LAKE MORAINE



LAKE IMPROVEMENT FEASIBILITY STUDY AND MANAGEMENT PLAN

for

Lake Moraine Improvement Board

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and

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INTRODUCTION

Lake Moraine is located in Sections 14, 15, and 22 of Brighton Charter Township, Livingston County, Michigan. The lake impoundment was created in 1958 upon the construction of a dam along the Mann Creek. The surface area of the lake is approximately 28 acres. The current land use around the lake is residential housing. The primary use of the lake is recreational.

Residents of Lake Moraine have stated that the quality of the lake has diminished due to excessive sedimentation, aquatic plant growth in the lake, and removal of lake level control structure.

In 2004, residents around Lake Moraine petitioned Brighton Charter Township for lake improvements, including dredging, weed control, dam improvements, recreational enhancements, and lake maintenance activities. By resolution of the Brighton Charter Township Board, a Lake Improvement Board was established, on November 3, 2004.

The Lake Improvement Board (LIB) developed a work plan for the completion of a feasibility study to assess the lake and dam and provide recommendations on improvements to the lake. This report summarizes the feasibility study, improvement recommendations, and cost estimates for identified improvements to the lake.

Included in the study are summaries of the following:

- Watershed Characteristics
- Lake Inspection and Assessment
- Bathymetric Survey
- Sediment Sampling and Testing
- Aquatic Habitat and Plant Survey
- Water Quality
- Dam Inspection and Assessment
- Aquatic Plant Control
- Best Management Practices and Lake Management Plan
- Recommendation and Cost Estimates for Lake Improvements

WATERSHED CHARACTERISTICS

The characteristics of the Lake Moraine watershed, including the drainage area, land use, soils, topography, influent creek (Mann Creek), soil erosion and socio-economics of the watershed, were reviewed. A general and brief assessment of the watershed was completed with the primary goal to understand the sustainability of potential lake improvements with emphasis on sediment transport and nutrient loading. Appendix 1 contains the maps of the watershed and Lake Moraine.

Hydrology

The Lake Moraine watershed has an area of 20.4 square miles (13,056 acres). During rainfall events, storm water runoff from the watershed flows into the Mann Creek and ultimately into Lake Moraine. The Michigan Department of Environmental Quality (MDEQ) has calculated the flow rates of storm water runoff for various frequency rainfall events. The flow rates are summarized in Table 1. The flow rates shown in Table 1 must pass through the dam at Lake Moraine.

The MDEQ also calculated the volume of storm water runoff for the 100-year storm event to be 1,800 acre-feet.

Table 1: Storm Water Runoff Rates into Lake Moraine for Various Storm Events

10-Year Storm:	210	cfs
50-Year Storm:	370	cfs
100-Year Storm:	470	cfs
200-Year Storm:	550	cfs
500-Year Storm:	700	cfs

Land Use

Historically, land use in the Lake Moraine watershed was primarily agricultural and rural. Development of the lands in the watershed has resulted in a significant change in land use. Agricultural and rural land uses have, in large part, given way to residential, industrial, and recreational land uses. Current land uses of the Lake Moraine Watershed are shown below in Figure 1. A land use drawing of the Lake Moraine Watershed is included in Appendix 1.

With the land use in the watershed changing, it can be expected that sediment and nutrient loading into Lake Moraine have changed. The exposed soils and farming activities have decreased, while impervious areas and maintained lawns have increased. It is expected that the rate of sediment loading in the future will be less than what has been experienced in the past. Increased nutrient loading is a concern, with emphasis on the maintenance of lawns and residential properties.

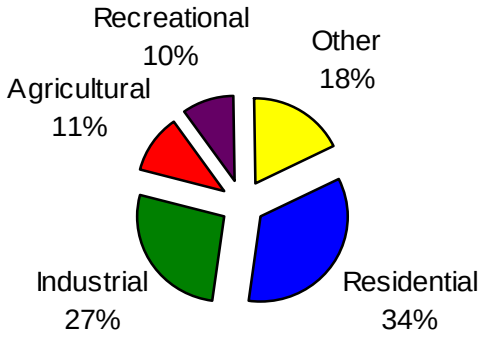


Figure 1: Current Land Use in the Lake Moraine Watershed

Soils

The soil survey maps help describe the tendencies and similarities of the soils within a region. Soil survey maps record information such as permeability, slopes, erodablity, growing ability, etc. The U.S. Department of Agriculture's (USDA's) 1973 soil survey of Livingston County, Michigan, reveals that the following soil associations are present or exist in Brighton Charter Township:

- *Fox-Boyer-Oshtemo-Houghton Association.* Nearly level to steep, well drained, moderately coarse textured and coarse textured soils, and very poorly drained organic soils on outwash piles.
- *Fox-Boyer-Oshtemo Association.* Steep or hilly, well drained, moderately coarse textured and coarse textures soils on moraines.
- *Miami-Hillsdale Association.* Strongly sloping to hilly, well drained, medium textured and moderately coarse textured soils on moraines and till plains.

