MAPLE LAKE IMPROVEMENT MANAGEMENT PLAN STUDY

Conducted pursuant to
PA 188 of 1954 as amended,
and the rules promulgated thereunder

Prepared for:

Village of Paw Paw and Paw Paw Township
Van Buren County, Michigan

LAKESHORE ENVIRONMENTAL, INC.

SCIENTISTS • ENGINEERS • PLANNERS

MAPLE LAKE MANAGEMENT PLAN AND STUDY

A LAKE MANAGEMENT PLAN AND STUDY FOR MAPLE LAKE, VAN BUREN COUNTY, MICHIGAN

OCTOBER, 2009

Prepared for:	**Village of Paw Paw** **C/o Mr. Larry Nielsen, Village Manager** **111 East Michigan Avenue** **Paw Paw, Michigan 49079**
Prepared by:	**Lakeshore Environmental, Inc.** **803 Verhoeks Road** **Grand Haven, Michigan 49417**

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OCTOBER, 2009

1.0 EXECUTIVE SUMMARY

Maple Lake is a 172-acre man-made, nutrient-rich (eutrophic) lake with nearly 5.7 miles of shoreline. The lake is rapidly becoming colonized by the invasive submersed macrophytes Eurasian Watermilfoil (*Myriophyllum spicatum* L.), and Curly-leaf Pondweed (*Potamogeton crispus*), and the emergent exotic macrophyte, Purple Loosestrife (*Lythrum salicaria*). Exotic submersed aquatic plant species threaten the biodiversity of the submersed native aquatic macrophyte communities, impedes navigation and recreational activities, decreases property values, and also harbors bacteria and nuisance algal growth which are not beneficial to the Maple Lake ecosystem. It is recommended that spot-treatments with highly selective systemic aquatic herbicides be used to treat the exotic species within and around the lake. Control of the exotic species that currently invade Maple Lake and its immediate watershed is critical to the protection of the lake ecosystem and the local economy.

The overall water quality of the Maple Lake ecosystem was measured as fair to poor. Thus, repeated sampling and implementation of Best Management Practices (BMP's) for the reduction of nutrient and sediment loads to Maple Lake are critical for long-term protection of Maple Lake water quality. A laminar flow aeration system is highly recommended for the south basin and possibly other regions of the lake to help reduce sediment organic matter and algal growth. Maple Lake contains a fair amount of submersed native aquatic plant biodiversity and a rich diversity of phytoplankton, which is the primary food source for zooplankton and forms the base of the food chain (i.e. primary producers). The high ratio of green algae (Division: Chlorophyta) and Diatoms (Division: Bacillariophyta) to Blue-Green algae (Division: Cyanophyta) is indicative of clean waters that support a rich fishery with 18 species of fish. Elevated nutrient levels have contributed to dense growth of filamentous algae which floats on the lake surface and degrades water quality.

2.0 AQUATIC ECOLOGY BACKGROUND INFORMATION

2.1 Introductory Concepts

The following terms are provided for a more thorough understanding of the forthcoming lake management recommendations for Maple Lake. Limnology is a multi-disciplinary field which involves the study of the biological, chemical, and physical properties of freshwater ecosystems. A basic knowledge of these processes is necessary to understand the complexities involved and how management techniques are applicable to current lake issues.

2.1.1 Lake Hydrology

Aquatic ecosystems include rivers, streams, ponds, lakes, and the Laurentian Great Lakes. There are thousands of lakes in the state of Michigan and each possesses unique ecological functions and socio-economic contributions (O'Neil and Soulliere 2006). Some lakes (seepage lakes) contain closed basins and lack inlets and outlets, relying solely on precipitation and/or groundwater as their water source. Seepage lakes generally have small watersheds with long hydraulic retention times which render them sensitive to pollutants. Other lakes receive significant water quantities from tributaries and rivers (drainage lakes). Drainage lakes contain at least one inlet and an outlet and generally are confined within larger watersheds with short hydraulic retention times and are thus less susceptible to pollution. Spring-fed lakes rarely contain an inlet but always have an outlet with considerable flow. The majority of water in this lake type originates from groundwater and is associated with a short hydraulic retention time. Drained lakes are similar to seepage lakes, yet rarely contain an inlet and have a low-flow outlet. The groundwater and seepage from surrounding wetlands supply the majority of water to this lake type and the hydraulic retention times are rather high, making these lakes relatively more vulnerable to pollutants. The water quality of a lake may thus be influenced by the quality of both groundwater and precipitation, along with other internal and external physical, chemical, and biological processes.

Maple Lake is classified as a drainage lake, since it receives large quantities of water from the East Branch of the Paw Paw River and Ackley Lake. The outlet on Maple Lake is located at the northern region of the lake and drains via a dam structure to the South Branch of the Paw Paw River.

2.1.2 Biodiversity and Habitat Health

A healthy aquatic ecosystem will possess a variety and abundance of niches (environmental habitats) available for all of its inhabitants. The distribution and abundance of preferable habitat will depend on limited influence from man and development, and preservation of sensitive or rare habitats. As a result of this, undisturbed or protected areas generally contain a greater number of biological species and are thus more diverse. A highly diverse aquatic ecosystem is preferred over one with less diversity because it will allow a particular ecosystem to possess a greater number of functions and contribute to both the intrinsic and socio-economic values of the lake. A healthy lake will have a greater biodiversity of aquatic macroinvertebrates, aquatic macrophytes (plants), fishes, phytoplankton, and may possess a plentiful yet beneficial benthic microbial community (Wetzel, 2001).

2.1.3 Watersheds and Land Use

A watershed may be defined as an area of land that drains to a common point and is influenced by both surface water and groundwater resources that are often impacted from land use activities. In general, a large watershed of a particular lake possesses more opportunities for pollutants to enter the system and alter water quality and ecological communities. In addition, watersheds that contain abundant development and industrial sites are more vulnerable to water quality degradation since the fate of pollutant transport may be increased and negatively affect surface waters and groundwater. Since many inland lakes in Michigan are relatively small in size (i.e. less than 300 acres), they are inherently vulnerable to nutrient and pollutant inputs due to a reduced water volume and small surface area. Due to this reduction in surface area and water volume, the living (biotic) components of the lake (i.e. fishery, aquatic plants, macroinvertebrates, benthic organisms, etc.) are highly sensitive to changes in water quality from watershed influences. Land use activities have a dramatic impact on the quality of surface waters and groundwater. In addition, the topography of the land surrounding a lake may make it vulnerable to nutrient inputs and consequential loading over time. The topography of the land and the morphometry (lake basin characteristics) of the lake dictate the ultimate fate transport of pollutants and nutrients into the lake within a particular watershed. Steep slopes on the land surrounding a lake may cause surface runoff to enter the lake more readily than if the land surface was at grade relative to the lake. In addition, lakes with a steep drop-off may act as collection basins for the substances that are transported to the lake from the land.

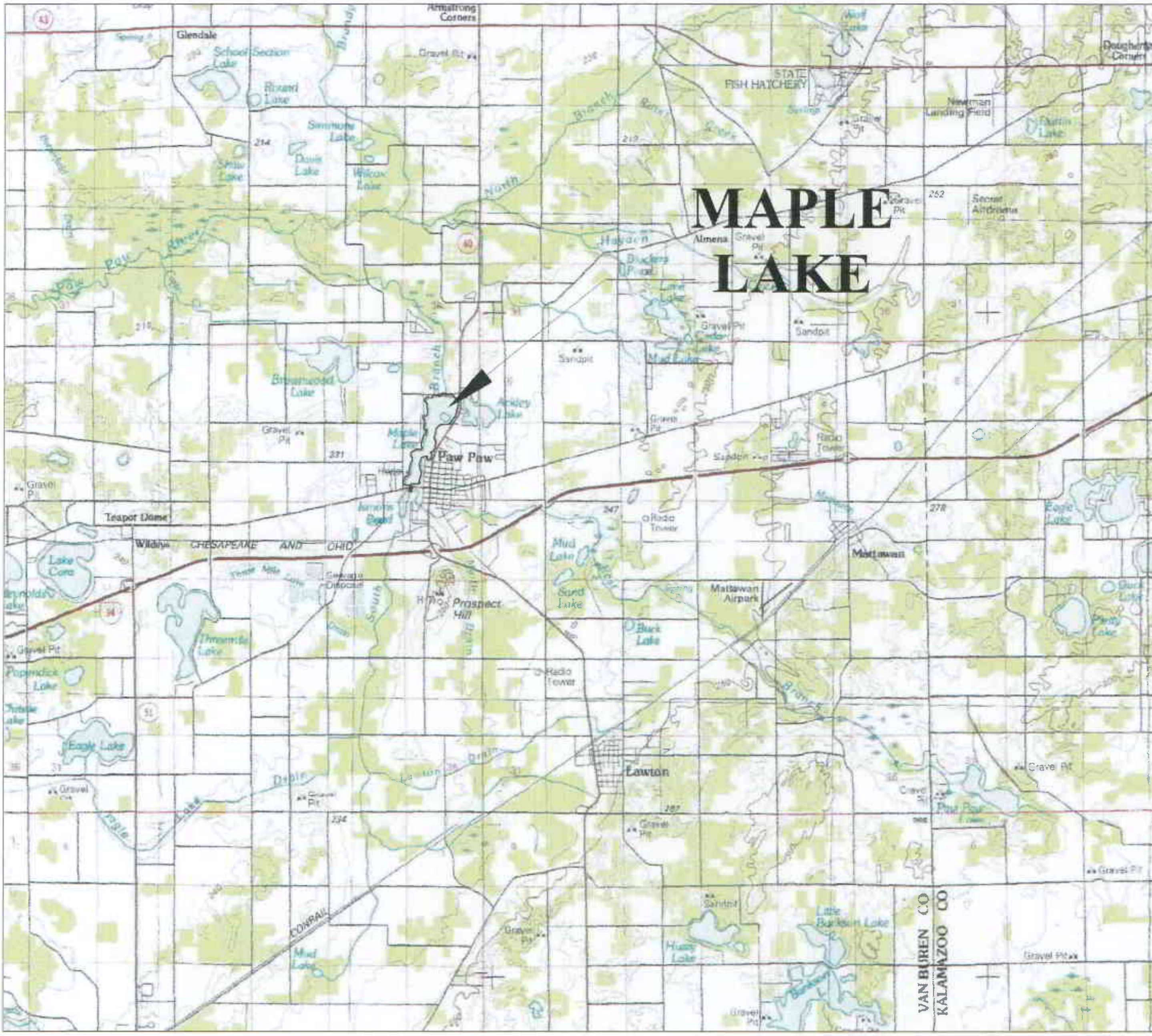
Many types of land use activities can influence the watershed of a particular lake. Such activities include residential land use, industrial land use, agricultural land use, water supply land use, wastewater treatment land use, and stormwater management. All land uses may contribute to the water quality of the lake through the influx of pollutants from non-point sources or from point sources. Non-point sources are often diffuse and arise when climatic events carry pollutants from the land into the lake. Point-source pollutants exit from pipes or input devices and empty directly into a lake or watercourse. Residential land use activities involve the use of lawn fertilizers on lakefront lawns, the utilization of septic tank systems for treatment of residential sewage, the construction of impervious (impermeable, hard-surfaced) surfaces on lands within the watershed, the burning of leaves near the lakeshore, the dumping of leaves or other pollutants into storm drains, and removal of vegetation from the land and near the water. In addition to residential land use activities, agricultural practices by vegetable crop and cattle farmers may contribute nutrient loads to lakes and streams. Industrial land use activities may include possible contamination of groundwater through discharges of chemical pollutants.

