = **300 CFU/100 mL**

Appendix F

Residential Lakeshore Zoning Ordinance Review

CENTER FOR WATERSHED PROTECTION

Memorandum

To: Ms. Maureen Kennedy Templeton
Grand Traverse County Drain Commissioner

Mr. Ron Harrison
Watershed Technician - Grand Traverse County

From: Center for Watershed Protection
Tom Schueler and Ted Brown

Date: January 28, 2000

Re: Review of Draft Ordinance for Long Lake Township's Lake Residential District

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Thanks for the opportunity to review the draft Long Lake Township's R-2 Lake Residential District Ordinance that you previously transmitted to us. We think it is a good start, but have some suggested improvements and refinements that might improve its ability to protect lake quality considerably.

It should be noted at the outset that our comments address some issues such as septic system treatment, stormwater treatment and nutrient loading goals which are not contained in the current draft, but may be covered under other local ordinances or regulations (or may exceed the scope of local zoning authority).

Comments

Phosphorus Loadings and Shoreline Disturbance Reduction

The most common impact of shoreline development is the increased phosphorus load contributed by nonpoint sources of pollution (including failing septic systems, lawn fertilizers, stormwater runoff, and a loss of buffering capacity). While it is unreasonable to expect landowners to meet a numeric performance standard for phosphorus loading, it is nevertheless important to convey why various management practices are needed to minimize phosphorus loads to lake systems. The language in the preamble section of the ordinance (9.1) could be amended to indicate that one purpose of the ordinance is to protect the lakes by reducing nonpoint phosphorus loads through shoreline buffers, better site design and natural area conservation.

Reduce Impervious Cover Threshold for Waterfront Parcels from 20% to 12%.

Prior research has shown that the typical impervious cover associated with 2-acre lot development is about 8 to 12%, including the road system. The 20% threshold is very generous. We have

attached (Attachment A) some sketch drawings that illustrate this point for 2-acre lot single family homes with a depth to width ratio of 4:1 and 1:1. Assuming a 4,000 square foot home, a four car parking area and a 15 foot connecting driveway (all extremely generous assumptions), we compute a total impervious cover of 12.4% and 7.5.% respectively (see Attachment A). The limitation of impervious cover is an integral element of the stormwater treatment plan.

Perhaps the impervious surface requirement under the site plan review requirements section (9.5.1) could be expressed in terms of a percentage and a not to exceed square footage. We would recommend a 12% lot coverage, with a maximum of 10,000 square feet. The square footage is a measurable benchmark that site plan reviewers can easily verify. An example of such language is provided in Waupaca County, Wisconsin's shoreline ordinance that states that impervious cover is limited to "no more than 25% of each shoreland lot, or 10,000 ft^2, whichever is less" (Standing et al., 1997). In addition, limits on total allowable disturbance during construction should be considered. Once again, Waupaca County, Wisconsin has a requirement that no more than 50% or 20,000 ft^2, whichever is less, may be disturbed on one acre shoreline residential lots (Standing et al., 1997).

Setbacks from Lakes for Septic Systems

For septic system considerations, the local Department of Health should likely be consulted for any existing guidance; however, we feel that the ordinances should specifically state that septic leach fields should be located outside of the proposed buffer (i.e, 100 feet from the shoreline). The way the ordinance is currently written one could clear trees within 25 feet of the shoreline in order to put in their leach field. From a water quality standpoint, a 150 foot setback would be ideal, and justifiable based on public health and nutrient loading considerations. The language in the buffer should also require a 100 foot setback between drain fields and water supply wells. We are not sure whether Michigan septic system requirements specify whether reserve fields are needed. If they are, then reserve field requirements should clearly specify that these areas need not be cleared of vegetation until they are actually needed.

Prior studies have shown that existing and new septic systems can be a source of phosphorus to lakes, and it may be advisable to suggest that more advanced septic technologies be used (such as recirculating sand filter systems). Even if this cannot be done, the ordinance should have some language about septic system maintenance requirements. For example, the ordinance could include a requirement to have systems inspected and cleaned on a 3 to 5 year basis. If this is deemed to be too much of an administrative burden, then a significant public education effort should be undertaken to have septic systems maintained.

Improving Stormwater Treatment

One of the real challenges is to reduce stormwater runoff from these lots without requiring complicated practices that confuse the owners and add to the local plan review burden. Our suggested approach is a simple one.

1. State in the buffer section that no new pipes or channels can be constructed to convey stormwater across the buffer (i.e., sheet flow conditions must be maintained).

2. Impervious cover must be less than 12% for the site.

3. Rooftop runoff must be disconnected (pretty easy to do on a 2-acre lot).

4. Driveways must be either (a) graded for sheetflow across the lot (i.e., no ditches) or (b) is constructed of less permeable material (e.g. river rock, blue stone, or grass pavers).

5. A minimum of one half of the lot area must be retained as natural vegetative cover, by deed restriction. This area cannot be disturbed during site construction, and would be shown as limits of disturbance on the erosion and sediment control (ESC) plan

Lots that meet these five requirements would be presumed to automatically meet stormwater quality requirements (i.e, these are minimum stormwater requirements for the shoreline lot -See Attachment B)

Lots that do meet these requirements must submit a stormwater plan that includes structural stormwater practices that treat the first inch of stormwater prior to entry into the buffer, prepared by a licensed engineer.

Most folks should have no difficulty meeting the five criteria, and would want to avoid the cost and hassle of doing a formal stormwater plan. Those that have unusual site conditions, and can't meet the five criteria would have to do the plan (which in most cases would involve an 800 to 1,000 square foot bioretention area in Tier 3 of the buffer).

Cluster or Open Space Development

If cluster or open space development options are allowed under general zoning, it would be worth adding a few sentences to describe how such subdivisions should be designed to protect the lake. For example, a "green space" target of 75% would be appropriate for such large residential lots.

Clearing of the Shoreline Buffer

The 3-tier buffer described in the site plan review standards section (9.5.2) is a good start; however, some minor revisions should be considered. Of greatest concern are the 30% clearing and 50% clearing thresholds that are allowed in Tier 1 and Tier 2. The ordinance should indicate that clearing is allowed for the purposes of a viewing lake corridor, and the amount that can be cleared should be expressed in terms of both a percent and a maximum width (e.g., 30 ft). In our roundup of local shoreline ordinances, we have seen communities take a number of alternative approaches to define how much of the shoreline can be cleared. These include:

- Limit clearing to no more than 30 feet in any 100 feet of shoreline (Bernthal et al.,

1997).

- Tree cutting is limited to 50% of the basal area of trees, and 50% of the total number of saplings in a 20 year period. A healthy, well-distributed stand of trees, saplings, shrubs, and ground covers must be maintained (Springs, 1999).
- No single clear-cut strip may exceed 10 feet in width–Langlade and Marinette Counties, WI (Standing et al., 1997).
- Limit clearing to no more than 30 feet in any 200 feet–Jackson and LaCrosse Counties, WI (Standing et al., 1997).
- Allow removal of a limited amount of vegetation in a "viewing and access corridor" of a certain total width per lot (Bernthal et al., 1997).
- Require all structures to be 75% screened by vegetation (Standing et al., 1997).
- Selective tree removal and pruning and thinning of natural vegetation may be allowed within a defined corridor in order to promote a view of the shoreline. Access paths shall be located within the view corridors to extent practicable. View corridors shall be prohibited in sensitive or critical habitat areas. (State of Rhode Island, 1994).

We recommend adopting language similar to the last bullet which was taken from the Rhode Island Coastal Zone Buffer Program (see Attachment C). In addition, we have included copies of the full documents prepared by Standing et al. (Attachment D) and Bernthal et al. (Attachment E).

Restricted Uses Within the Buffer

As noted earlier, it is very important to specify which uses are not allowed in each area of the buffer. The following are our suggestions for some uses which should be defined:

Septic System Leach Fields: Not allowed in any tier, must be setback 150 feet from shoreline

Impervious Cover: Not allowed in any tier

Trails: A single access path with limits on allowable width that can be cleared

Boathouses: In some areas, boathouses are exempt from setback and other zoning-related requirements. Other areas such as Marathon and Washburn County, WI, require as much as a 75 ft setback from the ordinary high water mark (OHWM) (Standing et al., 1997). It is recommended that limits be established on the dimensions and uses of boathouses (e.g., Rhode Island limits structures to 200 ft^2), and that they be setback from the OHWM to at least Tier 2.

Concentrated Flow (pipes, ditches, open channels): Not allowed in any tier, must have sheetflow entering this zone. Pipes and ditches may discharge to Tier 3, if it is used as a stormwater treatment area (e.g., a bioretention area).

Buffer Enforcement Mechanisms

During our review, it appeared that the only enforcement mechanism to protect the buffer is to approve, deny or condition the site plan. For example, it isn't clear whether the buffer would be a deed restriction or easement. It is quite likely, however, that problems will be encountered in the shoreline residential district after this plan review stage. Indeed, the property owner may encroach on the buffer, exceed allowable clearing limits, construct ancillary structures and impervious cover inside or outside the shoreline buffer, and remove natural vegetation on the site. Some enforcement provisions are needed during the post construction stage. We frequently reference the Baltimore County enforcement procedures which are paraphrased in the attached model ordinance (see attachment F).

Alternative Buffer

The language about the alternative buffer is a little ambiguous. For example, why wouldn't all landowners apply for the alternative buffer, since no quantitative or numeric criteria are given? On the other hand, it is equally difficult to anticipate all the combinations of shape, size, topography or existing improvements where flexibility would be needed. In these cases, we feel it is wiser to put in a generic section on variance procedures (see the excellent section on variances contained in the Standing (1997) shoreline zoning guide, Attachment D).

Parking and Driveway Coverage for Easements to Water (Conditional Use)

Allowing 15% of the site to be parking and driveway is very generous. It may be better to specify some maximum dimensions for driveways and parking stalls for these facilities, such as driveway width (16-20 ft) and parking stalls (18 ft length and 9 ft width). In addition, the parking requirement might make reference to use of permeable surfaces (e.g., river rock, blue stone, or grass pavers), particularly for parking spaces and trailer storage. Driveways and parking should be setback at least 100 feet from the ordinary high water mark.

Waterfront Access Provisions

Based on our review of other lake or shoreland ordinances, we feel the ordinance should address waterfront access, since it can have a strong impact on shoreline areas. These primarily deal with stairway and walkway requirements. It may be desirable to allow for a single stairway or walkway to access the water (due to steep slopes, wetlands, or handicap access purposes). Under these conditions, certain criteria should be met. For example, the Wisconsin Department of Natural Resources recommends that the maximum width of these structures be 4 feet and that they generally be supported only by piles or footings (Standing et al., 1997).

Summary

We think the draft Long Lake Township's R-2 Lake Residential District Ordinance is a good start; however, we encourage you to consider making changes in line with our comments so that the ordinance will be more comprehensive and do a better job at protecting the lake resources. We hope that you find our comments useful. Please let us know if you have questions. We would be happy to participate in a teleconference to discuss these further.

Attachments

A Sketch Drawings of 2 acre Residential Lots
B Diagram of Minimum Shoreline Stormwater Measures
C The Rhode Island Coastal Zone Buffer Program
D Standing et al. 1997 Annotated Shoreline Ordinance
E Bernthal et al. 1997 Literature Review
F Model Stream Buffer Ordinance with Post Construction Enforcement Provisions

References

Bernthal, T.W. 1997. *Effectiveness of Shoreland Zoning Standards to Meet Statutory Objectives: A Literature Review with Policy Implications.* Wisconsin Department of Natural Resources. 66pp.