Mann Creek

The Mann Creek is the primary tributary to Lake Moraine. The Mann Creek headwaters are located in Oakland County. The Mann Creek travels southwest through the GM Proving Ground and into Lake Moraine. As part of this study, the Mann Creek was inspected by Wetland and Coastal Resources (WCR) to locate and analyze sediment sources that currently may be contributing to the sediment loading of Lake Moraine.

The inspection of Mann Creek at Kensington Road, downstream of the GM Proving Ground, revealed no significant erosion. The water at this location was clear and free of sediments, before and during an observed rain event.

The inspection of the Mann Creek at the Pleasant Valley Road crossing found the water in the creek to be clear and free of sediment upstream of the crossing. Shortly after a light rain began, a sediment plume was easily distinguishable and traveling downstream into Lake Moraine. This sediment was observed running off of Pleasant Valley Road and into Mann Creek, causing turbidity in the water (see Figure 2). Upstream of Pleasant Valley Road, the water in the creek was still clear. Mann Creek at the Pleasant Valley Road crossing was observed again approximately one hour after the rain started. Water upstream of the crossing remained clear, while the plume of sediment caused by the ongoing roadside drainage had extended even further downstream of the crossing.

Residents indicated that there was an old dam in Mann Creek located between Lake Moraine and the GM Proving Ground site. The impoundment created by the old dam filled with sediment and when the dam was removed, the sediment was transported downstream depositing into Lake Moraine. It has been stated by long-time residents that the majority of the sediment deposited in the upper arm of Lake Moraine occurred as a result of this event.



Figure 2: Runoff entering Mann Creek from Pleasant Valley Road and from the drainage system

Socio-economic Character

The social and economic character of a community indirectly plays a role in how decisions and choices are made. Gender, age, income, and education statistics in Brighton Charter Township were compared with Michigan averages. The information was gathered from the United States Census Bureau Fact Finder website and is from the 2000 national census. A complete breakdown of the statistics can be found in Appendix 2.

Brighton Charter Township has a slightly larger male population at 51.2% than its female population at 48.8%. As a state, Michigan is the exact opposite with a 48.9% male population and 51.1% female population. The age distribution within Brighton Charter Township does vary from that of the State of Michigan, as shown in Figure 3.

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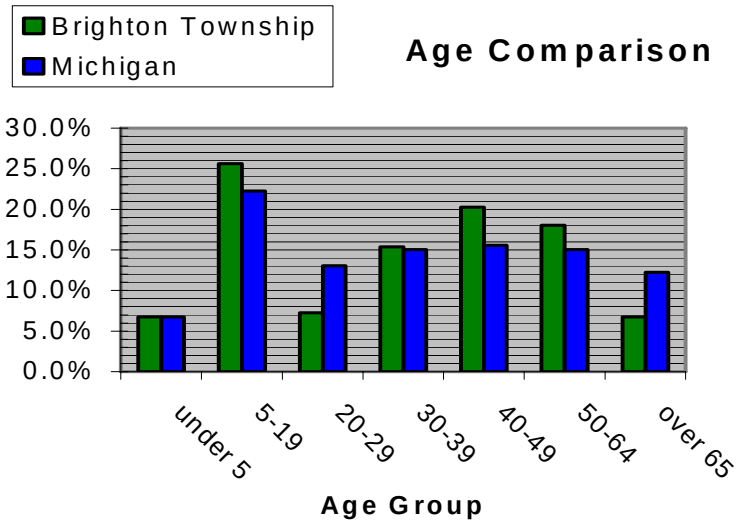


Figure 3: Age Comparison between Brighton Charter Township and Michigan

The income distribution in Brighton Charter Township is directly correlated with the education level of its residents. Approximately 36% of the residents in Brighton Charter Township have a bachelor's degree or higher, which is slightly higher then the State of Michigan at 34% of its residents 18 years or older have a bachelor's degree or higher. Of the residents in Brighton Charter Township 92% of them have at least a high school diploma and/or some college experience versus the State of Michigan at 30% of its residents having less then a high school diploma. Over 76% of the residents in Brighton Charter Township make more than $50,000 a year and over 55% make more than $75,000 a year. The income distribution can be seen in Table 2 below. The educational attainment in Brighton Charter Township can be seen below in Figure 4.