3.0 MAPLE LAKE PHYSICAL & WATERSHED CHARACTERISTICS

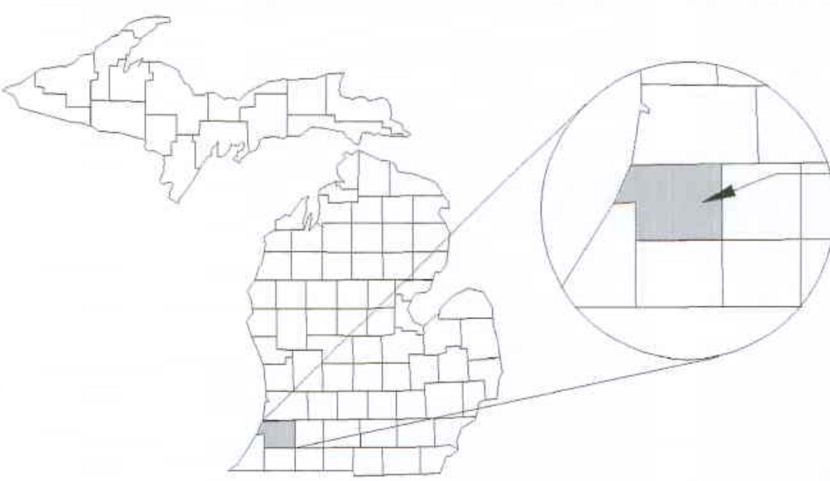
3.1 The Maple Lake Basin

Maple Lake is located in sections 1, 11, 12, 13, and 14 (T.3S, R.14W) of the Village of Paw Paw and Paw Paw Township, Van Buren County, Michigan (Figure 1). The lake surface area is approximately 172 acres (Michigan Department of Natural Resources, 2001) and may be classified as a eutrophic lake with one deep basin and a large-sized littoral zone. Maple Lake has a maximum depth of 15.0 feet (Figure 2), and an average depth of 7.0 feet (MDNR, 2005). The lake bottom consists primarily of sandy substrate and organic matter deposits.

Maple Lake has a large, immediate watershed of approximately 62,250 acres (97.3 mi^2; Figure 3) consisting of abundant agricultural land which contributes high quantities of fertile sediments and nutrients to the lake. The estimated hydraulic retention time depends on the lake water sources and outlet flow rate, but generally averages 7 days (Southwest Regional Planning Commission 1978). The East Branch of the Paw Paw River enters from the south end of Maple Lake and exits at the north end of the lake where it becomes the South Branch of the Paw Paw River. Additional water enters the lake from Ackley Lake at the northeast corner and from a small drainage area near the east shore of Maple Lake. The East Branch of the Paw Paw River is classified as a second-order designated trout stream and is supplied with cold groundwater and water from Little Paw Paw Lake (Kalamazoo County) and from Mattawan Creek in the Village of Mattawan. The East Branch transports large quantities of sand and silt into Maple Lake since it is approximately 8.4 miles in length and traverses a watershed rich in Houghton Mucks and Glendora Sandy Loams. Briggs Pond which is located in the Village of Paw Paw, is a sedimentation basin which has accumulated large amounts of sediment that are transported into Maple Lake. Figure 4 demonstrates individual sediment and water quality sampling sites. The South Branch of the Paw Paw River, which is upstream of the lake, is also a designated trout stream. Excessive sedimentation has led to the accumulation of sediments within Maple Lake, as well as increased turbidity, lower dissolved oxygen levels, high nutrient loading, and overgrowth of submersed aquatic vegetation and filamentous algae. Many of the sediments consist of a high fine fraction and organic matter content since they are derived from a large watershed that is comprised of primarily Adrian and Houghton Muck



USGS 30 X 60 MINUTE QUADRANGLE
KALAMAZOO, MICHIGAN (1982)



SECTIONS 1, 11, 12, 13 & 14; T3S, R14W;
VILLAGE OF PAW PAW
& PAW PAW TOWNSHIP;
VAN BUREN COUNTY, MICHIGAN

0 5,280' 10,560'

SCALE: 1 INCH = 2 MILES

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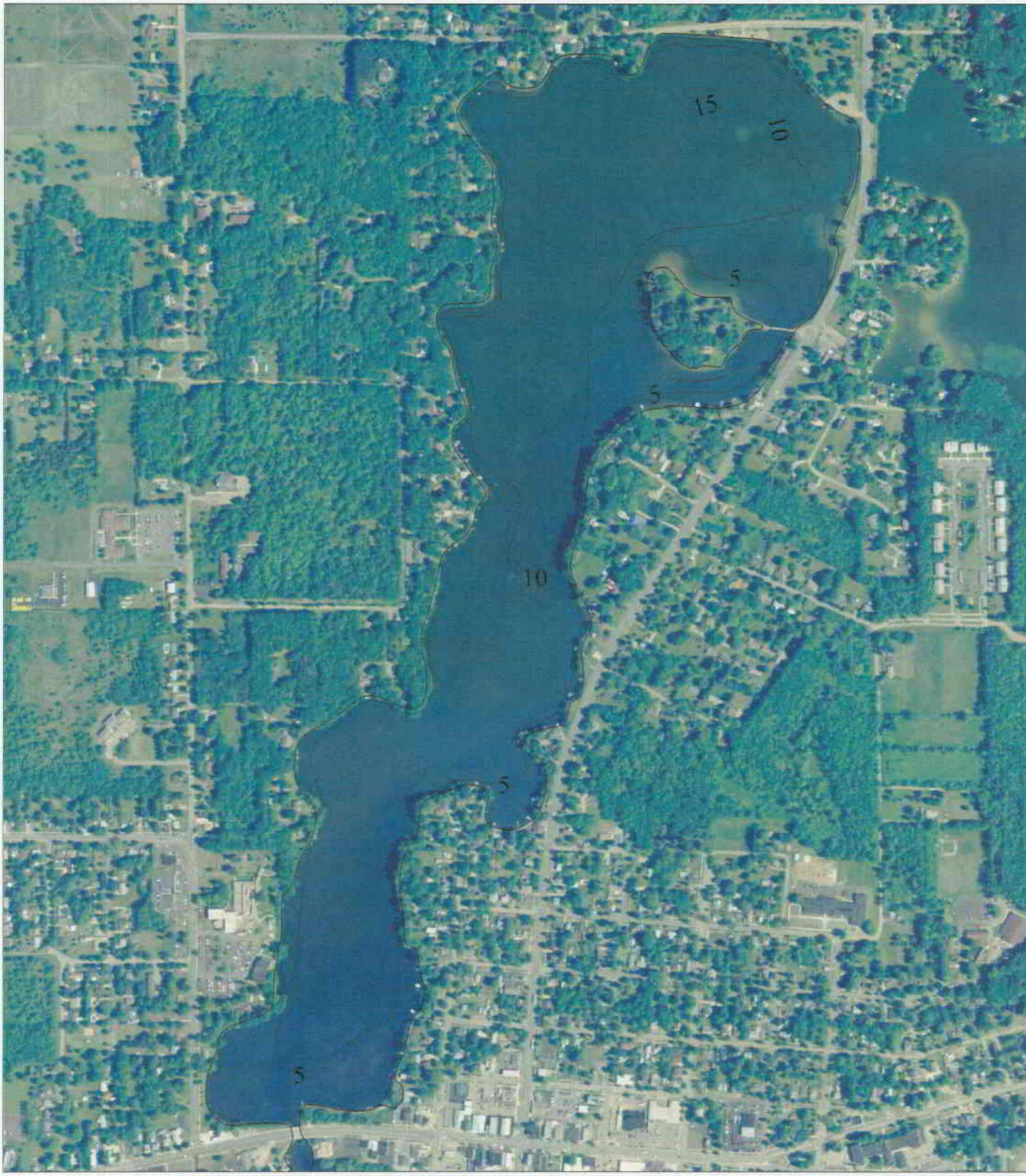
MAPLE LAKE
LOCATION MAP