Springs, G. 1999. *The Critical Edge Shoreland Protection Reference Guide.* New Hampshire Department of Environmental Services. 91pp.

Standing , B.H., Bernthal, T.W., and S. Jones.1997 *Shoreland Zoning Resource Guide: An Annotated Model Shoreland Zoning Ordinance.* Prepared for U.S. EPA Region V by Wisconsin Department of Natural Resources. 131pp.

State of Rhode Island. 1994. The Rhode Island Coastal Zone Buffer Program. Rhode Island Coastal Resources Management Council.

cc: Kami Brown, Williams & Works

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Appendix G

Land Protection Activities

Sample Draft Conservation Easement Attached

All Draft Conservation Easements are on file at the Grand Traverse County Drain Commissioner's Office

FINAL REPORT
LONG LAKE WATERSHED PROJECT
LAND PROTECTION

The Grand Traverse Regional Land Conservancy (GTRLC) was contracted to complete the land protection component of the Long Lake Watershed Project and participate in other grant related activities.

1. Identification and Prioritization of Land

The first step to the land protection component of the Long Lake Watershed Project was the identification and prioritization of the most significant, environmentally sensitive land in the watershed. An inventory of properties was established and priority was given to parcels the met the following criteria:

a. had significant acreage (typically over 40 acres);
b. were forested, farmland, or wetlands;
c. offered scenic views to the public; and,
d. helped preserve the water quality of Long Lake.

Data compiled in the Long Lake Township Community Forestry Plan assisted in the inventory and prioritization. Adopted in January 2000, the Forestry Plan included data on land cover that delineated Forested Areas, Wetland Areas, large acreage parcels and Future Forest Resource Areas (see Attachment 1). Meetings with the Drain Commissioner, Long Lake Township Supervisor, Land Protection staff from the GTRLC, and a landowner representative resulted in the finalization and prioritization of the parcel inventory.

From this inventory a database was created that included the name, address, and property tax identification number. This list totaled 39 property owners (see Attachment 2).

A targeted land protection outreach campaign was then mounted to educate the landowners of the priority parcels. A small packet of information was created and mailed to each of the priority parcel owners. This included:

- a carefully drafted letter, introducing the land conservation initiative underway in the watershed;
- a Land Conservation Options fact sheet specifically designed for the residents of the watershed – including photos of farmland in the watershed, that explains conservation easements, Purchase of Development Rights (PDR), Bargain Sale of Development Rights; and,
- in some cases GTRLC's conservation options brochure.

(see Attachment 3 for copies of all of the above)

Approximately 2 weeks after the mailing of the information packets, landowners were contacted by telephone to see if they were interested in discussing or pursuing any of the conservation options available to them.

2. Work with Individual Landowners

Prior to the targeted outreach campaign, Conservancy staff established contact with some of the property owners, toured properties, and discussed land conservation options. After the outreach campaign, interest was expressed by five private landowners and representatives of land owned by a scout camp. Of these six landowners, one person owned two important parcels. Conservancy staff visited the properties and met with the landowners and landowner representatives. Two of the six landowners felt they would only be interested in PDR, while the others were interested in possible conservation easement donations. To aid the landowners in their decision to donate or sell their development rights, three appraisals were completed that determined the fair market value of the development rights on the property (see Attachment 4). An accountant was also consulted in one case to help the landowner understand the capital gains and other tax implications of the sale of his development rights. This resulted in the development of 5 conservation easement drafts (see Attachment 5). Negotiations are underway with these possible conservation easement donors and funds are being sought for at least one of the two potential PDR projects.

In addition to the direct one-on-one contact with the individual landowners, the GTRLC also participated in Long Lake Township's summer workshop called, "Long Lake Naturally". At the workshop, the Conservancy staffed a display and provided area residents information on the different conservation options available to private landowners.

3. Land Protection Tools/PDR

The final land protection task of the workplan was to work with interested townships in the watershed to develop land protection tools such as a PDR program. Currently, the townships that encompass the Long Lake Watershed are served by two very active land conservancies – the Grand Traverse Regional Land Conservancy and the Leelanau Conservancy. Both of these conservancies offer a wide variety of land protection tools to landowners, however most of these options involve the donation of conservation easements/development rights and land. Funding a PDR program is very challenging. First, landowners must be willing to sell their development rights, and second a very lucrative funding source needs to be secured. To explore the possibility of a PDR program in the Long Lake Watershed it was necessary to first establish the willingness of landowners to sell their development rights. The information packets that were mailed to the landowners included PDR as an option and Conservancy staff discussed PDR as a possible land protection tool. This did not appear to have much support with landowners. The majority of landowners were elderly, planned to pass their land on to their heirs, and either trusted their heirs to keep the land preserved or as was the case the majority of the

time – the landowner realized the future value of their land and did not want to hinder their heir's future ability for financial security by restricting an asset at this time.

Efforts are underway to implement a county-wide ballot initiative that would create land preservation funding through an increase in property tax. This initiative is in its infancy, but may include a PDR component and funding for township land preservation projects.

4. Future Work in the Watershed

The goal of this outreach effort was to educate landowners of the different conservation options available to them. Deciding to permanently preserve one's land is a very significant and personal decision that takes time to consider. As is often times the case with targeted land protection efforts, the seeds that are planted today through our outreach efforts often times come to fruition a few months or years into the future. The Conservancy continues to get calls from landowners interested in donating land and conservation easements who learned of the Conservancy and land conservation options from outreach efforts conducted several years ago. There is no reason to believe that this will not be the case in Long Lake Township.

5. Other Grant Related Activities

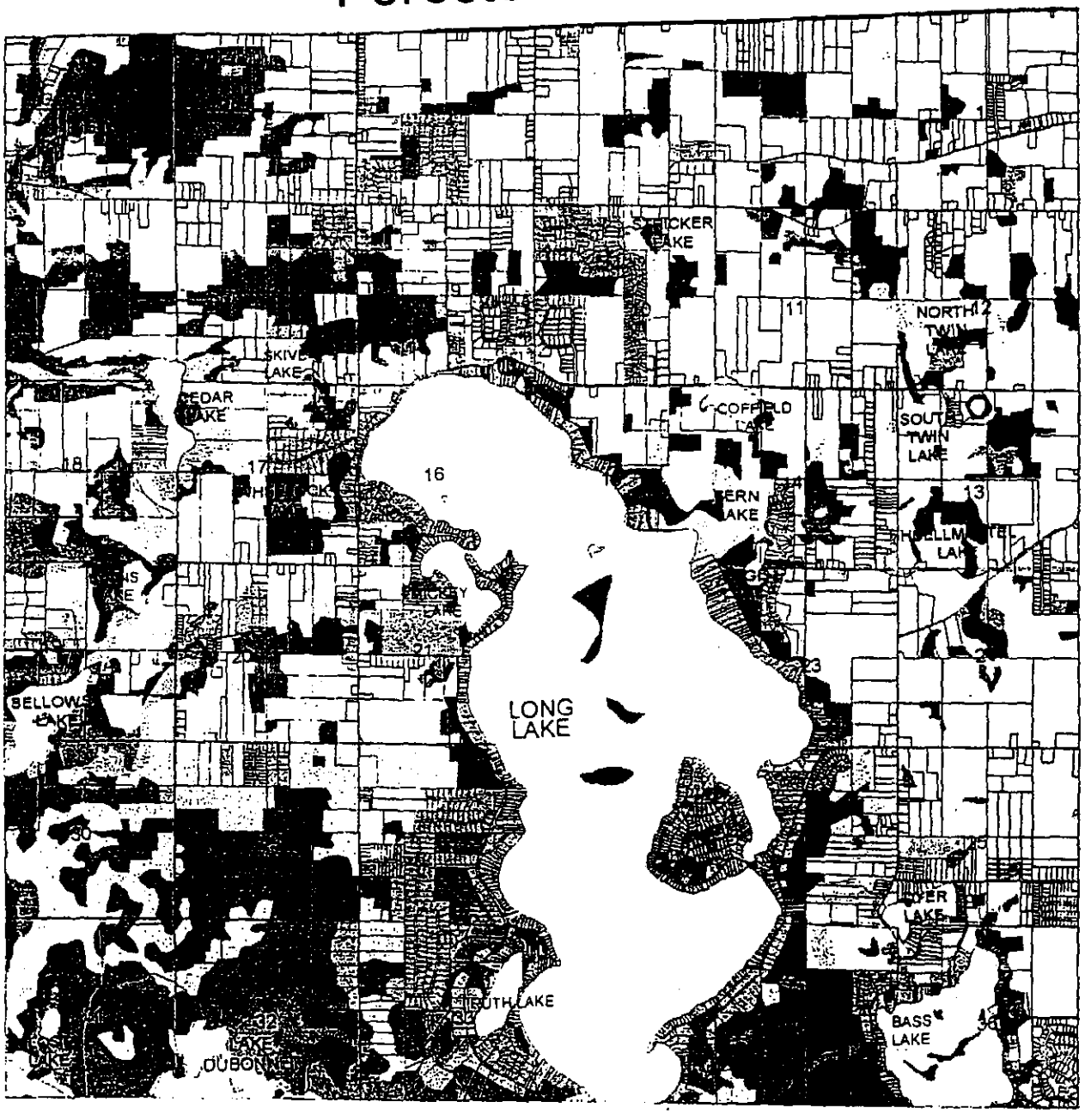
The Grand Traverse Regional Land Conservancy coordinated payment to Fen's Rim Publications of the Long Lake Landowners Handbook (see Attachment 6) and participated in all of the Long Lake Watershed Partnership Meetings to report on the progress of the land protection efforts.

ATTACHMENT 1

FORESTRY PLAN MAPS

Figure 2.8

Long Lake Township
Forested Areas



Legend

Upland Conifers	2044.5 A
Upland Hardwoods	5134.5 A
Lowland Conifers	237.0 A
Lowland Hardwoods	275.1 A
Wetlands	715.5 A
Developed Forest	2263.5 A
Water	

Data Souce:
MIRIS-Base Maps
Grand Traverse County-Parcels
Long Lake Township-Forestry