Table 2: Income Distribution within Brighton Charter Township

Income Distribution

Income	% of Population
Less than $20,000	6.3%
$20,000 to $30,000	6.6%
$30,000 to $40,000	4.8%
$40,000 to $50,000	5.9%
$50,000 to $75,000	20.6%
Great then $75,000	55.9%

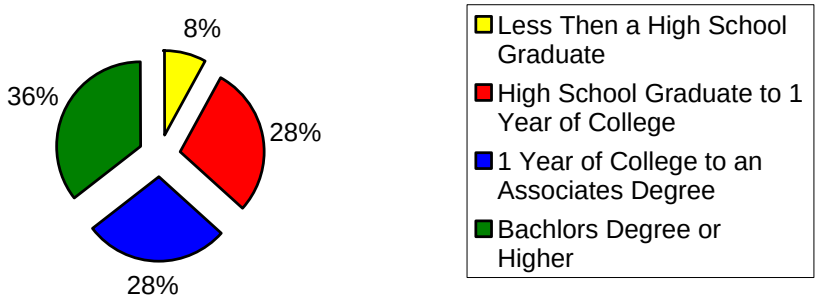


Figure 4: Educational Attainment for Brighton Charter Township Age 18 and Older

LAKE INSPECTION AND ASSESSMENT

The inspection and assessment of the lake and dam included the following:

- Bathymetric and topographic survey
- Sediment sampling and testing
- Aquatic habitat and plant survey
- Water quality testing
- Assessment of the dam

Bathymetric Survey

A bathymetric survey of Lake Moraine was completed to determine water depths and contours of the lake bottom. Cross sections of the lake were obtained and the depths from the water surface to the top of the sediment and to the point of survey rod refusal were measured. The topographical survey of the lake shoreline was completed. The data collected during the survey was used to develop a digital terrain model and maps of the lake. The contour maps of the lake bottom, water depth maps, sediment depth maps and cross sections are provided in Appendix 1.

The lake was divided into two "arms" for the report. The upper arm being upstream of Waycross Road and the lower arm being downstream of Waycross Road. In the upper arm, water depths ranged from 0.5 feet to 4.5 feet. Significant accumulations of loose sediment were measured in the upper arm, with the maximum accumulation of up to four feet. In the lower arm, water depth ranged from under 1 foot to over 8 feet, with the depths in the middle of the lake ranging from 4 feet to 8 feet. Sediment accumulation in the lower were also measured but were not as significant as in the upper arm.

Sediment Sampling and Testing

Soils and Materials Engineers, Inc. (SME) performed the sediment sampling and testing in accordance with MDEQ regulations for dredging. SME collected 30 sediment samples (S1 – S30). A map showing the sample locations is provided in Appendix 1 and in the SME report provided in Appendix 4. Brighton Analytical L.L.C. analyzed samples for analysis of polynuclear aromatic hydrocarbons (PAHs), arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc. Additionally, five samples were submitted for analysis of polychlorinated biphenyls (PCBs).

PAHs constituents were detected in samples S16 and S18 however the concentration detected do not exceed Part 201 Generic Residential Cleanup Criteria. No PCBs were detected.

Samples S1 through S8 and S26 contained concentrations of chromium, lead, manganese, selenium, and/or zinc that exceeded Part 201 Generic Residential Drinking Water and/or GSI Criteria. Samples S1 through S8 were collected at the southern end of Lake

Moraine's lower arm. Sample S26 was collected from the center of the upper arm. See the attached Sediment Sampling Map in Appendix 1.

SME performed a sieve and hydrometer analysis of 15 samples. Based on this analysis, the general composition of the deposited sediment is a sandy silt/clayey silt with some fine to medium sand. Water depths ranged from 0.25 to 7 feet where the samples were collected. Sediment thicknesses ranged from 1 foot to 5 feet. The sediment samples collected were black in color and contained trace to moderate amounts of organics. Samples exhibited an organic odor.

The results of soil sampling and testing indicate that any dredged spoils must be placed on an upland site with a deed restriction or at a Class II landfill. The complete sediment sampling results and sample location map are provided in SME's technical report in Appendix 4.

Aquatic Habitat and Plant Survey

WCR performed a survey of the aquatic plants and habitat quality in Lake Moraine. The upper arm of the lake contains excessive vegetation and invasive species such as Eurasian Water Milfoil and Curly Leaf Pondweed. The lower arm also has invasive plants in excessive amounts including Filimentour Algae and Blue-green Algae. A detailed listing of plant species is provided in the technical report prepared by WCR in Appendix 3.