VILLAGE OF PAW PAW AND PAW PAW TOWNSHIP,
VAN BUREN COUNTY, MICHIGAN

#09-1040	SEPTEMBER 17, 2009	FIGURE 1



0 800' 1600'

SCALE: 1 INCH = 800 FEET

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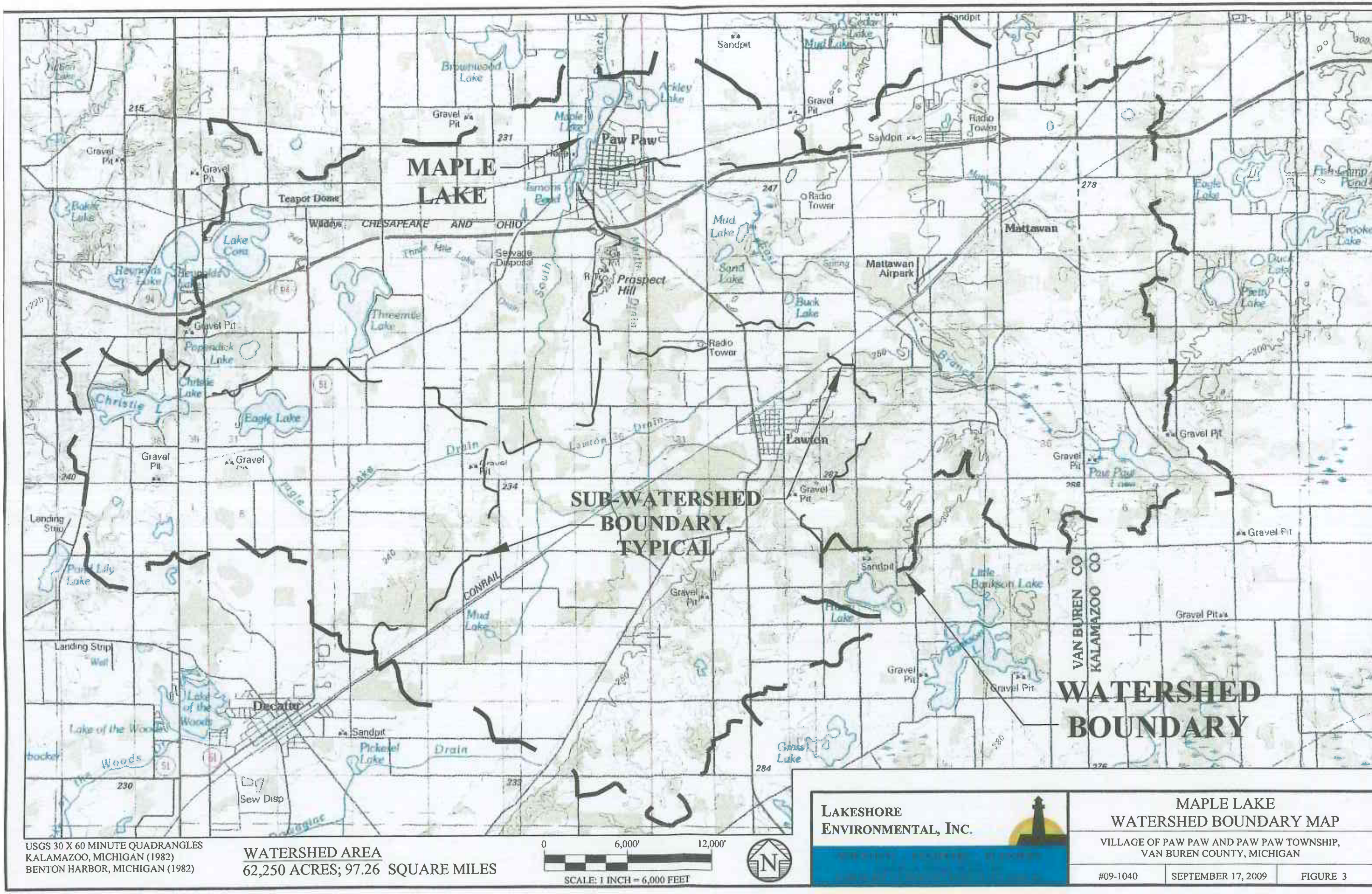
MAPLE LAKE DEPTH CONTOUR MAP

VILLAGE OF PAW PAW AND PAW PAW TOWNSHIP, VAN BUREN COUNTY, MICHIGAN

#09-1040	SEPTEMBER 17, 2009	FIGURE 2



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MAPLE LAKE
WATERSHED BOUNDARY MAP

VILLAGE OF PAW PAW AND PAW PAW TOWNSHIP, VAN BUREN COUNTY, MICHIGAN

#09-1040 | SEPTEMBER 17, 2009 | FIGURE 3 organic soils. The outlet for Maple Lake contains a hydropower dam which was constructed in 1907 and is located at the north end of the lake.

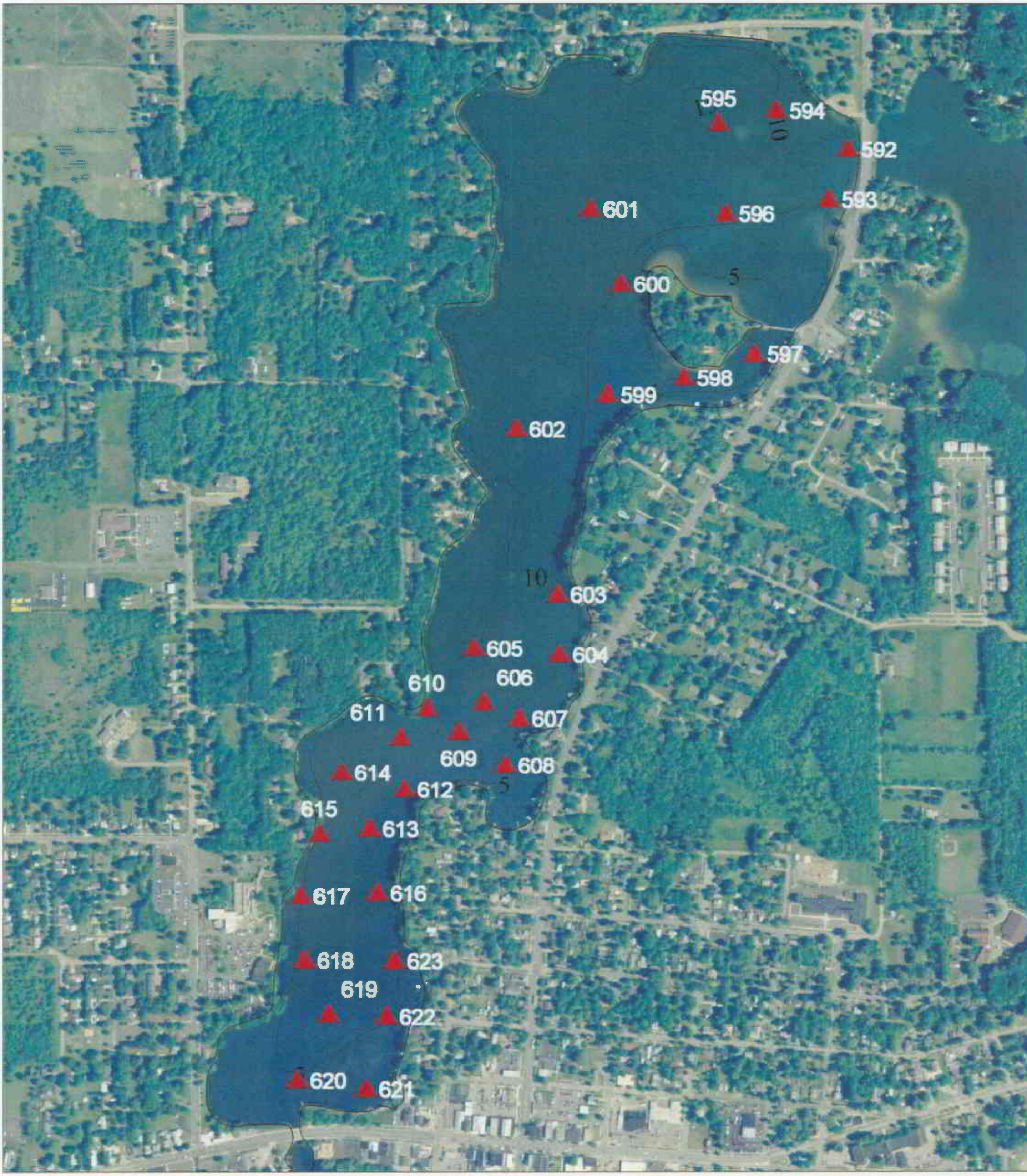
3.2 Maple Lake Extended and Immediate Watershed

Maple Lake is located within the St. Joseph River extended watershed which is approximately 2,998,400 acres (approximately 4,685 mi^2) in area and includes portions of fifteen counties, including Berrien, Branch, Calhoun, Cass, Hillsdale, Kalamazoo, St. Joseph, and Van Buren in Michigan, and De Kalb, Elkhart, Kosciusko, Lagrange, Noble, St. Joseph, and Steuben in Indiana (Michigan Department of Environmental Quality, 2008) counties. The St. Joseph extended watershed consists of primarily agricultural lands (55%), forested uplands and lowlands (25%), open fields (8%), urban (5%), wetlands (4%), and various lakes and waterbodies (2%). Maple Lake has been considered an impaired waterbody within the watershed, where a PCB Fish Consumption Advisory was noted by the United States Environmental Protection Agency under 303d under the federal Clean Waters Act in 2004.