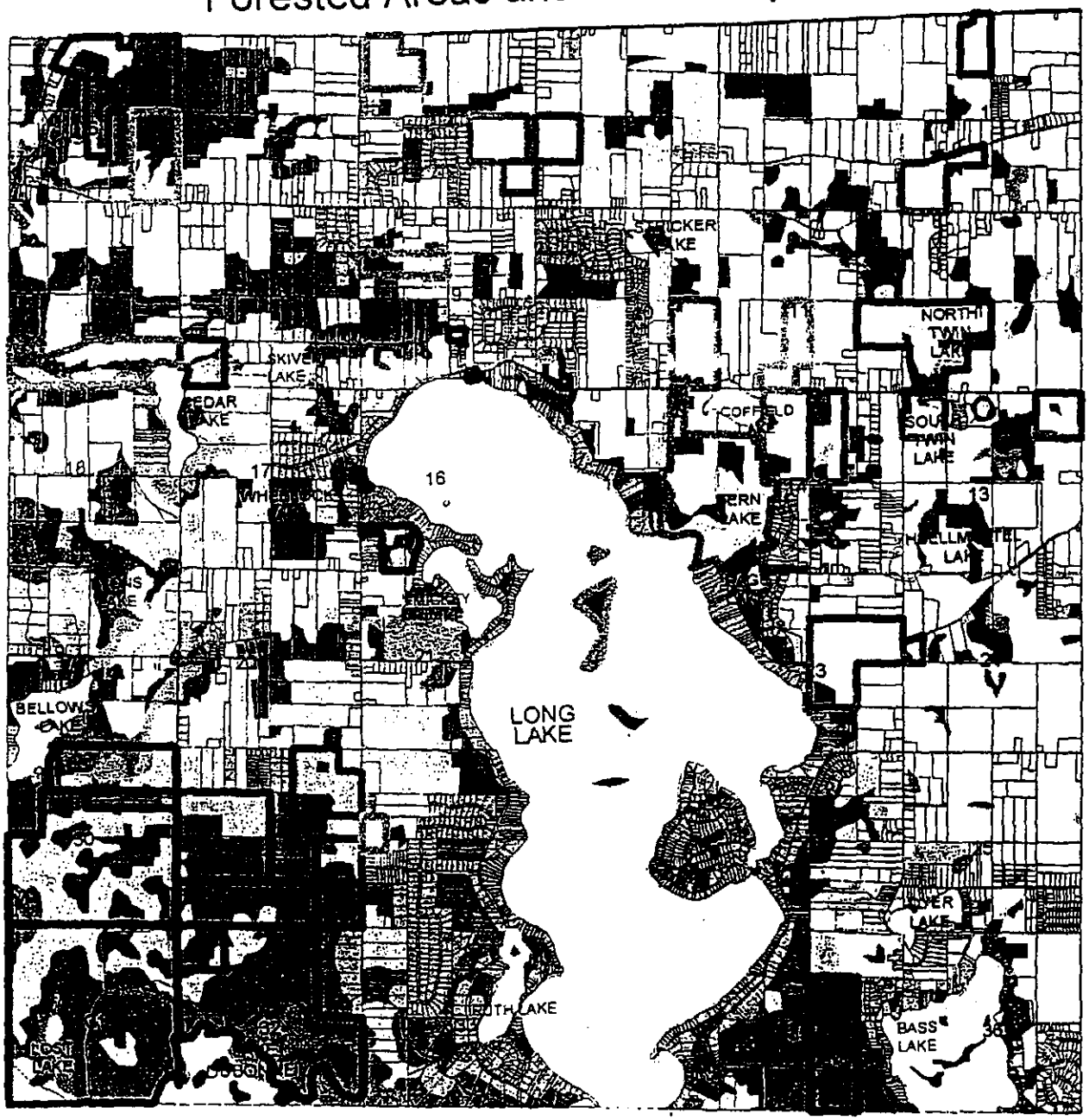
Long Lake Township

N
W E
S

1 Mile

This map is based on digital databases prepared by Grand Traverse County and Long Lake Township. Grand Traverse County and Long Lake Township do not warrant, expressly or impliedly, or accept any responsibility for any errors, omissions, or that the information contained in the map or digital databases is currently positionally accurate.

Figure 2.9
Long Lake Township
Forested Areas and Ownership Type



Legend

- Private Lands
- Semi-Public Lands
- Public Lands
- PA 116
- Conservation Easements
- CFA
- Upland Conifers
- Upland Hardwoods
- Lowland Conifers
- Lowland Hardwoods
- Wetlands
- Water
- Developed Forest

Data Souce:
MIRIS-Base Maps
Grand Traverse County-Parcels
Long Lake Township-
Forestry and Landuse

N
W E
S

1 Mile

Long Lake Township

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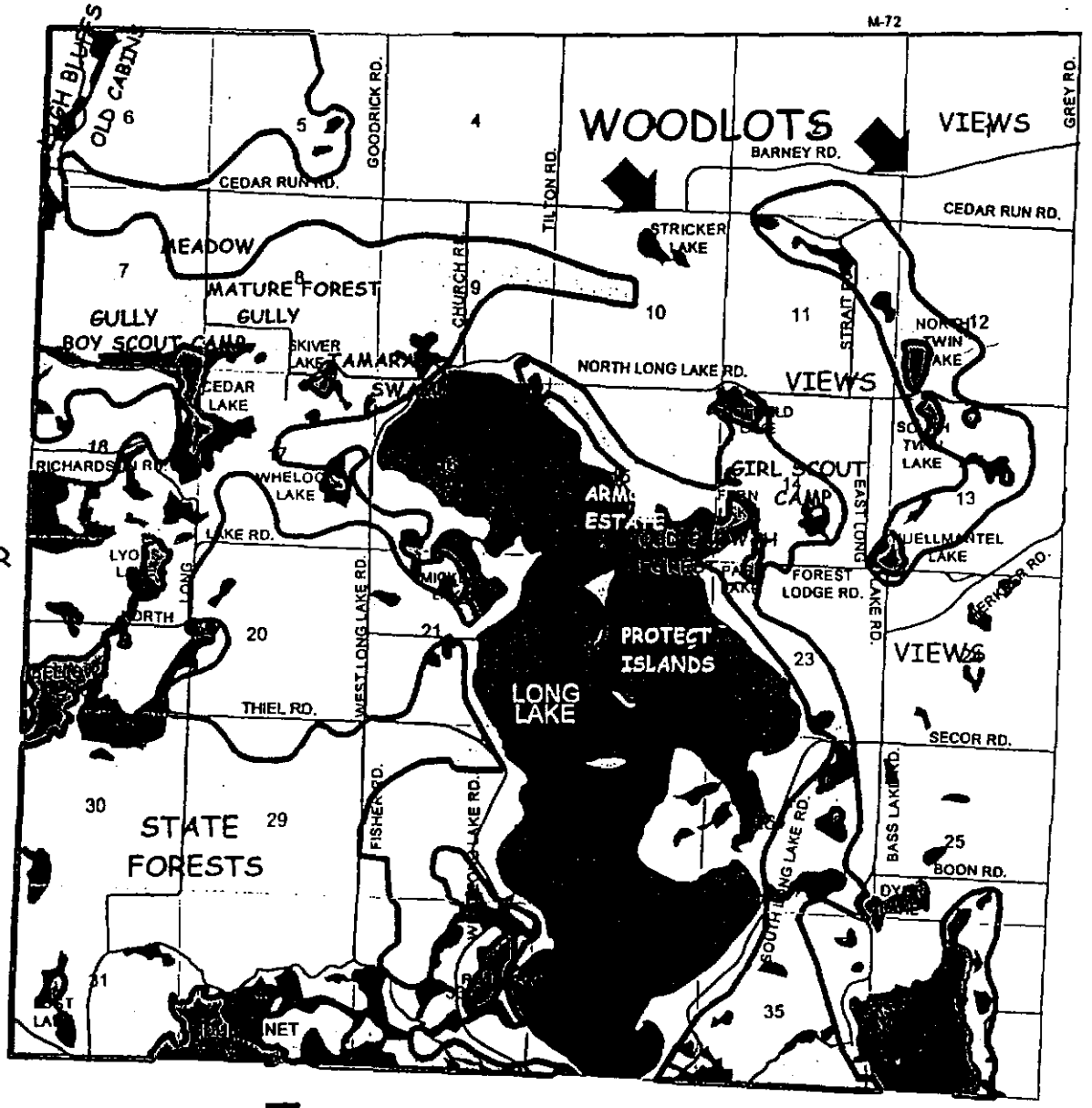
Long Lake Township Community Forestry Plan

Figure 3.1



REGIONAL CORRIDOR

URBAN-RURAL RESOURCE LINKAGES

REGIONAL CORRIDOR

PRIORITY RESOURCE AREAS

- Wetlands
- Ecological Corridors
- Corridor
- Water

Data Source:

MIRIS-Base Files
Grand Traverse County- Parcels and Roads

Prepared by: NEMCOG & Long Lake Twp.

N

1 0 1 Miles

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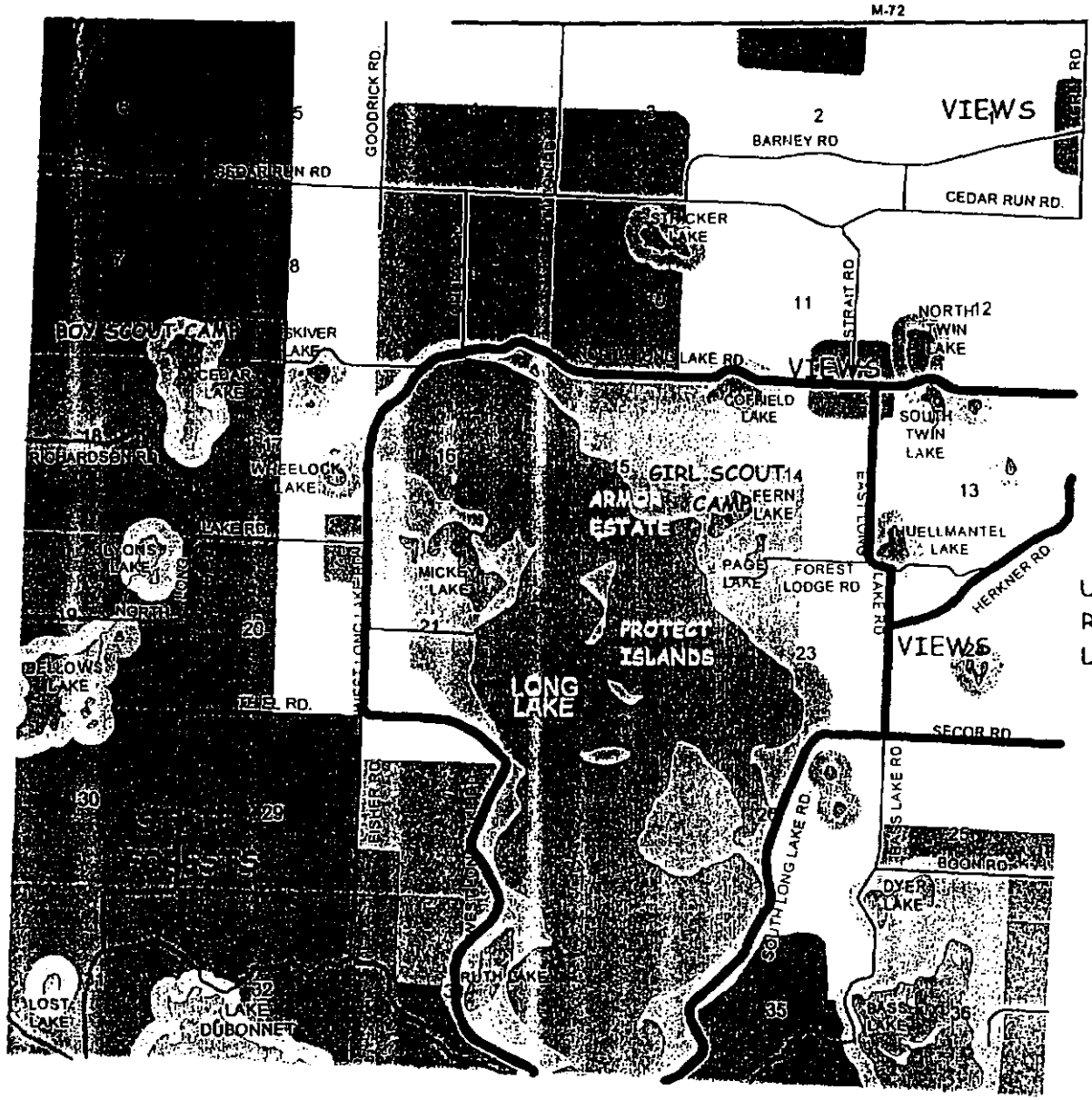
Future Forest Resource Areas
Long Lake Township
Figure 5.1



REGIONAL CORRIDOR

URBAN-RURAL RESOURCE LINKAGES

REGIONAL CORRIDOR

FUTURE FOREST RESOURCE AREAS
- LARGE TRACT FORESTS
- WOODLANDS & RIPARIAN FORESTS
- SUBURBAN FORESTS
- FARMLAND WOODLOTS & OPEN SPACE
- WATER FEATURES
- ROADSIDE WOODLAND CORRIDORS

Data Source:
MIRIS-Base Files
Grand Traverse County- Parcels and Roads

Prepared by: NEMCOG & Long Lake Twp.