A minimal amount of quality aquatic habitat was observed in the upper arm of the lake. In the lower arm, several areas of higher quality aquatic habitat were observed. Overall, the amount of quality aquatic habitat area in Lake Moraine is very small. The island in the lower arm is dominated by wetland vegetation and a shallow littoral zone and is considered an area of quality habitat. The locations of these areas are shown in Figure 3, page 10, of the WCR technical report in Appendix 3.

In the isolated areas of the lower arm where quality aquatic habitats were determined, desirable fish species were observed. These include the following: largemouth bass (*Micropterus salmoides*) and sunfish species (*Centrarchid*). A local resident indicated that sizeable northern pike (*Esox luscious*) have been caught in the lower arm. A number of carp (*Cyprinus carpio*) were also observed in the lake. Fisheries in the lake are currently inhibited by sedimentation and excessive vegetation growth.

Lake Moraine contains a limited frontage of natural, undeveloped shoreline. Figures 2 and 3, Page 9 and 10, in WCR's technical report in Appendix 3 depicts these areas. A majority of the lake is fronted by well-maintained turf grass lawns common to residential developments. Outfalls to the lake were also identified as part of the inspection. Only a 24-inch corrugated metal pipe (CMP) was identified emptying into Lake Moraine. The outfall had a small, steady discharge whose origin is unknown.

Water Quality

Four lake water samples were collected and tested for the following quality parameters (a) dissolved oxygen, (b) temperature, (c) Secchi depth, (d) total phosphorus, (e) total alkalinity, (f) Chlorophyll-a, (g) pH and (h) water depth.

Dissolved oxygen levels were slightly elevated, probably due to the high amount of photosynthesis occurring in the lake during the sampling period. Chlorophyll levels were above average, suggesting eutrophic lake conditions. The remaining tests were within the normal ranges for warm water lakes. Detailed results for the water quality testing can also be found in the technical report prepared by WCR in Appendix 3.

The county health department has identified Lake Moraine as having experienced a problem with elevated E. coli levels. During the inspection, a number of possible sources were identified that could explain this problem. Possible E. coli sources include, but are not limited to, failing septic systems and natural wildlife populations. A large local goose population on the north arm of the lake and between Kensington and Pleasant Valley Roads were observed.

Dam Inspection and Assessment

The dam was inspected pursuant to the requirements of Part 315, Dam Safety, Natural Resources and Environmental Protection Act, Act 451 of 1994 on October 20, 2005. The following is a summary of deficiencies observed during the inspection:

- The top of dam does not have a consistent grade or top elevation.
- There is a significant amount of trees, brush, and debris on the downstream face of the dam.
- The riser and outlet pipe are in poor condition and rusted (not operational).
- The stop logs in riser pipe are dry rotted.
- The top of the riser pipe is 9" above water surface elevation.
- Sinkholes were noticed along the riser structure outlet pipe.
- The dam cannot convey the required 100-year storm event.

It was identified that improvements to meet minimum safety standards of Part 315 are required. The MDEQ is aware of this and currently has issued a permit to the owner of the dam (B & V Construction) to make the necessary repairs to meet the minimum requirements for Part 315. In general, these repairs include (a) removing trees and debris from downstream face of dam, (b) providing a consistent elevation along top of the dam, (c) removing existing riser structure, and (d) filling the existing piping structure with concrete. A copy of the complete dam inspection report is included in Appendix 5.

BEST MANAGEMENT PRACTICES AND LAKE MANAGEMENT PLAN

Aquatic Plant Control

Excessive vegetation and invasive plant species have been identified by residents as a major concern. The nutrient rich sediment along with shallow water depths contributes to this annual problem. The property owner associations have been using chemical treatment to control the plant species on an annual basis. Best management practices for aquatic plant control are listed in order for recommended implementation:

- Dredging
- Sedimentation Basin
- Lake drawdown structure
- Weed harvesting
- Chemical treatment

Best management practices for aquatic plant control that are recommended, but cannot be implemented by the LIB, include:

- Natural buffer zones between lawn and shoreline
- Proactive septic tank maintenance
- Education

Dredging

Dredging Lake Moraine will have many positive impacts on the quality of the lake. By removing nutrient laden sediment, there will be less accumulation conducive to massive plant growth. Dredging will also reduce the aquatic coverage on the lake by reducing the amount of sunlight that reaches the bottom of the lake. Sediment removal will uncover the natural rocky lake bottom and establish additional high quality fish habitat areas. Dredging may disturb the water quality and natural habitat of the lake during the actual construction. The long-term impact of dredging will result in improved lake quality and habitat.

Sedimentation Basin

A sedimentation basin near Pleasant Valley Road will capture nutrient rich sediment coming from upstream sources. The capture of sediment in the basin will reduce the accumulation of sediment in the lake. The sedimentation basin would require long-term maintenance to remove the sediment on a regular basis and keep the sediment basin clean.