The immediate watershed surrounding Maple Lake consists of the area around the lake draining directly to the lake and measures approximately 62,250 acres (97.3 mi^2) in size. The immediate watershed is approximately 362 times larger than the size of the lake, which indicates the presence of a large-sized immediate watershed. There are numerous other lakes within the Maple Lake watershed including Ackley Lake, Threemile Lake, Lake Cora, Popendick Lake, Eagle Lake, Christie Lake, Mud Lake, Paw Paw Lake, Buck Lake, Sand Lake, and Mud Lake (Lakeshore Environmental, Inc., 2009).

3.3 Maple Lake Land Use

The predominant land use types surrounding Maple Lake are agricultural land, forested land, open fields, urban lands, wetlands, and open waters. The majority of the Maple Lake shoreline is developed with residential properties, and thus may have a significant impact on water quality. A shoreline development factor (SDF) is a ratio assigned to a lake to describe the degree of shoreline irregularity compared to the lake surface area. Lakes with a perfectly circular shoreline have an SDF of 1.0. Lakes with higher SDF values (> 1.0) contain more shoreline in relation to surface area and may therefore accommodate greater



0 800' 1600'

SCALE: 1 INCH = 800 FEET

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MAPLE LAKE SEDIMENT SAMPLE LOCATION MAP

VILLAGE OF PAW PAW AND PAW PAW TOWNSHIP, VAN BUREN COUNTY, MICHIGAN

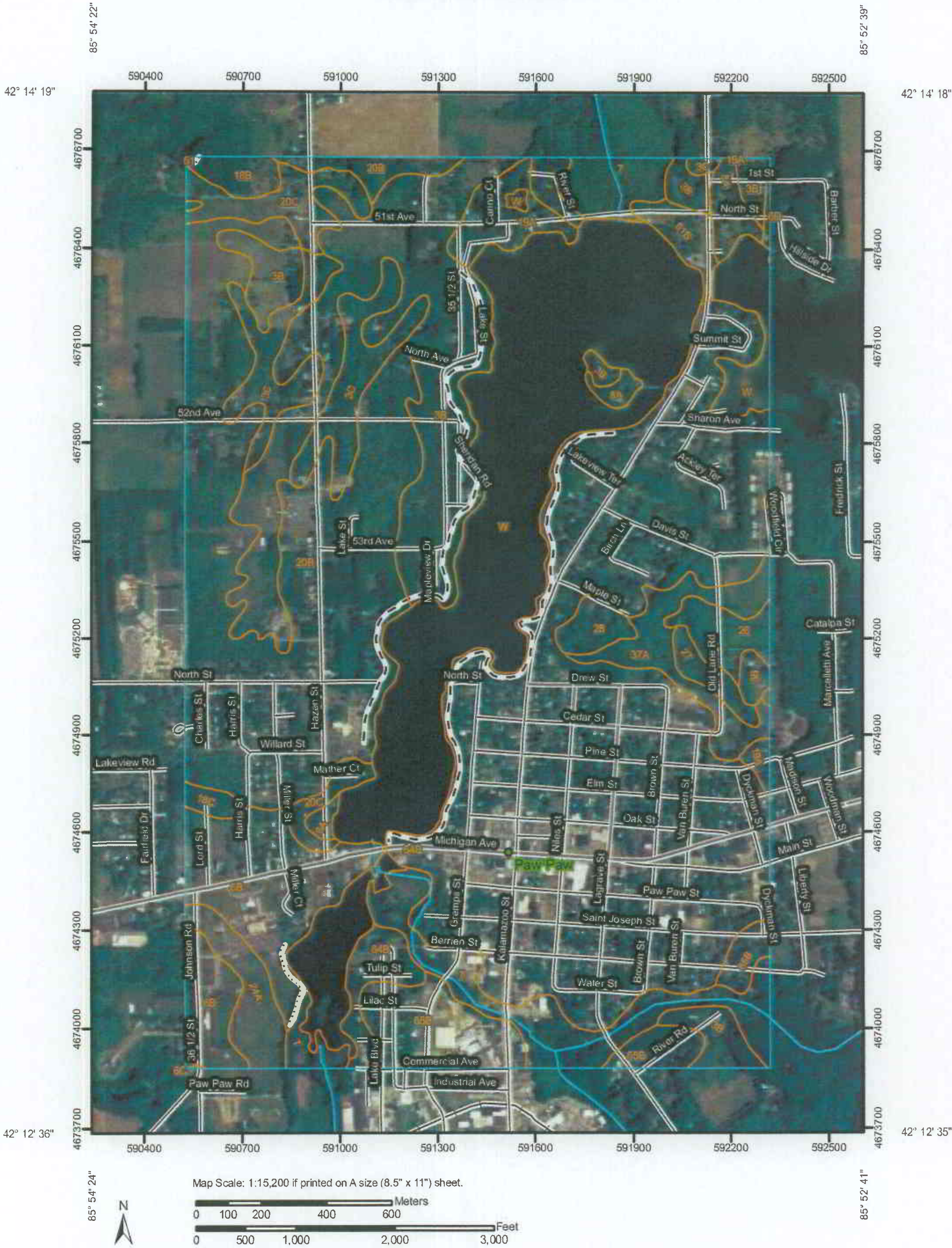
#09-1040	SEPTEMBER 17, 2009	FIGURE 4

shoreline development. The SDF of Maple Lake is 2.3 and thus may contain substantially more development than a lake of similar size with a perfectly circular shoreline.

3.4 Maple Lake Shoreline Soils

The 8 major soil series types immediately surrounding Maple Lake may have impacts on the water quality of the lake and may also dictate the particular land use activities associated within a location. Figure 5 (created with data from the United States Department of Agriculture and Natural Resources Conservation Service, 1999) demonstrates the precise soil types and locations around Maple Lake. Major characteristics of the dominant soil types directly surrounding the Maple Lake shoreline are listed in Table 1 below.

Soil Map—Van Buren County, Michigan
(Figure 5 Maple Lake Soils)



Map Scale: 1:15,200 if printed on A size (8.5" x 11") sheet.

USDA-NRCS Soil Series	*Maple Lake Location*	*Prominent Soil Type Characteristics*
Coloma Loamy Sand; 0-6% slope	Island & West shore (3B)	Excessively drained; Not prone to ponding; Depth to water table = 80"
Oshtemo Sandy Loam; 0-6% slope	South shore (6B)	Well drained; Not prone to ponding; Depth to water table = 80"
Morocco Loamy Sand; 0-2% slope	Island & South shore (8A)	Somewhat poorly drained; Not prone to ponding; Depth to water table = 6"
Ottokee Loamy Fine Sand; 0-3% slope	North region (19A)	Moderately well-drained; Not prone to ponding; Depth to water table = 24"
Spinks Loamy Sand; 0-6% slope	Southwest shore (20B)	Well drained; not prone to ponding; Depth to water table = 0"
Spinks Loamy Sand; 6-12% slope	South shore (20C)	Well-drained; not prone to ponding; Erodible; Depth to water table = 0"
Udipsamments/Udorthents; 0-4% slope	Northeast region (61B)	Excessively drained; Not prone to ponding; Depth to water table > 80"
Urban land-Brems Complex; 0-6% slope	Southeast & East shore (64B)	Excessively drained; Not prone to ponding; Depth to water table > 80"

Table 1. Maple Lake Shoreline Soil Types (USDA-NRCS, 1999).

There are eight major classes of soils that are found directly around the Maple Lake shoreline, include the Coloma Loamy Sands, Oshtemo Sandy Loams, Morocco Loamy Sands, Ottokee Loamy Fine Sands, Spinks Loamy Sands, Udipsamments and Udorthents, and the Urban land-Brems complex series. The immediate shoreline bordering the lake is surrounded by a composite of many different soil class types as identified in Figure 5. The Morroco Loamy Sands are the only highly moist soils found immediately surrounding the south shore of the lake and on the island. The soils from all of the other soil series are well drained to excessively drained and thus will not be prone to ponding, saturation, or flooding during high rain events. However, in areas around the lake with slopes greater than 6%, surface runoff and erosion may be a factor in contributing pollutants to the lake and thus every effort to implement low impact development (LID) techniques for construction of pervious surfaces close to the lake should be followed. In addition, land and sediment erosion is a considerable factor for water quality impairment in areas where land slopes exceed 3-6%.

4.0 MAPLE LAKE WATER QUALITY

Water quality is highly variable among Michigan's inland lakes, although some characteristics are common among particular lake classification types. The water quality of Maple Lake is affected by both land use practices and climatic events. Climatic factors (i.e. spring runoff, heavy rainfall) may alter water quality in the short term; whereas, anthropogenic (man-induced) factors (i.e. shoreline development, lawn fertilizer use) alter water quality over longer time periods. Although Maple Lake has a short hydraulic residence time (approx. 7 days, MDNR, 2000); excessive sedimentation to the lake has resulted in nutrient loading and pollution. Furthermore, lake water quality helps to determine the classification of particular lakes (Table 2). Lakes that are high in nutrients (such as phosphorus and nitrogen) and chlorophyll-*a*, and low in transparency are classified as **eutrophic**; whereas those that are low in nutrients and chlorophyll-*a*, and high in transparency are classified as **oligotrophic**. Lakes that fall in between these two categories are classified as **mesotrophic**. Maple Lake is classified as eutrophic based on its low transparency and high nutrient concentrations.