1 0 1 Miles

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ATTACHMENT 2

LANDOWNER DATABASE

08-000-002-00
WALL MARION M TRUST
1031 S BAYLOR DR
TUCSON, AZ 85710

08-001-001-00
LAUTNER CLETUS B
7948 EAST TRAVERSE HWY
TRAVERSE CITY, MI 49684

08-001-006-10
WITKOP MICHAEL H & LAVERNA
7100 EAST TRAVERSE HWY
TRAVERSE CITY, MI 49684

08-001-009-00
SACHTLEBEN GWENDOLYN TRUST
6971 BARNEY RD
TRAVERSE CITY, MI 49684

08-002-001-00
NOONAN GLENN & ELLA
1245 WEST TRAVERSE HWY
MAPLE CITY, MI 49664

08-002-007-00
HARIG MARY
7700 CEDAR RUN RD
TRAVERSE CITY, MI 49684

08-003-001-00
NINK JOHN & SUSAN
7183 HARRYS RD
TRAVERSE CITY, MI 49684

08-003-012-00
LAUTNER JOAN & LAUTNER JAME
12654 SOLON RD
CEDAR, MI 49621

08-003-014-00
STRICKER WAYNE STRICKER JER
8377 CEDAR RUN RD
TRAVERSE CITY, MI 49684

08-007-001-00
NORRIS JAY W & VIVIAN
11087 CEDAR RUN RD
TRAVERSE CITY, MI 49684

08-007-004-00
ELLIOTT T MICHAEL & G NANCY
11535 CEDAR RUN RD
TRAVERSE CITY, MI 49684

08-009-013-00
FARAH R DELIGHT
WATSON BEN
260 HWY 210
HOLLY RIDGE, NC 28445

08-010-001-10
LICHT NORMAN J
3514 AVERY TRL
TRAVERSE CITY, MI 49684

08-010-022-00
RITOLA VALBORG
8660 NORTH LONG LAKE RD
TRAVERSE CITY, MI 49684

08-010-030-00
HALL DANIEL R
8118 NORTH LONG LAKE RD
TRAVERSE CITY, MI 49684

08-011-019-20
WOOLFOLK GERALD & MARILYN
2780 HOLYOKE LN
ANN ARBOR, MI 48103

08-011-023-00

08-012-017-00

APSEY CHARLES & TONI
7821 S OUTER DR
TRAVERSE CITY, MI 49684

WHEELOCK KENNETH & VADA
6180 NORTH LONG LAKE RD
TRAVERSE CITY, MI 49684

08-013-006-00
GALLAGHER DOUG & JOANNE
5891 N LONG LAKE RD
TRAVERSE CITY, MI 49684

08-013-007-00
SPENCER JOHN R & CHARMAINE
6645 NORTH LONG LAKE RD
TRAVERSE CITY, MI 49684

08-013-010-00
BUYSSE EDWARD G
6772 HUELLMANTEL LAKE RD
TRAVERSE CITY, MI 49684

08-013-019-00
ALPERS BRYAN J ET AL
16 W SILVER LAKE RD S
TRAVERSE CITY, MI 49684

08-014-006-00
PLUMMER ROBERT E TRUST
7385 NORTH LONG LAKE RD
TRAVERSE CITY, MI 49684

08-014-007-00
FROEHLICH RICHARD & ALICE
7665 NORTH LONG LAKE RD
TRAVERSE CITY, MI 49684

08-014-011-00
FAIR WINDS COUNCIL G S A
2029-C S ELMS RD
SWARTZ CREEK, MI 48473

08-015-005-00
BRAYTON JOHN SR TRUST
8691 NORTH LONG LAKE RD
TRAVERSE CITY, MI 49684

08-016-019-00
BAILLIO CO
9740 EDGEWOOD AVE
TRAVERSE CITY, MI 49684

08-017-008-00
KINGDON ROBERT & GWENDOLYN
10688 NORTH LONG LAKE RD
TRAVERSE CITY, MI 49684

08-017-008-20
KINGDON ANDY & MONA
2056 SOUTH STINE RD
CHARLOTTE, MI 48813

08-019-001-00
BONNER LEON
547 FAIRBROOK
NORTHVILLE, MI 48167

08-021-002-00
COLEMAN GLEN & NANCY TRUST
2878 WEST LONG LAKE RD
TRAVERSE CITY, MI 49684

08-021-014-00
VAN VORST VIOLA
C/O NANCY ROSINSKI
5995 S CUMMINGS ST
SUTTONS BAY, MI 49682

08-022-001-00
OLESON FOUNDATION

08-022-002-00
KEEGSTRA EDWARD & NANCY

PO BOX 72
TRAVERSE CITY, MI 49685-0072

1459 MIAMI RD
BENTON HARBOR, MI 49022

08-023-001-00
HERKNER VINCENT & GLADYS
2561 EAST LONG LAKE RD
TRAVERSE CITY, MI 49684

08-025-007-00
SLOCUM GRACE L TRUST
6595 SECOR RD
TRAVERSE CITY, MI 49684

08-028-008-00
DALL'OLMO DANIEL & GAIL
1836 WEST LONG LAKE RD
TRAVERSE CITY, MI 49684

08-033-027-12
REEBER THOMAS M TRUST
905 WEST LONG LAKE RD
TRAVERSE CITY, MI 49684

08-035-002-00
HALL HAROLD E & MINNIE M
1043 BASS LAKE RD
TRAVERSE CITY, MI 49684

ATTACHMENT 3

LAND PROTECTION OUTREACH MATERIALS

ATTACHMENT 5

CONSERVATION EASEMENT DRAFTS

DRAFT
CONSERVATION EASEMENT

DATE: Draft Date - September 7, 2000

OWNER: Dan Hall *(need copy of deed for correct name and address. Also include any assigns, successors, administrators, etc., as appropriate.)*

CONSERVANCY: Grand Traverse Regional Land Conservancy, 3860 North Long Lake Road, Suite D, Traverse City, MI 49684

For Purposes of this Conservation Easement, the OWNER, and all subsequent Owners of the subject Property, will be referred to as the "Owner" throughout this Conservation Easement. The Grand Traverse Regional Land Conservancy will be referred to as the "Conservancy" throughout this Conservation Easement.

PROPERTY: The Property is located in Section 10, Township 27 North, Range 12 West, Long Lake Township, Grand Traverse County, Michigan, which is more fully described in Exhibit A and shown on Exhibit B.

CONVEYANCE: The Owner conveys and warrants to the Conservancy a perpetual Conservation Easement over the Property. The scope of the Conservation Easement is set forth in this agreement. This conveyance is a gift from the Owner to the Conservancy. Accordingly, this is exempt from Transfer Tax pursuant to MCL 207.505(a) and 207.523(a).

THE OWNER AND THE CONSERVANCY AGREE TO THE FOLLOWING:

1. PURPOSES OF THIS CONSERVATION EASEMENT.

A. This Conservation Easement assures that the Property will be perpetually preserved in its predominately natural, scenic, agricultural, forested, and open space condition. The Purpose of this Conservation Easement is to protect the Property's natural resource and watershed values; to maintain and enhance biodiversity; to retain quality habitat for native plants and animals, and to maintain and enhance the natural features of the Property. Any uses of the Property which may impair or interfere with the Conservation Values are expressly prohibited.

B. The Owner is the fee simple title owner of the Property and is committed to preserving the Conservation Values of the Property. The Owner agrees to confine use of the Property to activities consistent with the Purposes of this Easement and the preservation of the Conservation Values.

C. The Conservancy is a qualified holder of this Conservation Easement and is committed to preserving the Conservation Values of the Property and is committed to upholding the terms of this Conservation Easement. The Conservancy is a tax-exempt, nonprofit Michigan Corporation qualified under Internal Revenue Code Sections 501(c)(3) and 170(h)(3) and 170(h)(4)(ii) and (iii); and under the Conservation and Historic Preservation Easement, Sub Part 11 of Part 21 of Natural Resources and Environmental Protection Act, MCL §§ 324.2140 et seq. The Conservancy protects natural habitats of fish, wildlife, plants, and the ecosystems that support them. The Conservancy also

preserves open spaces, including farms and forests, where such preservation is for the scenic enjoyment of the general public or pursuant to clearly delineated governmental conservation policies and where it will yield a significant public benefit.

2. **CONSERVATION VALUES.** The Property possesses natural, scenic, open space, agricultural, and ecological values of prominent importance to the Owner, the Conservancy, and the public. These values are referred to as the "Conservation Values" in this Easement. The Conservation Values include the following:

A. The Property offers a scenic landscape and natural character which would be impaired by modification of the Property.

B. The Property offers a scenic panorama visible to the public from publicly accessible sites, such as, Long Lake Road, which would be adversely affected by modifications of the natural habitat, and, if preserved in its current forested and agricultural state has the potential to enhance tourism.

C. There is a reasonable possibility that the Conservancy may acquire other valuable property rights in nearby or adjacent properties to expand the Conservation Values preserved by this Conservation Easement.

D. The Property contains significant natural habitats in which wildlife, plants or ecosystems which support them thrive in a natural state.

E. The Property contains a diversity of plant and animal life in a broad range of habitats for a property of its size.

F. The Property contains valued wetlands, such as described in the Wetland Protection Act, Part 303 of the Michigan Natural Resources and Environmental Code MCL 324.30301 et seq.

G. Portions of the Property are characteristic of a northern hardwood forest. These plant communities are in a relatively natural and undisturbed condition and support the full range of wildlife species found in these habitat types.

H. The Property contains natural wetland areas that provide habitat for aquatic invertebrates, reptiles, amphibians, and aquatic and/or emergent vegetation.

I. The Property includes valued native forest land, which includes diverse native species, trees of many age classes and structural diversity, including a multi-story canopy, standing dead trees and downed logs.

J. Preservation of the Property enables the Owner to integrate the Conservation values with other neighboring lands.

K. The State of Michigan has recognized the importance of protecting our natural resources as delineated in the Constitution of State of Michigan; 1963, Article IV, Section 52: The conservation and development of the natural resources of the state are hereby declared to be of paramount public concern in the interest of the health, safety, and general welfare

of the people. The legislature shall provide for the protection of the air, water, and other natural resources of the state from pollution, impairment, and destruction.

L. The Property is preserved pursuant to a clearly delineated federal, state, or local conservation policy and yields a significant public benefit. The following legislation, regulations, and policy statements establish relevant public policy:

- Conservation and Historic Preservation Easement, Sub part 11 of Part 21 of the Michigan Natural Resources and Environmental Protection Act - MCL §§ 324.2140 *et seq.*;
- Wetland Protection, Part 303 of the Michigan Natural Resources and Environmental Act - MCL §§ 324.30301 *et seq.*; (Legislative Findings MCL § 324.30302);
- Farmland and Open Space Preservation, Part 361 of the Michigan Natural Resources and Environmental Protection Act - MCL §§ 324.36101 *et seq.*;
- Soil Conservation, Erosion, and Sedimentation Control, Parts 91 & 93 of Michigan Natural Resources and Environmental Protection Act – MCL §§ 324.9101 *et seq;* 324.9301 *et seq*; (Legislative Policy § 324.9302);

M. The Property consists **of approximately __% or entirely** of "prime farmland" and "farmland of local importance" as classified by the U.S. Department of Agriculture and the Natural Resources Conservation Service.