Lake Level Control Structure

A lake level control structure will enhance the lake biota and enable drawdown of the lake level for summer and winter conditions. The water level would be lowered in the fall/winter and nuisance vegetation would be exposed and controlled due to exposure to the freezing temperatures. This would be helpful in controlling the invasive species of vegetation that currently existing in both the upper and lower arms of Lake Moraine. In addition, a lake level control structure enables the mixing of the fresh oxygen rich Mann Creek runoff water and stagnant Lake Moraine water in the wintertime.

It is recommended to install a new riser pipe, a cold water return, and add additional spillway capacity. This involves replacing the existing structure with a 72-inch reinforced concrete pipe (RCP) riser and 60-inch RCP outlet. The riprap spillway would also need to be modified to gain additional conveyance capacity.

Paving Pleasant Valley Road

Sediment from the road has been observed flowing into the lake. It is recommended to pave the road near the creek to reduce the sediment loading from the gravel road.

Weed Harvesting

Harvesting the weeds will prevent the yearly accumulation of organic matter and nutrients on the lake bottom. Harvesting the weeds after lake dredging will allow the landowners to slow the process of the accumulation of decaying material on the lake bottom. Farmers can use harvested weeds as compost. There are several farming practices located near Lake Moraine that may accept the free composting material.

Chemical Treatment

Chemical treatment should be the last resort management practice. Prior to implementing chemical treatment for weed control, an assessment of the type and number of weeds should be completed to ensure that the proper amount and type of chemicals are used on the lake. This will reduce excess chemicals getting into the lake and causing problems in water quality. Until dredging is completed, the chemical weed treatment program should be maintained. However, chemical treatment will not result in long-term benefits of improvements to the lake.

Natural Buffer Zones Between Lawn and Shoreline

Each landowner along a lake faces a unique challenge in balancing recreational, land-use, aesthetic, economic, and environmental considerations on their property. Unique habitats, vegetation, soil conditions, and infrastructure exist, requiring consideration and proper planning. The activities taking place on or near the shoreline of Lake Moraine have a significant impact on the lake's water quality. A soil erosion and sedimentation

control plan for any type of construction, whether in the water or on-land, will help reduce the sediment load reaching the lake.

Lakefront property is often landscaped to improve aesthetic value and/or land use possibilities. Some of these aesthetic improvements, such as maintaining a manicured turf-grass lawn up to the water's edge, may be detrimental to water quality. Nutrients and chemicals applied to the lawn are easily transported into the lake during storm events. Maintaining a buffer between your lawn and the lake improves water quality by reducing nutrient and chemical loading.

A buffer strip or filter strip consists of a 10-foot (or greater) buffer of unmanicured area between your lawn and the lake. Planting of native plant, shrub, and tree species in this buffer strip will provide increased habitat, filter suspended sediment loads, and remove nutrients and chemicals from the runoff. In addition, the taller grass will discourage geese and help reduce the E. Coli levels in Lake Moraine. In addition, native vegetation has deeper root systems that help protect the shoreline in place and prevent erosion and sloughing.

Proactive Septic Tank Maintenance[1]

Failing on-site wastewater treatment systems, or septic systems, are a threat to surface water quality in the vicinity of Lake Moraine. A failing septic system does not adequately treat wastewater before it reaches a water body and/or the groundwater table. Furthermore, the soils and water conditions in the vicinity of a lake make septic systems less effective. Lake Moraine's elevated E. coli and nutrient levels may be due, in part, to inadequate treatment of wastewater, caused by a lack of maintenance, improper design, or illicit connection directly to the lake.

A septic system has three main components. First, a septic tank removes solids and floatable from wastewater. Next, the water is distributed in some fashion into the soil. This could be through a series of trenches, an infiltration bed, or some other system. Finally, natural biological processes treat the wastewater before it reaches the groundwater table or surface waters.

When undertaking new construction, licensed professionals should be contracted for design and installation of septic systems and its components. A number of legal regulations govern the design, operation, and installation of these systems and consultation of a professional is necessary.

Potential problems may exist if:

- Sewage backs up into your toilet or drains (this may appear as a black liquid),
- Toilets flush slower than expected,
- The drain field area is consistently wet or saturated,
- Excessive growth or algae blooms are noted adjacent to your home,

[1] *Maintain your Shoreline Septic System.* **BMPs for Protecting our Shorelines.** University of Minnesota Extension Service

- Foul odor is observed near your system, or
- Bacteria and/or nitrates are found in your well.