Lake Trophic Status	*Total Phosphorus ($\mu g\ L^{-1}$)*	*Chlorophyll-a ($\mu g\ L^{-1}$)*	*Secchi Transparency (feet)*
Oligotrophic	< 10.0	< 2.2	> 15.0
Mesotrophic	10.0 – 20.0	2.2 – 6.0	7.5 – 15.0
Eutrophic	> 20.0	> 6.0	< 7.5

Table 2. Lake Trophic Status Classification Table (MDNR)

4.1 Maple Lake Water Quality Parameters

Water quality parameters such as dissolved oxygen, water temperature, conductivity, turbidity, pH, total alkalinity, total phosphorus, total Kjeldahl nitrogen, chlorophyll-*a*, algal species, and Secchi transparency, among others, all respond to changes in water quality and consequently serve as indicators of water quality change. These parameters are discussed below along with water quality data specific to Maple Lake (Tables 3 and 4). In addition, water quality data collected from the south Branch of the Paw Paw River in 2007-8 and Briggs Pond in 1981 are shown in Tables 5-7. Graphical representations of the contributions of ammonia nitrogen and phosphorus by the South Branch of the Paw Paw River are shown in Figures 6 and 7. Historical water quality data may be found in Appendix A.

4.1.1 Dissolved Oxygen

Dissolved oxygen is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg L^{-1} to sustain a healthy warm-water fishery. Dissolved oxygen concentrations in Maple Lake may decline if there is a high biochemical oxygen demand (BOD) where organismal consumption of oxygen is high due to respiration. Dissolved oxygen is generally higher in colder waters. Dissolved oxygen is measured in milligrams per liter (mg L^{-1}) with the use of a dissolved oxygen meter and/or through the use of Winkler titration methods. The dissolved oxygen concentration readings collected from middle-depth in Maple Lake averaged 9.7 mg L^{-1} during the 1 September, 2009 sampling event and ranged between 7.6 – 11.5 mg L^{-1}, with concentrations variable among sampling sites (n = 32). It should be noted that bottom depth dissolved oxygen concentrations were significantly lower than values at middle depth due to a high biochemical oxygen demand (BOD) near the lake bottom. A decline in dissolved oxygen may cause increased release rates of phosphorus (P) from Maple Lake bottom sediments if dissolved oxygen levels drop to near zero milligrams per liter. Historical data of Maple Lake dissolved oxygen levels are scarce but indicate that the dissolved oxygen levels typically average 8.9 mg L^{-1} at middle-depth during late summer but increase to over 13.0 mg L^{-1} in the spring, since lower water temperatures hold more oxygen. Historical values for DO ranged between 3.8 - 13.3 mg L^{-1} from bottom to surface during 2006 (MDEQ data, 2006).

4.1.2 Water Temperature

The water temperature of lakes varies within and among seasons and is nearly uniform with depth under winter ice cover because lake mixing is reduced when waters are not exposed to wind. When the upper layers of water begin to warm in the spring after ice-off, the colder, dense layers remain at the bottom. This process results in a "thermocline" that acts as a transition layer between warmer and colder water layers. During the fall season, the upper layers begin to cool and become denser than the warmer layers, causing an inversion known as "fall turnover". In general, shallow lakes will not stratify and deeper lakes may experience single or multiple turnover cycles. Water temperature is measured in degrees Celsius (ºC) or degrees Fahrenheit (ºF) with the use of a submersible thermometer. The 1 September, 2009 water temperatures of Maple Lake demonstrated the lack of a thermocline between the surface and a "middle depth", with some decline in water temperatures near the bottom. Water temperatures ranged between 56.7ºF – 66.4ºF among both deep basin sampling locations. The lowest water temperatures were present near the south-central and south regions of the lake.

4.1.3 Conductivity

Conductivity is a measure of the amount of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. Conductivity is measured in microsiemens per centimeter with the use of a conductivity probe and meter. Conductivity values for Maple Lake were relatively high for an inland lake and variable among sampling sites.

Conductivity was consistent within sites and ranged from 528 µmhos cm^{-1} – 662 µmhoscm^{-1} and averaged 604 µmhos cm^{-1} for 1 September, 2009 water samples among sites (n = 32). Historical values for conductivity ranged between 453 - 581 µmhos cm^{-1} (MDEQ data, 2006). Thus, values for conductivity have increased since 2006. Baseline parameter data such as conductivity are important to measure the possible influences of land use activities (i.e. road salt influences) on Maple Lake over a long period of time, or to trace the origin of a substance to the lake in an effort to reduce pollutant loading. Conductivity values were highest at the south basin of the lake near the primary inlet.

4.1.4 Total Dissolved Solids

Total Dissolved solids (TDS) are a measure of the amount of dissolved organic and inorganic substances that is present in the water column. High concentrations of Total Dissolved Solids often result in elevated turbidity readings in an aquatic system. The turbidity of water increases as the number of total suspended and dissolved particles increases. Total Dissolved Solids may originate from erosion inputs, phytoplankton blooms, stormwater discharge, urban runoff, re-suspension of bottom sediments, and by large bottom-feeding fish such as carp. Total Dissolved Solids is measured in milligrams per liter (mg L^{-1}) with the use of a digital water quality probe meter. The mean Total Dissolved Solid concentration of Maple Lake was 0.285 mg L^{-1} during the 1 September, 2009 sampling event. Total Dissolved Solids were highest at the south and south-central regions of the lake.

4.1.5 pH

pH is the measure of acidity or basicity of water. The standard pH scale ranges from 0 (acidic) to 14 (alkaline), with neutral values around 7. Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes (pH < 7) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). pH is measured with a pH electrode and pH-meter in Standard Units (S.U). The pH of Maple Lake water ranged from 7.6 – 8.3 during the 1 September, 2009 study. Historical values for pH ranged between 7.6-8.6 (MDEQ data, 2006). Lakes in the southern region of Michigan generally have slightly basic pH values due to the underlying geological features which help determine pH. From a limnological perspective, Maple Lake is considered "slightly basic" on the pH scale.

4.1.6 Total Suspended Solids

Total Suspended Solids (TSS) is the measure of the amount of suspended particles in the water column. Particles suspended in the water column absorb heat from the sun and raise the water temperature. Total suspended solids is often measured in mg L^{-1} and analyzed in the laboratory. The lake bottom contains many fine sediment particles which are easily perturbed from winds and wave turbulence. Spring values would likely be higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. The concentration of TSS in Maple Lake during the 1 September sampling event ranged from < 10.0 mg L^{-1} to 29 mg L^{-1}. Total Suspended Solids were highest at the southern basin of the lake near the primary inlet. Historical values for TSS ranged between 6.0 - 20.0 mg L^{-1} (MDEQ data, 2006).

4.1.7 Total Phosphorus

Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. Lakes which contain greater than 0.020 mg L^{-1} of TP are defined as eutrophic or nutrient-enriched. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. Total phosphorus is measured in micrograms per liter (µg L^{-1}) with the use of a chemical autoanalyzer. Total Phosphorus (TP) concentrations for the Maple Lake sampling sites (based on the n = 32 sampling sites) during the study ranged < 0.015 - 0.053 mg L^{-1}. Total phosphorus concentrations were highest at the south and south-central regions of the lake. Historical values for TP ranged between 0.022 - 0.036 mg L^{-1} (MDEQ data, 2006).

4.1.8 Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is the sum of nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_4^+), and organic nitrogen forms in freshwater systems. Much nitrogen (amino acids and proteins) also comprises the bulk of living organisms in an aquatic ecosystem. Nitrogen originates from atmospheric inputs (i.e. burning of fossil fuels), wastewater sources from developed areas (i.e. runoff from fertilized lawns), agricultural lands, septic systems, and from waterfowl droppings. It also enters lakes through groundwater or surface drainage, drainage from marshes and wetlands, or from precipitation (Wetzel, 2001). In lakes with an abundance of nitrogen (N: P > 15), phosphorus may be the limiting nutrient for phytoplankton and aquatic macrophyte growth. Alternatively, in lakes with low nitrogen concentrations (and relatively high phosphorus), the blue-green algae populations may increase due to the ability to fix nitrogen gas from atmospheric inputs. Lakes with a mean TKN value of 0.66 mg L^{-1} may be classified as oligotrophic, those with a mean TKN value of 0.75 mg L^{-1} may be classified as mesotrophic, and those with a mean TKN value greater than 1.88 mg L^{-1} may be classified as eutrophic. The TP concentration of Maple Lake ranged from < 0.50 mg L^{-1} – 0.83 mg L^{-1}. The N: P ratio for all sampling sites was greater than 15.0 mg L^{-1} and indicated that phosphorus was a limiting nutrient for phytoplankton or macrophyte growth at the time of sampling. However, the abundant concentrations of sedimentary phosphorus contribute to the majority of rooted aquatic plant growth. Total Phosphorus in the water column was suitable for abundant non-rooted macrophyte and algal growth.