N. The Property has a long history of productive farming, contains significant areas with soil classifications designated as **(INSERT)**.

3. **BASELINE DOCUMENTATION.** Specific Conservation Values of the Property have been documented in a natural resource inventory signed by the Owner and the Conservancy. This "Baseline Documentation Report" consists of maps, a depiction of all existing human-made modifications, prominent vegetation, identification of flora and fauna, land use history, distinct natural features, and photographs. The parties acknowledge that this natural resources inventory, the Baseline Documentation Report, is an accurate representation of the Property at the time of this donation.

4. **PERMITTED USES.** The Owner retains all ownership rights which are not expressly restricted by this Conservation Easement. In particular, the following rights are reserved:

A. Right to Convey. The Owner retains the right to sell, lease, mortgage, bequeath, or donate the Property. Any conveyance will remain subject to the terms of the Conservation Easement and all subsequent Owners will be bound by all obligations in this agreement.

B. Right to Maintain and Replace Existing Structures. The Owner retains the right to maintain, renovate, and replace the existing structure(s) as noted in the Baseline Documentation Report in substantially the same location and size. Any expansion or replacement may not substantially alter the character or function of the structure.

Prior to beginning expansion or replacement of the existing structures, the Owner shall provide a written plan to the Conservancy for the Conservancy's review and approval.

Such approval shall not be unreasonably withheld.

C. Right to Add, Maintain, and Replace Designated Structures. The Owner retains the right to construct, maintain, and replace the following structures within the area designated as the Building Envelope on the Baseline Documentation Map:

1. Two (2) additional ancillary structures, such as barns or greenhouses.

At least thirty (30) days prior to initiating any proposed construction the Owner shall deliver a written plan to the Conservancy for review and approval. Also, at least 30 days prior to initiating any proposed construction the Owner must install stakes identifying the location of the buildings to allow the Conservancy to confirm its location within the designated Building Envelope. The Conservancy's approval shall not be unreasonably withheld.

D. Right to Cut Vegetation and Conduct Forestry Activities. The Owner retains the right to cut vegetation and conduct the following forestry activities on the Property as follows:

1. Dangerous or diseased trees. Cutting or removing trees or other vegetation is permitted under the following conditions:
   a. to remove dangerous trees;
   b. to remove trees in order to reduce a natural threat of infestation posed by diseased vegetation (as documented by a professional forester or other natural resource specialist and as approved by the Conservancy); or,
   c. to control invasive non-native plant species that endanger the health of native species.

2. Forest Management. Forest management for the growth and harvest of trees is permitted if it is conducted in accordance with the following criteria:
   a. it is undertaken with the following goals:
      i. maintenance of the forested character of the Property for scenic and habitat values; and,
      ii. conservation of native plant and animal species.
   b. it is in accordance with a Forest Management Plan prepared by a Professional Forester or other qualified natural resources specialist.
   c. it is undertaken in a manner not detrimental to the Conservation Values of the Property.
   d. it is in compliance with the standards set forth in the then current Best Management Practices, as outlined in "Water Quality Management Practices on Forest Land," (1994) Michigan Department of Natural Resources, and in accordance with the recommendations in "Riparian Forest Buffers," (Welsch, 1991) Forest Resources Management, USDA Forest Service, Radnor, PA, NA-PR-07-91, or similar successor publications approved by the Conservancy.
   e. it complies with all applicable local, state, federal and other governmental laws and regulations.
   f. it does not include high-grading as a harvesting method.
   g. it maintains, over the entire forest, a well-distributed stand of uneven-aged and multiple species of trees that mimic a natural forest ecosystem.

Forest Management Plan. The Forest Management Plan must be prepared prior to any management activities or harvesting, updated at least every fifteen (15) years, and shall be provided to the Conservancy. The Conservancy shall have 60 days from receipt of the Forest Management Plan to review and either approve or notify the Owner of any deficiencies in the Plan that relate to protecting the Conservation Values of the Property. The Conservancy's approval may be withheld only upon a reasonable determination by the Conservancy that the proposed action(s) would be inconsistent with the purposes of this Conservation Easement or detrimental to the Conservation Values of the Property.

Notice of Commercial Harvest. The Owner shall provide the Conservancy with a written Notice of Harvest at least 30 days prior to commencement of harvesting activities and upon completion, including required reclamation work, which Notice shall include the location of the harvest, contemplated dates, a cutting plan, a plan for ingress and egress, and a summary of activities and practices intended to achieve compliance with the requirements of this paragraph. Timber harvesting shall be conducted under a written contract with competent operators, which contract shall specify relevant requirements for compliance with this Conservation Easement.

E. Right to Maintain Agricultural Operations. The Owner retains the right to maintain agricultural operations and uses on the Property. Agricultural use is permitted in areas designated as Agriculture on Baseline Documentation Map and is defined as the planting and harvesting of crops, nursery stock, and trees for silviculture, and, the raising and housing of livestock. Agricultural management operations shall employ generally accepted agricultural management practices as defined and recommended in the Michigan Right-to-Farm Act, Public Act 93 of 1981, as amended, MCL 286.472, 286.473, and 286.474, so as to minimize soil erosion and other damaging occurrences. There shall be no commercial confinement facilities for livestock, swine, or poultry on the Property.

Owners must erect and maintain adequate fencing to prevent livestock from entering areas designated as Forest or Building Envelope on the Baseline Documentation Map.

Livestock pasturing practices in the area designated as Agriculture on the Baseline Documentation Map shall be permitted pursuant to a certified Conservation Plan, completed by a Natural Resource Conservation Service - United States Department of Agriculture (USDA) representative, which, including future revisions of the Conservation Plan, shall be submitted to the Conservancy for review and approval. Such approval shall not be unreasonably withheld. The Conservation Plan shall satisfy all of the following conditions:

1. State the recommended grazing capacity in animal units (as defined by USDA) for the area designated as Agriculture on the Baseline Documentation Map based on recommended pasture mixtures. Special consideration must be given to the any areas designated as Highly Erodible Land by USDA to insure proper protection of the soil resources in that area.
2. Require a protective vegetative buffer strip on the Agricultural side of all

fencing adjacent to Natural Areas and Managed Woodland as noted on the Baseline Documentation Map to effectively filter nutrients.

F. Right to Manage Vegetation for Lawns and Gardens. In areas designated as Building Envelopes on the Baseline Documentation Map, the Owner retains the right to: remove, trim, and otherwise manage vegetation; and grow and harvest fruits and vegetables.

G. Right to Maintain Trails. The Owner retains the right to add and maintain trails (via removing and/or trimming vegetation) for low-impact use provided such clearing does not adversely impact the Conservation Values of the Property.

H. Right to Operate Motorized Vehicles. The Owner retains the right to operate motorized vehicles on the Property on the established driveways, trials, and parking areas indicated in the Baseline Documentation Report. The Owner also retains the right to operate motorized vehicles off-road on the Property for the purpose of achieving the permitted management uses described herein and for the Owners personal enjoyment. However, the right to operate off-road recreational vehicles (ORV's) may be extinguished if use of ORV's causes irreparable harm to the Conservation Values of the Property.

I. Right to Place Signs. The Owner retains the right to place signs on the Property stating one or more of the following items:

· The name and address of the Property.
· The owner's name.
· That the area is protected by this Conservation Easement.
· That any unauthorized entry or use is prohibited.
· That the Property is for sale or rent.

5. **PROHIBITED ACTIONS.** Any activity on or use of the Property which is inconsistent with the Purposes of this Conservation Easement or which is detrimental to the Conservation Values is expressly prohibited. By way of example, but not by way of limitation, the following activities and uses are explicitly prohibited:

A. Division. Any division or subdivision of the Property is prohibited.

B. Commercial Activities. Any commercial activity on the Property, including, but not limited to, any commercial recreational activity greater than *de minimis* use is prohibited, except as associated with permitted timber and agricultural management activities, as specified in paragraphs 4D and 4E.

C. Industrial Activities. Any industrial activity on the Property is prohibited.

D. Construction. The placement or construction on the Property of any man-made modification, such as buildings, structures, bridges, dams, broadcast towers, roads and parking lots is prohibited, except as specified in paragraphs 4B and 4C.

E. Cutting Vegetation. Cutting down or otherwise destroying or removing trees or other vegetation whether living or dead is prohibited, except as specified in paragraphs 4C, 4D, 4E, 4F, and 4G.

F. Land Surface Alteration. Any mining or alteration of the surface of the land is prohibited, including any substance that must be quarried or removed by methods that will consume or deplete the surface estate, including, but not limited to, the removal of topsoil, sand, gravel, rock, and peat. In addition, exploring for, developing, and extracting oil, gas, hydrocarbons, or petroleum products is prohibited.

G. Dumping. Waste and unsightly or offensive material is not allowed and may not be accumulated on the Property.

H. Water Course Alteration. Natural water courses, lakes, wetlands, or other bodies of water may not be altered.

I. Livestock confinement facilities. Livestock confinement facilities, including, but not limited to, confinement facilities for livestock, swine, or poultry on the Property are prohibited.

J. Off-Road Recreational Vehicles. Motorized off-road vehicles such as, but not limited to, snowmobiles, dune buggies, all-terrain vehicles, and motorcycles may not be operated off of designated roads and trails on the Property, except as specified in paragraph 4H.

K. Signs and Billboards. Billboards are prohibited. Signs are only permitted as specified in paragraphs 4I and 6D.

6. **RIGHTS OF THE CONSERVANCY**. The Owner confers the following rights upon the Conservancy to perpetually maintain the Conservation Values of the Property:

A. Right to Enter. The Conservancy has the right to enter the Property at reasonable times to monitor the Conservation Easement Property. Furthermore, the Conservancy has the right to enter the Property at reasonable times to enforce compliance with, or otherwise exercise its rights under, this Conservation Easement. The Conservancy may not, however, unreasonably interfere with the Owner's use and quiet enjoyment of the Property. The Conservancy has no right to permit others to enter the Property. The general public is not granted access to the Property under this Conservation Easement.

B. Right to Preserve. The Conservancy has the right to prevent any activity on or use of the Property that is inconsistent with the Purposes of this Conservation Easement or detrimental to the Conservation Values of the Property.

C. Right to Require Restoration. The Conservancy has the right to require restoration of the areas or features of the Property which are damaged by any activity inconsistent with this Conservation Easement.

D. Signs. The Conservancy has the right to place signs on the Property which identify the land as protected by this Conservation Easement. The number and location of any signs are subject to the Owner's approval.

7. **CONSERVANCY REMEDIES**. This section addresses cumulative remedies of the Conservancy and limitations on these remedies.

A. Delay in Enforcement. A delay in enforcement shall not be construed as a waiver of the Conservancy's right to eventually enforce the terms of this Conservation Easement.

B. Acts Beyond Owner's Control. The Conservancy may not bring an action against the Owner for modifications to the Property resulting from causes beyond the Owners' control, including, but not limited to, unauthorized actions by third parties, natural disasters such as unintentional fires, floods, storms, natural earth movement, or even an Owner's well-intentioned actions in response to an emergency resulting in changes to the Property. The Owner has no responsibility under this Conservation Easement for such unintended modifications.