Regular inspection and maintenance of a septic system is recommended. The public health department may be able to help inspect your system. Other household tips include:

- Household habits
    - *Conserve water.* Excessive water use is the most common cause of septic failure, so reduce water used for bathing, laundry, and flushing the toilet.
    - *Identify and repair* leaking pipes, sticking float valves in toilets, and dripping faucets to reduce water waste. A dripping faucet can waste 15-20 gallons per day.
    - *Shorten shower times and choose showers over baths* to minimize wasted water. A full bath uses 50-60 gallons, while a shower uses only about 5 gallons per minute. Of course, a 20-minute shower is not a savings over a bath.
    - *Install low-volume toilets and low-flow showerheads.* Typical toilets use 5-6 gallons per flush, providing nearly half the wastewater from a house. Flush toilets using 1-1/2 gallons of water are available.
    - *Keep a container of drinking water in the refrigerator.* This saves having to run water until its cold.
    - *Use toilet tissue that breaks up easily when wet* to help prevent clogging. To test tissue quality, place a piece in a jar half full of water and shake. If the tissue breaks up easily, it is suitable. The color of tissue has no effect on septic system action.
    - *Do not use the toilet as a wastebasket.* Don't flush facial tissue, diapers, tampons, or any kind of plastic down the drain.
    - *Eliminate the use of garbage disposals.* Ground-up garbage does not decompose easily, causes rapid buildup of solids in the tank, and may move out of the tank into the drain field, clogging distribution pipes and soil pores. If you have a disposal--don't use it. When building or remodeling--don't install one.
    - *Never put coffee grounds down your drain.*
    - *Dispose of household hazardous waste properly.*
- For cleaning and laundry
    - *Wash only full loads in the dishwasher.* Typical dishwashers use about 13 gallons for each wash. Newer models use 8-gallons.
    - *Use low-phosphate dishwasher detergent. Some* brands are designed to reduce phosphate levels without effecting performance. Check the label and try to use detergent with 10% or less phosphate.
    - *Wash only full loads of clothes and use front-loading washers and suds-savers to save water.* To avoid overloading your system, spread washing over the week instead of washing several loads on one day. A single load takes about 40 gallons.

    - *Use liquid laundry detergent* because it's less likely to have fillers or carriers that may damage the septic system. Try to use the minimum amount because detergents can cause problems with the system.
    - *Minimize use of household chemicals and cleaners.* Normal amounts of household detergents, bleaches, drain cleaners, toilet bowl deodorizers, and other cleaners won't harm bacterial action in the septic tank.
- Maintain the septic tank
    - *Discharge all sewage waste from the house into the septic tank. Don't* run wastewater from laundry or saunas directly into the drain field as the detergent or soap scum will quickly clog soil pores and cause failure.
    - *Do not add "starters" to your septic system.* Enough bacteria are available in the wastes flushed into the septic tank. Even after the tank has been pumped, enough bacteria will be provided when you use the system again.
    - *Do not use additives in your system.* They are of no benefit and may harm the system. Additives that cause the accumulated sludge to increase in volume or float will result in sludge being flushed into the drain field, plugging soil pores. Also, some additives, particularly degreasers, may be carcinogens that will flow into ground water with treated wastewater.
    - *Pump the septic tank every year to remove solids and scum.* Although tanks away from lakes or rivers may not need it every year, annual pumping is excellent insurance near shorelines.
    - *Remove the manhole cover when having the tank pumped* to make sure that all solids have been removed. The sludge in the tank should be mixed during pumping. A tank cannot be adequately cleaned through a 4-inch inspection pipe. Pumping through the inspection port may clog the outlet baffle with scum and grease.

Education

One of the most important aspects of the Lake Moraine Management Plan is the inclusion of a diverse, active education program for the landowners surrounding Lake Moraine. Providing education about the basic impacts of everyday activities on the lake will help reduce pollution to the water body. Education programs exist through local, regional, state, and national efforts to help educate the residents of the Lake Moraine watershed. Recommended topics include, but are not limited to:

- Exotic and Invasive Species
- Nutrient Management
- Soil Erosion and Sedimentation Control
- Habitat Development
- Waterfront Landowner Rights and Responsibilities
- Fisheries Management

Huron Chain of Lakes Watershed Management Plan

The Charter Township of Brighton is an active participant in the watershed planning process for the Huron Chain-of-Lakes Watershed Management Plan (WMP). The plan identifies nutrient loading and sedimentation as two of the primary problems throughout the chain of lakes.

- Section 4.5 of the WMP, *Huron Chain of Lakes Action Plan*[2], sets forth a set of recommended goals and actions to achieve improved water quality. In addition to those activities recommended in this document, the WMP proposes a total of 96 BMPs including: 71 Managerial, 14 Vegetative, and 11 Structural Practices recommended for the watershed. These BMPs, are listed for Brighton Charter Township, as currently underway, planned for short-term, planned for long-term, wish list, and County Soil Erosion and Sedimentation Control (SESC) Standards in the WMP.