4.1.9 Algal Species Composition

The algal species composition in Maple Lake was determined by collecting a composite sample of the algae throughout the water column at the primary deep basin site from just above the lake bottom to the lake surface on 1 September, 2009. Algal genera from a composite water sample collected over the deep basin of Maple Lake were analyzed under a compound brightfield microscope. The genera present included the Chlorophyta (green algae): *Euglena* sp., *Micrasterias* sp., *Chlorella* sp., *Gleocystis* sp., *Pandorina* sp., *Protococcus* sp., *Zygnema* sp., *Scenedesmus* sp., *Dictyosphaerium* sp., *Pediastrum* sp., *Botryococcus* sp., *Synechococcus* sp., *Chroococcus* sp., *Aphanothece* sp., *Phormidium* sp., *Rivularia* sp., *Cryptomonas* sp., *Ulothrix* sp., *Rhizoclonium* sp., *Closterium* sp., *Cladophora* sp., *Hydrodictyon* sp., *Spirogyra* sp., *Pithophora* sp., and *Chloromonas* sp. the Cyanophyta (blue-green algae): *Oscillatoria* sp., and *Gleocapsa* sp., *Microcystis* sp., *Anabaena* sp., and *Nostoc* sp.; the Bascillariophyta (diatoms): *Synedra* sp., *Navicula* sp., *Cyclotella* sp., *Fragilaria* sp., *Nitzschia* sp., *Asterionella* sp., and *Tabellaria* sp. The aforementioned species indicate a diverse algal flora and represent a relatively balanced freshwater ecosystem, capable of supporting a strong zooplankton community in favorable water quality conditions. Blue-green algae such as *Oscillatoria* sp. and *Microcystis* sp. are capable of producing microtoxins (Rinehart et al. 1994) that can cause neurologic or hepatic (liver) dysfunction in animals or humans if ingested in large quantities. Blue-green blooms are usually visible as a bluish tinted surface "scum layer" on lake waters when they are a threat and these areas should be avoided when obvious surface layer blooms are present.

4.1.10 Secchi Transparency

Secchi transparency is a measure of the clarity or transparency of lake water, and is measured with the use of an 8-inch diameter standardized Secchi disk. Secchi disk transparency is measured in feet (ft) or meters (m) by lowering the disk over the shaded side of a boat around noon and taking the mean of the measurements of disappearance and reappearance of the disk. Elevated Secchi transparency readings allow for more aquatic plant and algae growth. Eutrophic systems generally have Secchi disk transparency measurements less than 7.5 feet due to turbidity caused by excessive planktonic algae growth. The Secchi transparency of Maple Lake ranged between 3.5-5.0 feet over the deep basin region during the 2009 study sampling period. This transparency is adequate to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake. Secchi transparency is variable and depends on the amount of suspended particles in the water (often due to windy conditions of lake water mixing) and the amount of sunlight present at the time of measurement.

4.1.11 Oxidative Reduction Potential

The oxidation-reduction potential (E_h) of lake water describes the effectiveness of certain atoms to serve as potential oxidizers and indicates the degree of reductants present within the water. In general, the Eh level (measured in millivolts) decreases in anoxic (low oxygen) waters. Low E_h values are therefore indicative of reducing environments where sulfates (if present in the lake water) may be reduced to hydrogen sulfide (H_2S). Decomposition by microorganisms in the hypolimnion may also cause the E_h value to decline with depth during periods of thermal stratification. The E_h (ORP) values for Maple Lake ranged between 6.5 mV and 38.2 mV from the surface to the bottom within the lake, and thus were low and indicate the presence of a reducing environment in sampling locations.

4.1.12 Sediment Organic Matter and Nutrients

The amount of organic carbon in lake sediments contributes greatly to the growth of rooted aquatic plants which depend on the sediments for nutrients such as phosphorus and nitrogen. Lake bottom sediment samples were collected at the Maple Lake sampling locations with the use of a stainless steel hand auger. The upper horizons of the sediment were kept intact for accurate evaluation of organic matter content in the upper layers. Samples were placed on ice and taken to a certified laboratory for analysis of sediment total phosphorus and percentage of organic matter. The percentage of fine sediments was determined through a sieve analysis (No. 200 standard sieve, 74 μm mesh size), after sediments were dried in a muffle furnace at 550ºF. Sediment total phosphorus concentrations ranged from 47.0 mg kg^{-1} – 1,000 mg kg^{-1}, with the highest values present at the south and south-central basin near the primary inlet. Organic matter content ranged from 1.2% - 56.0% with the highest values also present at the south and south-central basin. There was a substantial positive linear correlation (R^2 = 0.44) between organic matter content and sediment total phosphorus (Figure 8). The percentage of fine sediment among samples ranged from 1.4% - 58.8%, and was weakly correlated with sediment total phosphorus (R^2 = 0.24; Figure 9) and sediment organic matter content (R^2 = 0.25; Figure 10).

Sample Station	*Water Temp °F*	*DO mg L⁻¹*	*pH S.U.*	*Cond. µS cm⁻¹*	*Total Diss. Solids mg L⁻¹*	*ORP mV*	*Total Kjeldahl Nitrogen mg L⁻¹*	*Total Susp. Solids mgL⁻¹*	*Total Phos. mg L⁻¹*
592	65.1	9.0	7.9	535	--	16.9	< 0.50	< 10.0	0.019
593	64.9	8.6	8.0	536	--	10.3	< 0.50	< 10.0	0.019
594	64.5	11.2	8.0	535	--	22.1	< 0.50	< 10.0	0.018
595	64.4	9.2	8.0	543	--	25.5	< 0.50	< 10.0	0.017
596	64.6	9.6	8.0	545	272	28.0	< 0.50	< 10.0	< 0.015
597	66.4	9.3	7.7	535	267	32.6	< 0.50	< 10.0	< 0.015
598	66.1	9.4	7.7	528	264	37.8	< 0.50	< 10.0	0.026
599	64.9	10.0	8.0	538	269	35.6	< 0.50	< 10.0	0.023
600	64.5	11.4	7.9	542	271	34.2	< 0.50	< 10.0	0.015
601	64.4	10.9	8.0	549	275	31.9	< 0.50	< 10.0	0.015
602	65.2	10.3	9.3	542	271	13.2	< 0.50	< 10.0	0.022
603	64.5	9.7	8.0	555	227	23.8	< 0.50	< 10.0	0.022
604	64.4	10.1	8.0	553	277	29.1	< 0.50	< 10.0	0.022
605	64.7	10.9	8.0	572	286	31.0	< 0.50	< 10.0	0.017
606	63.9	10.4	8.0	585	291	31.2	0.52	< 10.0	0.033
607	63.8	9.5	8.0	577	289	35.8	< 0.50	< 10.0	0.022
608	63.3	9.8	7.9	610	305	37.2	< 0.50	< 10.0	0.027
609	62.5	9.3	8.0	567	283	34.2	< 0.50	< 10.0	0.025
610	63.7	9.2	7.9	595	297	34.8	0.66	< 10.0	0.041
611	61.3	7.8	7.8	628	315	36.5	0.55	< 10.0	0.027
612	58.3	7.6	7.7	627	314	37.6	< 0.50	< 10.0	0.016
613	57.9	9.1	7.7	633	316	38.2	0.55	< 10.0	0.015
614	57.2	9.0	7.8	657	328	6.5	0.74	10.0	0.031
615	57.4	9.4	7.7	662	331	23.5	< 0.50	< 10.0	0.027
616	57.7	9.1	7.9	627	314	29.3	< 0.50	< 10.0	0.015
617	57.6	9.1	7.8	657	325	30.2	0.59	< 10.0	0.020
618	58.4	8.9	7.7	643	322	31.7	0.83	13.0	0.053
619	57.6	10.8	7.8	639	319	10.8	0.51	< 10.0	0.019
620	56.7	9.8	7.7	640	320	18.6	< 0.50	29.0	0.022
621	56.7	11.5	7.7	606	303	16.9	< 0.50	16.0	0.015
622	57.5	10.7	7.7	614	307	27.2	< 0.50	< 10.0	0.015
623	60.0	10.5	7.6	621	311	32.9	< 0.50	13.0	0.015

Table 3. Maple Lake water quality data collected at the sampling stations (n = 32) on 1 September, 2009.

Sample Station	*Sediment TP mg kg $^{-1}$*	*Organic Matter %*	*Sediment Fines %*
592	58.0	2.4	3.8
593	47.0	1.2	6.6
594	190.0	2.8	--
595	--	--	--
596	460.0	12.0	16.6
597	460.0	31.0	--
598	320.0	10.0	--
599	430.0	33.0	--
600	--	--	--
601	610.0	7.8	--
602	980.0	16.0	12.1
603	850.0	25.0	27.2
604	200.0	5.7	1.4
605	950.0	25.0	58.8
606	1200.0	56.0	17.1
607	290.0	18.0	--
608	480.0	35.0	--
609	460.0	17.0	44.8
610	140.0	1.8	3.4
611	750.0	20.0	53.7
612	370.0	23.0	13.4
613	68.0	0.5	4.8
614	430.0	4.0	--
615	1,000.0	30.0	--
616	660.0	20.0	--
617	900.0	26.0	--
618	300.0	32.0	50.4
619	450.0	22.0	--
620	520.0	11.0	--
621	380.0	21.0	--
622	120.0	1.9	7.0
623	640.0	44.0	--

Table 4. Maple Lake sediment data collected at the sampling stations (n = 32) on 1 September, 2009.

Statistic	*Year*	*NH_3 (mg L^{-1})*	*TP (mg L^{-1})*	*TSS (mg L^{-1})*	*DO mg L^{-1}*	*Flow (ft^3 sec^{-1})*
Mean + Std. Er	2007	0.10 ± 0.00	0.77 ± 0.59	8.4 ± 0.45	9.5 ± 0.31	45.7 ± 2.0
Minimum	2007	0.00	0.00	0.00	5.6	14.8
Maximum	2007	0.18	145.0	63.0	60.0	290.0
Confidence (95%)	2007	0.01	1.16	0.88	0.60	3.9

Table 5. Historical water quality data collected from the South Branch of the Paw Paw River during 2007.