C. Notice and Demand. If the Conservancy determines that the Owner is in violation of this Conservation Easement, or that a violation is threatened, the Conservancy shall provide written notice to the Owner. The written notice will identify the violation and request corrective action to cure the violation and, where the Property has been injured, to restore the Property.

However, if the Conservancy determines, at its sole discretion, that the violation constitutes immediate and irreparable harm, no written notice is required prior to the Conservancy pursuing its remedies to prevent or limit harm to the Conservation Values of the Property. Furthermore, in the event the Conservancy sent written notification of the violation and during the 28-day cure period defined below, the violation constitutes immediate and irreparable harm, the Conservancy may pursue its remedies without waiting for the cure period to expire.

Furthermore, if the Conservancy determines that this Conservation Easement is, or is expected to be violated, and the Conservancy's good-faith and reasonable efforts to notify the Owner are unsuccessful, the Conservancy may pursue its lawful remedies to mitigate or prevent harm to the Conservation Values without prior notice and without awaiting the Owner's opportunity to cure. The Owner agrees to reimburse all reasonable costs associated with this effort.

D. Failure to Act. If, within 28-days after written notice, the Owner does not implement corrective measures requested by the Conservancy, the Conservancy may bring an action in law or in equity to enforce the terms of the Conservation Easement. In the case of immediate or irreparable harm, or if an Owner is unable to be notified, the Conservancy may invoke these same remedies without notification and/or awaiting the expiration of the 28-day period.

The Conservancy is entitled to enjoin the violation through temporary or permanent injunctive relief and to seek specific performance, declaratory relief, restitution, reimbursement of expenses, and/or an order compelling the Owner to restore the Property. If the court determines that the Owner has failed to comply with this Conservation Easement, the Owner shall also reimburse the Conservancy for all reasonable litigation costs and reasonable attorney's fees, and all costs of corrective action or Property restoration incurred by the Conservancy.

E. Unreasonable Litigation. If the Conservancy initiates litigation against the Owner to

enforce this Conservation Easement, and if the court determines that the litigation was initiated without reasonable cause or in bad faith, then the court may require the Conservancy to reimburse the Owner's reasonable costs and reasonable attorney's fees in defending the action.

F. Actual or Threatened Non-Compliance. The Conservancy's rights under this Paragraph, Conservancy Remedies, apply equally in the event of either actual or threatened violations of the terms of this Easement. The Owner agrees that the Conservancy's remedies at law for any violation of the terms of this Easement are inadequate and that the Conservancy shall be entitled to injunctive relief, both prohibitive and mandatory, in addition to such other relief to which the Conservancy may be entitled, including specific performance of the terms of this Conservation Easement, without the necessity of proving either actual damages or the inadequacy of otherwise available legal remedies.

G. Cumulative Remedies. The preceding remedies of the Conservancy are cumulative. Any, or all, of the remedies may be invoked by the Conservancy if there is an actual or threatened violation of this Conservation Easement.

8. **CONSERVATION EASEMENT REQUIREMENTS UNDER MICHIGAN LAW AND U.S. TREASURY REGULATIONS.**

A. This Conservation Easement is created pursuant to the Conservation and Historic Preservation Easement, Sub part 11 of Part 21 of the Michigan Natural Resources and Environmental Protection Act (NREPA) - MCL §§ 324.2140 *et seq.*

B. This Conservation Easement is established for conservation purposes pursuant to the Internal Revenue Code, as amended at Title 26, U.S.C.A., Section 170(h)(1)-(6) and Sections 2031(c), 2055 and 2522, and under "Treasury Regulations at Title 26 C.F.R. § 1.170A-14 *et seq*, as amended.

C. The Conservancy is qualified to hold conservation easements pursuant to the Conservation and Historic Preservation Easement, Sub part 11 of Part 21 of the Michigan Natural Resources and Environmental Protection Act (NREPA) - MCL §§ 324.2140 *et seq.*, and under IRC Section 170(h)(3), to wit: a publicly funded, non-profit 501(c)(3) organization operated primarily to accept lands and easements for the purpose of preserving and protecting natural, scenic, educational, recreational, and open space values of real property; and having a commitment to protect the Conservation Purposes of this Conservation Easement, and the resources to enforce the restrictions hereof.

9. **OWNERSHIP COSTS AND LIABILITIES.** In accepting this Conservation Easement, the Conservancy shall have no liability or other obligation for costs, liabilities, taxes, or insurance of any kind related to the Property. The Conservancy's rights do not include the right, in absence of a judicial decree, to enter the Property for the purpose of becoming an operator of the Property within the meaning of the Comprehensive Environmental Response, Compensation, and Liability Act. The Conservancy, its members, trustees or directors, officers, employees, and agents have no liability arising from injury or death to any person or physical damage to any property on the Property. The Owner agrees to defend the Conservancy against such claims during the tenure of the Owner's ownership of the Property.

10. **HAZARDOUS MATERIALS**. The Owner warrants that they have no knowledge of a release of hazardous substances or hazardous wastes on the Property. The Owner agrees to protect and defend the Conservancy against any claims of hazardous materials contamination on the Property.

11. **CESSATION OF EXISTENCE**. If the Conservancy shall cease to exist or if it fails to be a "qualified organization" for purposes of Internal Revenue Code Section 170(h)(3), or if the Conservancy is no longer authorized to acquire and hold conservation easements, then this Conservation Easement shall become vested in another entity. This entity shall be a "qualified organization" for purposes of Internal Revenue Code Section 170(h)(3). The Conservancy's rights and responsibilities shall be assigned to any entity having similar conservation purposes to which such right may be awarded under the *cy pres* doctrine.

12. **TERMINATION**. This Conservation Easement may be extinguished only by an unexpected change in condition which causes it to be impossible to fulfill the Conservation Easement's purposes, or by exercise of eminent domain.

    A. Unexpected Change in Conditions. If subsequent circumstances render the Purposes of this Conservation Easement impossible to fulfill, then this Conservation Easement may be partially or entirely terminated only by judicial proceedings. The Conservancy will then be entitled to compensation in accordance with the provisions of IRC Treasury Regulations Section 1.170A-14(g)(6)(ii).

    B. Eminent Domain. If the Property is taken, in whole or in part, by power of eminent domain, then the Conservancy will be entitled to compensation by the same method as is set forth in IRC Treasury Regulations Section 1.170A-14(g)(6)(ii).

13. **LIBERAL CONSTRUCTION**. This Conservation Easement shall be liberally construed in favor of maintaining the Conservation Values of the Property and in accordance with the Conservation and Historic Preservation Easement, Sub part 11 of Part 21 of the Michigan Natural Resources and Environmental Code MCL 324.2140 *et seq*.

14. **NOTICES**. For purposes of this agreement, notices may be provided to either party by personal delivery or by mailing a written notice to the party (at the address shown at the top of this agreement, or at last known address of a party) by First Class mail. All notices shall be deemed to have been duly given when hand delivered or when deposited, properly addressed, with the US Postal Service with sufficient pre-paid postage.

15. **SEVERABILITY**. If any portion of this Conservation Easement is determined to be invalid, the remaining provisions will remain in force.

16. **SUCCESSORS**. This Conservation Easement is binding upon, and inures to the benefit of, the Owner's and the Conservancy's successors in interest. All subsequent Owners of the Property are bound to all provisions of this Conservation Easement to the same extent as the current property owner.

17. **TERMINATION OF RIGHTS AND OBLIGATIONS**. A party's future rights and obligations under this Conservation Easement terminate upon transfer of that party's interest in the Property. Liability for acts or omissions occurring prior to transfer will survive the transfer.

18. **MICHIGAN LAW**. This Conservation Easement will be construed in accordance with Michigan Law.

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19. **ENTIRE AGREEMENT**. This Conservation Easement sets forth the entire agreement of the parties. It is intended to supersede all prior discussions or understandings.

WITNESSES: (*Print/type names under signatures) OWNER:

_____ _____

* Dan Hall

_____ _____

*

STATE OF MICHIGAN)
)Ss.
COUNTY OF _____)

Acknowledged before me on this _____ of _____, of 2000, by Dan Hall,

_____
Notary Public
_____County, Michigan
My commission expires: _____

This portion of the page is intentionally left blank. Document continues on next page.

WITNESSES: (*Print/type names under signatures)

_____
*

_____
*

CONSERVANCY:

_____
*
its:

STATE OF MICHIGAN)
)Ss.
COUNTY OF _____)

Acknowledged before me on this _____ of _____, of 2000, by _____, known to me to be the _____ of the Grand Traverse Regional Land Conservancy.

_____
Notary Public
_____ County, Michigan
My commission expires: _____

AFTER RECORDING RETURN TO:
Grand Traverse Regional
Land Conservancy (GTRLC)
3860 North Long Lake Road, Suite D
Traverse City, MI 49684

SEND TAX BILL TO:
Owner

PREPARED BY:
Matthew McDonough
GTRLC

Appendix H

Public Awareness and Education Program Reports

IMPLEMENTING THE PARTNERSHIP AGREEMENT PROCESS IN THE LONG LAKE WATERSHED

FINAL PROGRESS REPORT
TO
GRAND TRAVERSE COUNTY DRAIN COMMISSIONER'S OFFICE

SUBMITTED BY

THE CONSERVATION RESOURCE ALLIANCE, INC.

James R. Haveman
Project Coordinator

FEBRUARY 7, 2001

LONG LAKE WATERSHED PARTNERSHIP AGREEMENT PROJECT

BACKGROUND OF THE PARTNERSHIP AGREEMENT PROCESS

Since 1985 the Conservation Resource Alliance (CRA) has used the partnership agreement as an effective way to work with diverse groups in solving complex resource and community problems. Recognizing the need for training local people to use this concept, CRA submitted a funding proposal in May 1991 to the W.K. Kellogg Foundation.

In late 1991 CRA received funding from the W.K. Kellogg Foundation to develop a training handbook entitled, **"Developing Partnership Agreements: A Process to Resolve Resource Management Issues in the 1990's"**. This handbook was tested and refined through two workshops that trained 47 community leaders on the process. Participants rated the handbook and training experience an overwhelming success.

Although dozens of handbooks were mailed to people at their request, it had become apparent that without the "hands on experience" of actually writing a partnership agreement and developing a work plan, people were confused on where to start and what to do next. A formal evaluation of the partnership agreement training program indicating that the personalized workshop training is an essential ingredient required for people to learn and gain confidence in the partnership agreement process.

In early 1994, a Phase II effort was approved by W.K. Kellogg to expand this training effort to reach other groups and individuals in the Great Lakes Basin. The primary goal of this proposal was to complete twelve (12) workshops over a two-year period. The 22 organizations and conferences that received training through the phase II project included over 950 people.

Five categories of obstacles or barriers were identified by workshop participants interviewed in the Phase II evaluation study. These included legal issues concerning the agreement, time necessary to develop an agreement, political concerns including hidden agendas, organizational constraints and the lack of specific actions coming from the agreement.

Based on the responses from questionnaires and follow-up interviews it appears that the following four items were most useful:

* The training handbook as a reference document.
* Working with people in the workshop on assignments and getting to know others.
* Use of partnership agreement process as a method for communicating better with those in their area.
* Partnership agreements as a new tool for managing local conflicts in a positive, trusting way.

CRA was fortunate to receive a commitment from the W.K. Kellogg Foundation for Phase III funding prior to the completion of the phase II effort. The Phase III "train-the-trainer" opportunity allowed CRA to keep the momentum going. Since many organizations continued to call CRA for information related to the partnership agreement process, it allowed CRA to promote and advertise the advanced phase III training series at the same time.