LAKE DREDGING ALTERNATIVES

There are several factors that need to be considered and identified prior to dredging a lake. These factors help determine overall project costs and each factor considered influence the decision on the other factors. These factors are:

- Type of dredging methods
- Volume of dredge material to be removed
- Spoil and water separation
- Disposal of dredge material
- Permits

Type of Dredging Methods

There are two types dredging methods, hydraulic and mechanical to remove sediment from the lake bottom. Both methods result is sediment spoils that need to be disposed of. The difference between hydraulic and mechanical dredging is the location of the equipment and how the sediment spoils are received. A hydraulic dredge floats on the surface of the lake and looks much like a large pontoon boat. A slurry mix of sediment and water is pumped from the lake, through a pipe, to where the water and sediment are separated. The clean water is discharged back into the lake.

A mechanical dredge operates similar to an excavator on land. Sediment is scooped or bucketed from the lake bottom and removed from the lake. Water is removed and discharged back into the lake. In mechanical dredging the excavator would typically sit on a barge in the lake and scoop the sediment out of the lake and onto another barge that

[2] Complete document available at: http://co.livingston.mi.us/drain/phaseII/huron/default.htm

would require a deep draft. Then when the barge is full the sediment would have to be moved off the barge and handled for a second time, before being disposed of.

Based on the physical characteristics of the lake and water depths, hydraulic dredging is most feasible for this project. There are several small types of hydraulic dredges that can be efficiently used to work on improving Lake Moraine.

Volume of Dredge Material Removed

Economics play an important roll in determining how much sediment is recommended to be removed from the lake. In most cases, all the loose sediment should be removed from the lake bottom. Two alternatives were analyzed to determine the most cost effective solution for the lake management of Lake Moraine.

Dredging Volume Alternative 1

This alternative includes a target water depth for the upper arm of 5 feet and a target depth of the lower arm of 8.5 feet. There would be minimal dredging within 20 feet of the shoreline. In total, this alternative would dredge approximately 80,500 cubic feet from the lower arm and 45,000 cubic feet from the upper arm. The total proposed volume dredged would be about 125,500 cubic feet. Due to the large volume of dredging with this alternative, the LIB and lake residents requested a second and more cost feasible alternative to consider.

Dredging Volume Alternative 2

Alternative 2 was developed to meet expectations of landowners while limiting the economic impact of the project and still optimizing the use of Lake Moraine. The target minimum water depth for the upper and lower arms is 4 feet, with 1 foot of sediment being removed from target areas of the lake. The target areas of the lake are the deeper parts up the upper arm and the upper half of the lower arm. See proposed dredging maps for the upper and lower arms of Lake Moraine in Appendix 1 for more information.

A 4-foot minimal depth was chosen for Lake Moraine since it is a typical water depth for recreational use. One foot of sediment would be removed from the target areas of the lake that are currently greater then 4 feet in depth, because by removing one foot of sediment, important nutrients and chemicals are being removed that assist in the increase of growth in aquatic vegetation. There will be minimal dredging within 20 feet of the shoreline.

This alternative features overall shallower depths, with dredging in targeted areas to reduce volume, in turn, reducing the economic impact. Approximately 17,000 cubic yards of sediment would be dredged from the lower arm and 22,000 cubic yards of sediment from the upper arm, totaling 39,000 cubic yards of dredged material.

Based on input from residents around the lake, Alternative 2 is recommend for implementation to remove the sediment from Lake Moraine. This alternative will provide the improvements and enhancements needed for Lake Moraine, but on a more economical scale then Alternative 1.

Spoil and Water Separation

There are two options to separate the water and the dredge spoil material. These options are as follows:

Spoil Management: Alternative 1

The first option for dredge spoil management is to pump the slurry mix of water and sediment directly to the spoil disposal facility. This requires the disposal site to be relatively close to the lake or a series of pumps along the course of the pipeline. This alternative also requires that a dewatering system be available to direct water back into the lake or upstream of the construction site. The disposal site must be large enough to accommodate the settling of the spoils and large water volume. Easements may be required depending on the route of the pipeline.

Spoil Management: Alternative 2

A second alternative for dredge spoil management is to de-water the slurry on-site and haul the spoils to another location. This alternative requires a larger staging area, as well as increased infrastructure, including geotubes or a flocculation tank. Increased equipment and truck traffic will be present. As the volume of dredge spoils increases, the cost effectiveness of this option decreases.