Statistic	*Year*	*NH_3 (mg L^{-1})*	*TP (mg L^{-1})*	*TSS (mg L^{-1})*	*DO mg L^{-1}*	*Flow (ft^3 sec^{-1})*
Mean + Std. Er	2008	0.10 ± 0.00	0.07 ± 0.00	8.1 ± 0.48	9.0 ± 0.08	68.3 ± 5.9
Minimum	2008	0.00	0.00	1.20	5.9	16.9
Maximum	2008	0.18	0.30	41.2	12.1	1220.0
Confidence (95%)	2008	0.005	0.01	0.95	0.16	11.7

Table 6. Historical water quality data collected from the South Branch of the Paw Paw River during 2008.

Statistic	*Year*	*NH_3 (mg L^{-1})*	*TP (mg L^{-1})*	*TSS (mg L^{-1})*
Mean + Std. Er	1981	0.57 ± 0.19	0.15 ± 0.07	21.2 ± 1.5
Minimum	1981	0.00	0.00	2.0
Maximum	1981	12.3	4.0	73.0
Confidence (95%)	1981	0.39	0.14	3.1

Table 7. Discharge of total suspended solids and nutrients from Briggs Pond in 1981.

Figure 6. Annual contributions of the nutrients total phosphorus and ammonia nitrogen to Maple Lake by the South Branch of the Paw Paw River in 2007.

Figure 7. Annual contributions of the nutrients total phosphorus and ammonia nitrogen to Maple Lake by the South Branch of the Paw Paw River in 2008.

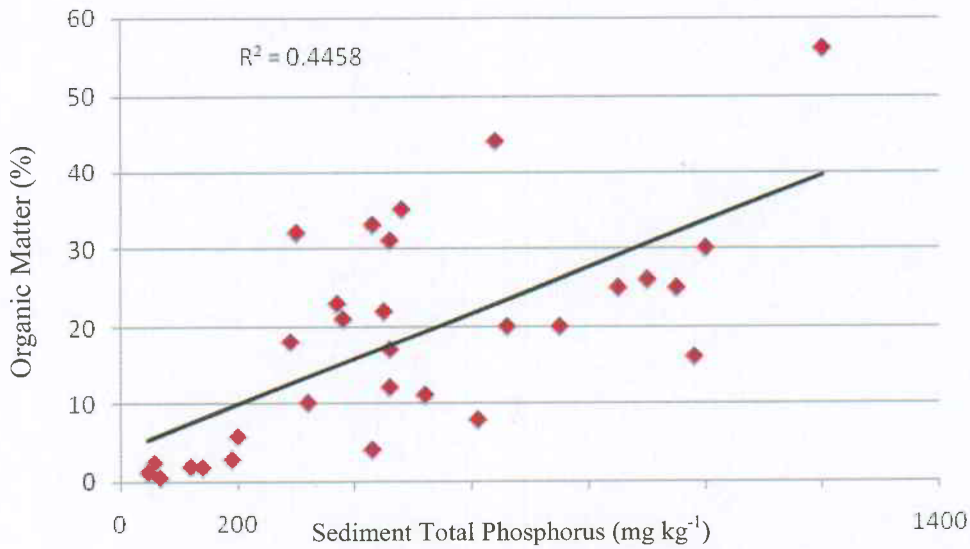


Figure 8. Correlation graph of % organic matter and sediment total phosphorus in Maple Lake sediment samples (n = 30)

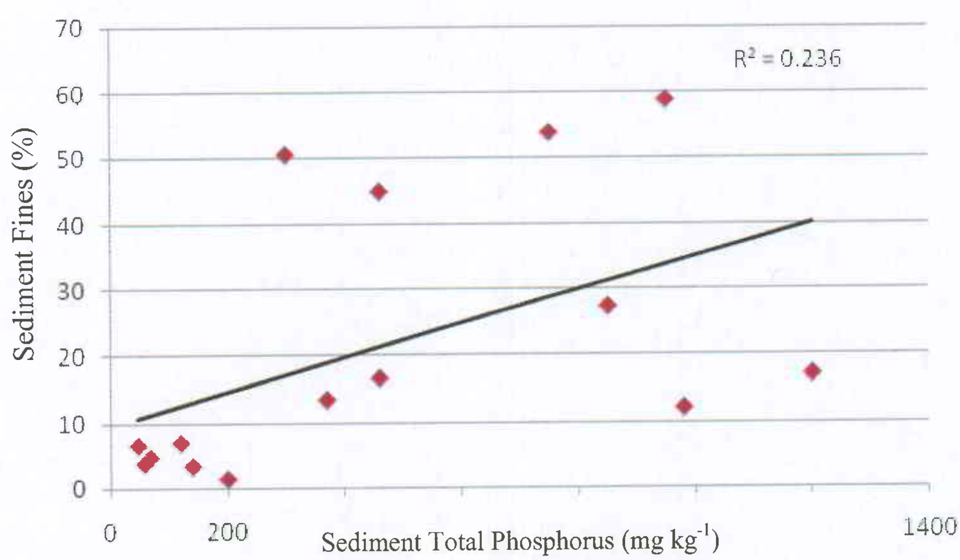


Figure 9. Correlation graph of % sediment fines and sediment total phosphorus in Maple Lake sediment samples (n = 15).

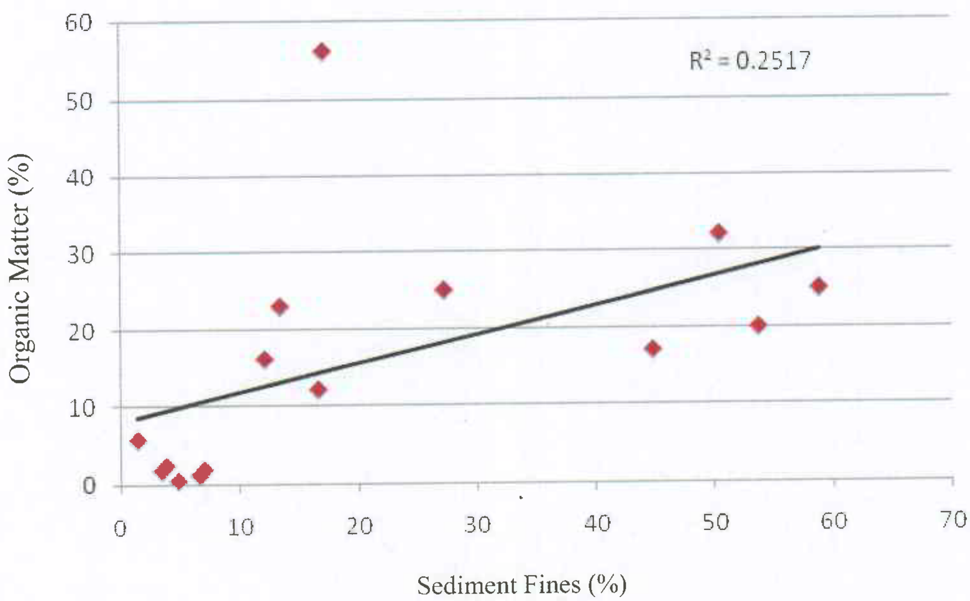


Figure 10. Correlation graph of % organic matter and % sediment fines in Maple Lake sediment samples (n = 15).

4.2 Maple Lake Fish Community

The fishery of Maple Lake has been studied by the Michigan Department of Natural Resources and may be defined as a warm-water fishery due to the shallow overall mean depth of the lake. Fish communities consist of 18 species including Yellow Perch (*Perca flavescens*), Bluegill (*Lepomis macrochirus*), Pumpkinseed Sunfish (*Lepomis gibbosus*), Green Sunfish (*Lepomis cyanellus*), Hybrid Sunfish (*Lepomis gibbosus* x *L. macrochirus*), Blackside Darter (*Percina maculata*), Warmouth (*Lepomis gulosus*), Bluntnose Minnow (*Pimephales notatus*), Golden Shiner (*Notemigonus crysoleucas*), Largemouth Bass (*Micropterus salmoides*), Rock Bass (*Ambloplites rupestris*), Brown Bullhead Catfish (*Ameiurus* sp.), Yellow Bullhead (*Ameiurus natalis*), White Sucker (*Catostomus commersonii*), Walleye (*Sander vitreus*), Black Crappie (*Pomoxis nigromaculatus*), Shorthead Redhorse (*Moxostoma macrolepidotum*), Walleye (*Sander vitreus*), and the Common Carp (*Cyprinus carpio*). The lake has an extensive fish stocking history, as the Michigan Department of Natural Resources had planted Walleye in 1980 and between

1981-1992, 1994-1999, and in 2001, 2003, 2005, and 2006. In 1991, Largemouth Bass were stocked in the lake (MDNR, Dexter, 2000). The Maple Lake fishery will benefit from a diverse (yet balanced) native aquatic plant community, control of invasive aquatic plant and animal species, ample supply of zooplankton, and abundance of submerged habitats (i.e wood structures and weed beds).