Phase III funding allowed CRA to institutionalize the process by holding four train-the-trainer workshops to prepare leaders in Great Lakes region to teach and implement both the successful partnership agreement approach and the "how to" evaluation techniques developed under another CRA sponsored project entitled, **Signs of Success.** These evaluation materials were tested on the participants and their feedback used to refine the next generation of evaluation tools.

The results of the phase III training can be summed up with a comment from a previous training session. After hearing a presentation on partnership agreements at a Great Lakes Commission meeting, Dr. John Hartig from Wayne State University asked if CRA was not experiencing "the re-birth of the democratic process" which allowed people to take control of their lives. CRA could not agree more! In recent decades, local people have felt helpless in an increasingly complex society. This frustration has surfaced with anger, resentment and eventually apathy towards numerous local, state and federal issues and organizations. Today the partnership agreement process has given local people a healthy,

productive outlet for feelings of frustration with the political system. Today, thanks to the training provided through this W.K. Kellogg Foundation grant, numerous leaders in the Great Lakes Basin have the tools to help people help themselves to a better way of solving local problems.

At the conclusion of the phase III funding from the Kellogg Foundation, CRA continued to work with and train local people by consulting on various projects that would likely benefit from the partnership agreement process. These projects ranged from working with the City of Flint on Kearsley Park to various watershed related projects like the Long Lake Watershed Project. On these projects, CRA used the attached, updated partnership agreement training handbook entitled, **"Developing Partnership Agreements: A Process to Resolve Resource and Community Issues."**

GOALS OF THE PARTNERSHIP AGREEMENT PROCESS FOR THE LONG LAKE PROJECT

As project coordinator for several on-going watershed restoration projects in northern Michigan, CRA has found that the most successful watershed projects have solid partnerships behind them. These partnerships bring together all the players and diverse interests needed to prioritize and implement long term restoration projects on a watershed basis. By its nature, a partnership facilitates open discussion and fosters cooperation among watershed residents, users and managers. Partnerships accomplish what no one organization can. CRA proposed to the Grand Traverse County Drain Commissioner's Office that a Long Lake Watershed Partnership Agreement would capitalize on the strengths of partners, reduce duplication of efforts and enable technical and financial resources to be pooled and utilized more efficiently.

CRA proposed the following four tasks to accomplish this goal:

- Develop a draft Partnership Agreement for the Long Lake Watershed Project.
- Develop Partnership Agreement mailing list for the watershed project.
- Facilitate multiple task force and partnership meetings to assist the Drain Commissioner's Office in:
    - Signing the Partnership Agreement document.
    - Providing historical input for the watershed plan from partners and potential partners.
    - Facilitating the partnership process to help prioritize best management practices for implementation.
    - Meeting 319 project goals for the watershed.
- Complete an evaluation of the partnership process and submit a written report to Drain Commissioner.

The Long Lake Watershed Partnership Agreement has the potential for providing many benefits. It will improve the water quality and fish and wildlife habitat of the watershed for generations to come because it establishes a framework and forum to prioritize and establish practical, ongoing, watershed based restoration activities. The pooling of technical and financial resources capitalizes on the strengths and interests of all, encourages cooperative projects and information sharing, helps predict unforeseen problems, leverages funding from multiple sources and more effectively and efficiently implements strong restoration projects "in the community". Partnerships compound the efforts of any single organization.

IMPLEMENTATION OF THE LONG LAKE PARTNERSHIP AGREEMENT

The first step in starting the partnership agreement document is to assemble a task force to facilitate the process. It is important to identify 6-9 people that know the watershed and its residents well. The task force members need to be able to identify all the potential partners and the key staff members that work for them. Since the task force prepares the first draft of the partnership agreement process, it also important that they need to understand how residents think and feel about issues within the watershed. Because partnership agreements are written to build consensus, it is important to use words that do not alienate people or bring up divisive issues from the past.

The Long Lake Partnership Task Force fulfilled these goals well. They committee was composed of the following people:

- Karen Rosa, Long Lake Township
- Jim Haveman & Kim Kook, Conservation Resource Alliance
- Garth Aslakson, MDEQ – Surface Water Division
- Lois Feichtenbiner, Landowner and Long Lake Association
- Bob Flannery, Landowner
- Maureen Templeton, Grand Traverse County Drain Commissioner's Office
- Matt McDonough, Grand Traverse Regional Land Conservancy
- Jo Rundio, Landowner
- Bob Doerr, Long Lake Foundation and Long Lake Peninsula Association

The Task Force held its first meeting in the early spring of 1999 and in the next 5 months held six separate meetings. During these meetings they developed and finalized a mailing list for the partnership and a draft partnership agreement. In August this document was mailed out with a cover letter (see attached) to all potential partners promoting the first informational meeting for the partnership. This meeting was held in late August and was well attended.

At this meeting the Long Lake Watershed Steering Committee discussed using the partnership agreement to launch an initiative to improve the water quality, fish and wildlife habitat and protect the scenic and natural resources that make this area unique. The portion of the partnership agreement that states, ***"we believe that the keys to protecting the water resources are education, resource sensitive development and the protection of remaining wetland areas which act as filtering buffers for ground and surface waters"*** was emphasized as being critical to the partnership.

The steering committee was told that a partnership agreement:

- **Is** a general cooperative agreement.
- **Is not** a legally binding contract.
- **Does not** require a commitment of funds.
- **Will** be used by various partners to apply for funding from foundations and governmental agencies to continue funding a multi-year effort to improve the watershed.
- **Will give** them direct input into setting the directions, goals and measurable progress of the Long Lake Watershed Partnership.

Those in attendance were asked to take three action steps;

1) Read and discuss the partnership agreement with their respective organization; if they have questions, or are interested in a presentation, a member of the task force was available to meet with them.
2) Mail back your copy in the envelope provided with an indication of which person you will appoint to represent your group.
3) Send your representative to the next Partnership Steering Committee meeting.

Ultimately the end product of this process resulted in the attached signed copy of the Long Lake Watershed Partnership Agreement that included 28 organizations signing the document. This is excellent and indicates strong support for the Long Lake Watershed Project.

EVALUATION OF THE LONG LAKE PARTNERSHIP

Further evaluation of the partnership agreement process was another part of this project. The evaluation was patterned after CRA's soon to be published, ***"Seeking Signs of Success"*** handbook for watershed managers. Attached is a copy of the handbook portions that relate directly to watershed evaluation. The questions used were similar to the questions used in "Worksheet Five" as attached.

Here are the questions that were used to evaluate the effectiveness of the partnership agreement process in the Long Lake Watershed Planning Project.

1. Do you think the partnership agreement (PA) process will be helpful in obtaining implementation funding for the project?
2. Do you feel that the PA process improved the quality of the watershed plan document?
3. Did the PA process improve local leadership skills within the watershed?
4. Did the PA process improve communication with the residents of the watershed?
5. Do you think the PA process improved the coordination efforts of various organizations involved in the project?
6. What could have improved the PA process for the Long Lake Watershed Project?

Partners that were involved with the project were somewhat randomly selected and, in person or by phone, talked through the above six questions. I tried to select people that had attended at least 2 or more task force or steering committee meetings.

Of the 9 people interviewed the responses were very positive. Virtually everyone answered the first five questions with yes! When asked why, most felt that the partnership agreement process really improved communication and participation at the local level. They, in turn, believe that this results in more ownership for the project and greater commitment to working on implementation activities. The only suggestion for improvement (Question 6) was that more meetings of the partnership agreement steering committee might have encouraged more organizations to sign the partnership agreement document. From my experience 28 organizations signing a partnership in a watershed this size is still very good.

FUTURE PLANS FOR THE LONG LAKE WATERSHED PARTNERSHIP

As stated earlier, CRA has used the partnership agreement model for over 15 years to manage large and complex watershed projects. We strongly recommend that the Grand Traverse County Drain Commissioner's Office continue to use this process as implementation funding becomes available. We recommend that 2-4 meetings be held each year with published minutes sent to the full Long Lake Watershed mailing list. From our experience this provide a process in which local people both feel like they are included in the watershed implementation activities and more importantly feel like this is their project and not some outside government agency's project.

CRA will continue to use the partnership agreement process in northern Michigan and will continue to help past contacts in a one-to-one consulting basis. CRA strongly believes that the partnership agreement process is one of the most effective tools available in helping local people solve complex, community issues.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

LONG LAKE WATERSHED PROJECT

2325 Garfield Road, North • Traverse City, MI 49686

July 27, 1999

Dear Citizen, Official, Organization:

Earlier this summer a group of interested citizens and agency representatives met to discuss the future of the Long Lake Watershed. This group discussed using a partnership agreement to launch an initiative to improve the water quality, fish and wildlife habitat and protect the scenic and natural resources that make this area unique. As the partnership agreement document states, ***"we believe that the keys to protecting the water resources are education, resource sensitive development and the protection of remaining wetland areas which act as filtering buffers for ground and surface waters."*** We are contacting you because we believe that your organization is critical to the future of this watershed partnership effort.

If you are not familiar with the partnership agreement approach, a partnership agreement:

* Is a general cooperative agreement.

* Is not a legally binding contract.

* Does not require a commitment of funds.

* Will be used by various partners to apply for funding from foundations and governmental agencies to continue funding a multi-year effort to improve the watershed.

By becoming a partner you will have direct input into setting the directions, goals and measurable progress of the Long Lake Watershed Partnership. We are fortunate to have a dedicated core of people from the public and private sector that have helped organize this draft partnership. Listed below are people who will be glad to answer questions you have about the program or partnership agreement.

Karen Rosa, Long Lake Township	(231) 946-2249
Jim Haveman & Kim Kook, Conservation Resource Alliance	(231) 946-6817
Garth Aslakson, MDEQ – Surface Water Division	(231) 775-3960
Lois Feichtenbiner, Landowner and Long Lake Association	(616) 947-5747 or 956-1498
Bob Flannery, Landowner	(231) 946-8188
Maureen Templeton & Ron Harrison, GT County Drain Commissioner's Office	(231) 922-4624
Keiran Fleming, GT Regional Land Conservancy	(231) 929-7911
Jo Rundio, Landowner	(231) 929-4927
Bob Doerr, Long Lake Foundation and Long Lake Peninsula Association	(231) 947-5628

Enclosed please find a draft partnership agreement and a self-addressed envelope. We will cut and paste all signatures together and send you a copy of the partnership agreement when it is complete.

LONG LAKE ASSOCIATION

LONG LAKE

Grand Traverse County

We are writing to ask you to take three action steps;

1) Read and discuss the partnership agreement with your group; if you have questions, or are interested in a presentation to your group, please call Jim Haveman (231) 946-6817 or one of the persons listed above.
2) Mail back your copy in the envelope provided with an indication of who you will appoint to represent your group.
3) Send your representative to the first Partnership Steering Committee meeting. A separate agenda will be mailed later. Please send a person to this meeting even if you have not yet signed the partnership.

Partnership Steering Committee Meeting
August 19, 1999
7:00 P.M. - 8:30 P.M.
Long Lake Township Hall
8870 N. Long Lake Road

Thank you for your commitment and concern for the quality of life, environment and natural resources of the Long Lake Watershed.

Sincerely,

Lois Feichtenbiner

Lois Feichtenbiner, President
Long Lake Association

Karen J Rosa

Karen Rosa, Supervisor
Long Lake Township

Maureen K. Templeton

Maureen Templeton, Drain Commissioner
Grand Traverse County Drain Commissioner's Office

PARTNERSHIP AGREEMENT

LONG LAKE WATERSHED PROJECT

This document serves as a Partnership Agreement between various units of government, education, business, special interest groups and private sector organizations interested in the future of the Long Lake Watershed.