The final dredge spoil management alternative must be both cost effect and expedient. With the relatively small size of dredged materials being produced, 39,000 cubic yards, Spoil Management Alternative 2 is the best for Lake Moraine, as finding and acquiring a site close to the lake does not seem probable or cost effective.

Staging Area

A staging area will need to be established for the contractor to work from. Loss of access and use of that staging area during the construction should be expected. Three different staging locations were determined and can be seen in the Staging Location Map in Appendix 1. The three locations are as follows: (a) the park on the northwest side of the lower arm of Lake Moraine, (b) along the northwest corner of Lake Moraine, and (c) along Waycross Road.

Disposal of Dredge Material

Spoil management is a key for the success of this project. Finding a proper site to dispose of the material can be time consuming and expensive. The two main management techniques is disposal at a landfill or a spoil disposal facility on private property. The volume of material dredge and water separation technique will impact the recommended solution for disposal of the spoils. The two spoil disposal alternatives are outlined below.

Spoil Disposal Facility

This requires that a site be located for disposal of the spoils and that the site either be purchased or an easement obtained. The size required is dependant upon the volume of sediment dredged and the characteristics of the site. A flat area is preferred, with farming being the ideal land use. While the sediment was not characterized to require disposal in a specialized landfill, a deed restriction is required by the MDEQ. This deed restriction is to notify future landowners of the disposal of these spoils on-site and that the dredge material exceeds contact limits but not drinking limits for dredge material. The Spoil Deposition Site map in Appendix 1 shows 10 potential spoil deposition sites that have been identified in the Lake Moraine Watershed area. Any site chosen requires extensive coordination with a number of landowners and agencies for the project to take place.

Class II Landfill

Small volumes of dredge materials become economical to be hauled to a class II landfill. Based on the proposed volume to be dredge, it is recommended that the spoils from Lake Moraine be disposed of at a class II landfill. This eliminates the need to acquire property for spoil disposition.

Permitting

Dredging of the lake bottom and construction of the sedimentation basin will require permits to be obtained. A MDEQ joint permit will be required for inland lake and stream, wetlands, and disposal of the dredge material. A permit for the discharge of the decanted water discharge back to the lake will also require a NPDES II discharge permit. Depending on the size of the staging area used, a soil erosion permit may be required.

FEASIBILITY SUMMARY

The data prepared and reviewed support that it is feasible to make vast improvements to Lake Moraine. The suggested improvements will help restore the natural habitat and quality of Lake Moraine. The following improvements are recommended for Lake Moraine:

- Dredging Alternative 2 (39,000 cubic yards)
- Spoil Management Alternative 2 (Class II landfill)

- Aquatic Plant Control
- Lake Level Control Structure
- Sedimentation Basin
- Paving of Pleasant Valley Road
- Implement Best Management Practices

Dredging Alternative 2 includes the establishment of a minimum water depth of 4 feet and the removal of 1 foot of sediment from target areas. This will serve to enhance aquatic habitat, reduce vegetative growth, and improve recreational uses. The preliminary estimate of costs associated with dredging Lake Moraine is $1,357,000.00. A further breakdown of the cost can be seen in Appendix 6.

Spoil Management Alternative 2 includes the dewatering of the dredged materials and hauling the sediment off site to a Class II landfill. This is the quickest alternative in relation to time and provides the easiest means to dispose of dredge spoils. The cost associated with disposal of the spoils is included in the cost of dredging.

Until lake dredging and other lake improvements are implemented, chemical weed treatment should be continued. The preliminary estimate of costs associated with weed control is $117,000.00 for the first 5 years, and this can be seen in Appendix 6.

The implementation of a lake level control structure would allow the water levels to be adjusted for summer/winter draw downs to help control the excessive vegetation within Lake Moraine. The preliminary estimate of costs associated with it is $160,900.00 and a breakdown of the cost can be seen in Appendix 5, in the Dam Inspection Report.

Installing a sedimentation basin in Mann Creek would be used to settle out any sediment before it enters into Lake Moraine. The preliminary estimate of costs associated with constructing the sedimentation basins is $58,000.00 and a breakdown of this cost can be seen in Appendix 6.

Paving of Pleasant Valley Road would reduce sediment entering Lake Moraine from the road. The preliminary estimate of cost for this is $44,000.00.

Best management practices have been included as a means to help ensure water quality in the Huron Chain of Lakes. These practices range from capital outlay to legislation to every-day activities for members of the general public. While a number of BMPs are outlined in the Huron Chain of Lakes Watershed Management Plan, this report highlights several BMPs that are most appropriate to Lake Moraine and its residents. Costs associated with the Best Management Practices have not been included in the preliminary estimate of costs due to the varying nature in which practices are implemented.