The parties committed to this partnership are united by a mutual concern for the conservation and improvement of the water quality, fisheries, wildlife and recreational appeal of the Long Lake Watershed for this and future generations. The parties also believe that the enhancement of this watershed will provide aesthetic, quality of life and economic benefits for the region and the state.

BACKGROUND

The Long Lake Watershed is located approximately 2 miles west of Traverse City in northwest, lower Michigan. This roughly, 23 square mile drainage basin lies within the greater portion of Long Lake Township and portions of Garfield and Green Lake Townships in Grand Traverse County as well as a small portion of Solon and Elmwood Townships in Leelanau County. The watershed contains over twenty lakes ranging in size from six acre Bullhead Lake to the impressive 3,000 acre Long Lake. The Long Lake Watershed begins the drainage system of the Platte River, a significant river to Lake Michigan.

Rapidly increasing development poses threats to the current, good water quality of all the lakes in the watershed. Nonpoint source pollution will be a primary concern as residential and commercial development expands. Sand and other sediments, nutrients from fertilizers and septic systems, and chemical runoff from lawns and paved surfaces are all pollutants of concern. The keys to protecting the water resources in the Long Lake Watershed are education, resource sensitive development standards and the protection of remaining wetland areas which act as filtering buffers for ground and surface waters.

PROPOSED ACTION

The purpose of this partnership agreement is to launch a cooperative initiative to maintain and improve the water quality, fish and wildlife habitat and protect the scenic and natural resources that make this watershed unique.

We, the undersigned, agree to cooperate fully and to provide technical and financial assistance, as available, to support the Long Lake Watershed Project. Coordination will be accomplished jointly through the Long Lake Watershed Steering Committee. This steering committee will be comprised of representatives from the organizations signing this partnership agreement. This committee will recommend the proposed actions within the project.

Long Lake Township

Karen J. Rosa — 7-20-99

Supervisor — Date

Grand Traverse County Drain Commissioner's Office

Maureen K. Templeton — 7-20-99

Drain Commissioner — Date

Long Lake Association

Fritz Leichtenberger — 7/20/99

President — Date

Grand Traverse Conservation District

for Chairman — 8/11/99

Date

Grand Traverse County Board of Commissioners

Richard Aikens — 7/30/99

Chairman — Date

Conservation Resource Alliance, Inc.

David A. Hobbell — 7/21/99

Chairman — Date

Northwest Michigan Council of Governments

Chairman — Date

Grand Traverse County Road Commission

Chairman — Date 8/4/99

Long Lake Foundation

President — Date 7-20-99

Grand Traverse Regional Land Conservancy

Executive Director — Date 7/28/99

MDEQ-Surface Water Quality Division (Cadillac Office)

District Supervisor — Date July 20, 1999

Grand Traverse County Planning Department

Director — Date 7/28/99

Grand Traverse County Health Department

Director, RS — Date 7/30/99

Friends of Bullhead Lake

President — Date 7/20/99

Green Lake Township

Supervisor — Date 8/10/99

Farm Bureau

Director — Date

Ma-Me-Ne-Sewong Garden Club

Chairman — Date

New Designs for Growth

Chairman — Date 7/29/99

Leelanau County Drain Commissioner's Office

Drain Commissioner — Date 17 Aug, 1999

Leelanau County Road Commission

Chairman — Date

Elmwood Township

Supervisor — Date

Solon Township

Supervisor — Date

Grand Traverse Regional Community Foundation

Chairman — Date 8/2/99

Oleson Foundation

Chairman — Date

Long Lake Peninsula Association

President — Date 7-30-99

Forest Lodge Association

Kristine O. Drake — October 2, 1999

President — Date

Lake Ann Association

President — Date

Platte Lake Association

8/7/99

President — Date

Michigan Lakes & Stream Association

~~Chairman~~ President — Date

Traverse City Area Chamber of Commerce

7/29/99

Chairman — Date

Traverse City West High School

Joseph T. Tibaldi — 8.16.99

Principal — Date

Grand Traverse Solid Waste Coordinator

Coordinator — Date

Michigan Golf Association

Chairman — Date

Garfield Township

9/16/99

Supervisor — Date

1999/2000 Long Lake Watershed Student Education Project Final Report

Project Summary

Project Successes:

The Long Lake Student Education Project was a success. The monies from this grant allowed 75 high school students to engage in local watershed management activities and projects. Highlights of this program included:

- students learning and working with Geographic Information Systems technology to delineate and evaluate impervious surfaces within Long Lake Watershed.
- integration of academic content language arts, global studies, and environmental science with actual watershed management activities.
- Engaging the local citizenry in a historical and cultural look at the watershed.
- The project culminated with 75 students monitoring sites on Long Lake and reporting out results at the regional Water Quality Student congress.

Project Challenges:

Integration requires team work and commitment of all parties to blend the sum of the parts into the whole. It was continually a challenge to keep everyone engaged and on the same page throughout the project. When coordinating teachers who have different timelines objectives and required outcomes a great deal of planning is necessary to insure integration is taking place. It is very easy for one teacher to take off on their own and forget that there others within the project to be considered. Commitment of all parties to the project becomes the key factor. Time spent on planning and team building is essential to projects of this type. Communication is another important element and proved to be challenging within this project.

Recommendations:

Time spent in the planning process is key to the successful integration of classroom work and outside project work. There are many players to coordinate. Task accomplishment will depend on the communication and understanding of who is doing what when. A monthly project newsletter would serve as a nice update and reminder to retain continuous effort. Also, a review of the availability of transportation funds is an essential consideration when creating the budget.

Project Summary by Task

Planning: Budgeted $1000

Tasks

Host and facilitate a series of meetings which will unite the schools within the Long Lake Watershed along with the organizations involved in the 319 project. These meeting will focus on the components of Water Watch as well as to determine the role the students will play in establishing a long term watershed management plan. The meetings will conclude with the creation of an action plan for implementation.

Action:

Three meetings took place with a curriculum team from West Senior High School, the Grand Traverse Regional Math, Science and Technology Center, and New Designs for Growth. From these meetings it was decided that West Senior High would commit an interdisciplinary team to work with the Long Lake 319 Project. Additional planning meetings were held to determine who would be on the team, what subject areas would be covered, and how activities were to be structured. It was determined that a summer training program would be best for planning the school year. Accommodations and adjustments to our budget were made to pay teachers a stipend for their planning time during the summer.

Summary of Meetings:

The goal of the first meeting was to orient the teachers to the Water Watch program and discuss the educational component areas that they would like to see included in the project. A Water Watch slide show was given to provide a visualization of many of the program's potential component areas. The slide show was open to questions throughout and ideas began to take shape. Of concern was the logistical constraints that the teachers faced in facilitating a project of this scope. It was determined that before any real brainstorming of program components could take place, the barriers which hinder the ability to teach to this project style had to be addressed. The second meeting would address these issues.

Meeting two. The meeting revolved around the school logistics and content areas which need to be taught and who should be involved. Each teacher had an opportunity to discuss what was taught in their respective class/subject areas. Discussion turned to the appropriateness of having a multidisciplinary approach and that a block schedule would be needed. Other issues at hand were the discussion of recruiting students, and conflicting schedules with other activities. The meeting was then adjourned with the teachers involved and the principal agreeing to reorganize the 1999-2000 school schedule, checking education materials to insure compatibility, and talking to counselors about the students who should enroll in this program.

Meeting Three. It was determined that a "core group" of teachers would team teach the students involved in the project. These teachers will work in the same block of time and thus enabling the multiple discipline approach to the program. There will be approximately 75 students, mostly in grades 10 and 11. The project should have a report component that requires students to present data and findings to a local panel of citizen and other watershed stakeholders.

It was decided that the following teachers and their respective subject areas should be represented:

Environmental Science	Cindy Harris
Global Studies	Barbara Coulter
Language Arts	Jason Carmien
Technology	Bob Sturtz

In addition, the teachers felt strongly that the principal should be involved as well.

Actual $537

Training: Budgeted $1500

Tasks

Training for teachers, volunteers, and students is a key element for successful implementation. Training will include hands-on activities in the following areas:

- Understanding the Watershed Concept
- Physical and Chemical Monitoring Skills
- Understanding Habitat, Stream Site Evaluation, and Aquatic Macroinvertebrate Monitoring
- Data Analysis and Action/Service Learning Components
- Curriculum Planning

Teachers need to have the confidence in their own specific knowledge on the subjects to be taught. This workshop will reinforce the support necessary to implement the program. Hence, our training will revolve around enhancing content knowledge appropriate to the project, providing experts who can visit the classroom, as well providing activities for the classroom. Further, emphasis will be placed on the relationship of this program to the Michigan Educational Assessment Program, its alignment with curriculum, and the educational goals of the schools involved.

Action

The bulk of the work this quarter has been spent working with teachers and administrators to plan and prepare for next school year. While the Long Lake program fits well with the environmental science curriculum, restructuring and tying in global (social) studies and language arts can be challenging. To justify change in these areas time must be spent going through activities and comparing educational outcomes to state and local curriculum standards. Our work at the workshop, June 21- 24, was productive in beginning this task.

An important accomplishment has been the development of a timeline of the activities and labs for the Environmental Science (ES) classroom. It will be ES which takes the lead and guides the work of the other classrooms. The first few weeks of the ES class will be focused on the definition and understanding the watershed concept. This will concurrently flow with the Language Arts (LA) classroom's historical investigation of the watershed. By conducting surveys and interviews of the "elders of the watershed" it is hoped that the students will get a rich narrative of what the watershed was like in the past.

Other activities and projects which are beginning to take shape are:

- Web pages highlighting the projects work
- Field research - will need the assistance of the project partners

- Panel discussions
- Student involvement in watershed planning meetings/workshops
- Student presentation of findings to 319 group
- Global comparison/sharing with other watersheds via the internet

Training occurred over the course of one week in the summer.

Actual **$1486**
Plus teacher stipends **$ 560**

Implementation: Budgeted $1500

Tasks
The implementation phase will take the form of a coordinated event, such as, a fall monitoring program and/or spring program. As a part of implementation, the coordinator will work closely with the teachers, administrators and community resources to support the program. In addition students in this program are welcome to present there findings at the Water Watch Annual Student Congress.

Action
Environmental Science began their study by looking at the geology of the watershed. The Language Arts class will begin its oral histories program in October and November. Global Studies will create posters of the watershed, and build a timeline which highlights the development and history of the watershed.

Ron Harrison gave a nice overview of the Long Lake 319 which helped build the framework from which the students will work. Eleven watershed resident volunteers came into the classroom to share their observations of the watershed throughout their lives.

Accomplishments:

- Finalized the curriculum blueprint of the next school year.
- Coordinated and facilitated several small working sessions with teachers.
- Continued the curriculum integration process.
- Kick-off project with presentation by Ron Harrison.
- Began curriculum
- Oral histories of the watershed a great success with 11 citizens sharing their stories
- Fall field trips to watershed and historical areas
- Spring Monitoring Events (3 days) and Water Watch Student Congress Participation

Actual **$1540**

Evaluation

Budgeted $ 500
Actual **$0**

Budget Summary

Total Project Budget	$4500
Total Actual Expenditures	$4123

Last Transportation Bill not included.

Appendix I

Long Lake Watershed: A Landowner's Handbook