4.3 Maple Lake Aquatic Vegetation Communities

Aquatic plants (macrophytes) are an essential component in the littoral zones of most lakes in that they serve as suitable habitat and food for macroinvertebrates, contribute oxygen to the surrounding waters through photosynthesis, stabilize bottom sediments (if in the rooted growth form), and contribute to the cycling of nutrients such as phosphorus and nitrogen upon decay. In addition, decaying aquatic plants contribute organic matter to lake sediments which further supports healthy growth of successive aquatic plant communities that are necessary for a balanced aquatic ecosystem. An overabundance of aquatic vegetation may cause organic matter to accumulate on the lake bottom faster than it can break down. Aquatic plants generally consist of rooted submersed, free-floating submersed, floating-leaved, and emergent growth forms. The emergent growth form (i.e. Cattails, Native Loosestrife) is critical for the diversity of insects onshore and for the health of nearby wetlands. Submersed aquatic plants can be rooted in the lake sediment (i.e. Milfoils, Pondweeds), or free-floating in the water column (i.e. Coontail). There is evidence that the diversity of submersed aquatic macrophytes can greatly influence the diversity of macroinvertebrates associated with aquatic plants of different structural morphologies (Parsons and Matthews, 1995). Therefore, it is possible that declines in the biodiversity and abundance of submersed aquatic plant species and associated macroinvertebrates, could negatively impact the fisheries of inland lakes. Alternatively, the overabundance of aquatic vegetation can compromise recreational activities, aesthetics, and property values.

4.3.1 Maple Lake Exotic Aquatic Macrophytes

Exotic aquatic plants (macrophytes) are not native to a particular site, but are introduced by some biotic (living) or abiotic (non-living) vector. Such vectors include the transfer of aquatic plant seeds and fragments by boats and trailers (especially if the lake has public access sites), waterfowl, or by wind dispersal. In addition, exotic species may be introduced into aquatic systems through the release of aquarium or water garden plants into a water body. An aquatic exotic species may have profound impacts on the aquatic ecosystem. Eurasian Watermilfoil (*Myriophyllum spicatum*; Figure 11) is an exotic aquatic macrophyte first documented in the United States in the 1880's (Reed 1997), although other reports (Couch and Nelson 1985) suggest it was first found in the 1940's. *M. spicatum* has since spread to thousands of inland lakes in various states through the use of boats and trailers, waterfowl, seed dispersal, and intentional introduction for fish habitat. *M. spicatum* is a major threat to the ecological balance of an aquatic ecosystem through causation of significant declines in favorable native vegetation within lakes (Madsen et al. 1991), and may limit light from reaching native aquatic plant species (Newroth 1985; Aiken et al. 1979). Additionally, *M. spicatum* can alter the macroinvertebrate populations associated with particular native plants of certain structural architecture (Newroth 1985).

Some individual plants of *M. spicatum* were found at depths of approximately 10 feet; however, the majority of the growth was located at depths between 5-10 feet. *M. spicatum* growth is thus capable of growing in most of the littoral zone of Maple Lake. *M. spicatum* growth in Maple Lake is quite robust, with wide, thick stems, capable of producing dense surface canopies. The results of detailed GPS-guided aquatic vegetation (AVAS) survey of Maple Lake on 1 September, 2009 demonstrated that approximately 50 acres of pure *M. spicatum* infested the lake. It is imperative that lakes which are in close proximity to Maple Lake also adopt sound lake management strategies with respect to exotic species control to prevent the spread of exotic species such as *M. spicatum* which are a constant threat to the ecological balance of the Maple Lake ecosystem. The submersed aquatic exotic plant, Curly-leaf Pondweed (*Potamogeton crispus*; Figure 12), was also found in abundant quantities throughout the lake. It is susceptible to natural deterioration by early July and does not fragment; however, it produces robust seed pods called turions that overwinter in the seed bank. Thus, management of the plant should include removal via the use of mechanical or chemical methods before this turion is seasonally formed. In addition to *M. spicatum*, Maple Lake contained ample quantities of the emergent exotic Purple Loosestrife (*Lythrum salicaria*; Figure 13), which appeared to be dying. Figure 14 shows a combination of *P. crispus* and filamentous algae on the lake. Excessive algal blooms on Maple Lake are shown in Figure 15.

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Figure 11. A photograph showing the seed structures (a), dissected leaves (b), and lateral branches (c) of (pure strain) Eurasian Watermilfoil (*Myriophyllum spicatum*).

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Figure 12. A photograph showing the stem And leaf portion of Curly-leaf Pondweed (*Potamogeton crispus*)

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Figure 13. A photograph of Purple Loosestrife (*Lythrum salicaria*) in a drainage basin

An Aquatic Vegetation survey was conducted on Maple Lake on 1 September, 2009 at each of the sampling location sites (n = 32), and were marked with GPS. Each macrophyte species corresponds to an assigned number designated by the Michigan Department of Environmental Quality (MDEQ). In addition to the particular species observed (via assigned numbers), a relative abundance scale is used to estimate the percent coverage of each species within the sampling site. Exotic aquatic plant species in all studied regions of Maple Lake are shown in Table 8 below.

Exotic Aquatic Plant Species	***Common Name***	***Growth Habit***	***Abundance in or around Maple Lake***
Myriophyllum spicatum, 1	Eurasian Watermilfoil	Submersed; Rooted	Common/Dense
Potamogeton crispus, 2	Curly-Leaf Pondweed	Submersed; Rooted	Common/Dense
Lythrum salicaria, 43	Purple Loosestrife	Emergent	Sparse

Table 8. Maple Lake Exotic Aquatic Plant Species (September, 2009).

Figure 14. A canopy of Curly-Leaf Pondweed on Maple Lake (September, 2009).

Figure 15. Abundant filamentous algae on the surface of Maple Lake (September, 2009).

4.3.2 Maple Lake Native Aquatic Macrophytes

There are hundreds of native aquatic plant species in the waters of the United States. The most diverse native genera include the Potamogetonaceae (Pondweeds) and the Haloragaceae (Milfoils). Native aquatic plants may grow to nuisance levels in lakes with abundant nutrients (both water column and sediment) such as phosphorus, and in sites with high water transparency. The diversity of native aquatic plants is essential for the balance of aquatic ecosystems, because each plant harbors different macroinvertebrate communities and varies in fish habitat structure. Maple Lake contained 7 submersed, and 2 emergent aquatic plant species (Table 9), for a total of 9 native aquatic macrophyte species during the September sampling period. The majority of the emergent macrophytes may be found along the shoreline of the lake, and especially along the undeveloped shorelines. The dominant aquatic plants in the main part of the lake included the submersed non-rooted aquatic plant, Coontail (*Ceratophyllum* *demersum*) which was present in 66% of the sampling locations. Also abundant, was Common Waterweed (*Elodea canadensis*), which was present in 50% of the sampling locations. Large-leaf Pondweed (*Potamogeton amplifolius*), a tall rooted submersed plant was found to occupy 19% of the sampling locations and is considered preferred fishery habitat. Also present in 19% of the sampling locations, was the pondweed, Thinleaf Pondweed (*Potamogeton pectinatus*), which appears as fragile threads, yet can grow in thick, obstructive beds. In lower abundance, was the low-growing pondweed, Flatstem Pondweed (*Potamogeton zosteriformis*), which was present in 13% of the sampling locations. Slender Naiad (*Najas flexilis*) is a low-growing annual which was present in 6% of the sampling locations. The Macroalga, Muskgrass (*Chara vulgaris*) creates a thick "carpet-like" layer on the lake bottom in nearly 3% of the sampled areas, which helps to inhibit the rooting of Eurasian Watermilfoil fragments in some areas. There is a strong abundance of both rooted and non-rooted aquatic plants in the lake which suggests that the lake sediments and water column are both strong sources of nutrients for aquatic plants of these growth forms. *Cladophora* sp., and *Spirogyra* sp., are both filamentous green algae which form dense mats on the lake surface and eventually fall to the lake bottom to decay and contribute nutrients to the lake sediments. Excessive quantities of these two algal genera are known to cause declines in water quality and decrease the aesthetic value of lakes. Both species were abundant along the west and east shorelines, and in the southern basin of Maple Lake.

The Emergent plants, such as *Typha latifolia* (Cattails), and *Scirpus acutus* (Bulrushes), are critical for shoreline stabilization as well as for wildlife and fish spawning habitat. The presence of Purple Loosestrife (*Lythrum salicaria*) around the Maple Lake shoreline could become an imminent threat to the emergent macrophyte populations if their populations are left uncontrolled. The Michigan Department of Environmental Quality has designated abundance codes for the aquatic vegetation surveys, where a = found (occupying < 2% of the surface area of the lake), b = sparse (occupying 2-20% of the surface area of the lake), c = common, (occupying 21-60% of the surface area of the lake), and d = dense (occupying > 60% of the surface area of the lake).

Native Aquatic Plant Species	*Common Name*	*Abundance in/around Maple Lake*	*Growth Habit*
Chara vulgaris, 3	Muskgrass	Sparse	Submersed, Rooted
Potamogeton pectinatus, 4	Thinleaf Pondweed	Sparse	Submersed, Rooted
Potamogeton zosteriformis, 5	Flatstem Pondweed	Sparse	Submersed, Rooted
Potamogeton amplifolius, 11	Large-leaf Pondweed	Common	Submersed, Rooted
Ceratophyllum demersum, 20	Coontail	Common	Submersed, Non-Rooted
Elodea canadensis, 21	Common Elodea	Common	Submersed, Rooted
Najas guadalupensis, 25	Southern Naiad	Sparse	Submersed, Rooted
Typha latifolia, 39	Cattails	Common	Emergent
Scirpus acutus, 40	Bulrushes	Sparse	Emergent
Cladophora sp., 51	Filamentous Algae	Dense	Algae
Spirogyra sp., 52	Filamentous Algae	Common	Algae

Table 9. Maple Lake Native Aquatic Plants (September, 2009).

5.0 MAPLE LAKE MANAGEMENT IMPROVEMENT METHODS

Improvement strategies are available for the various problematic issues that threaten the water quality and ecological stability of Maple Lake including the management of exotic aquatic plants, control of beach and shoreline erosion, and nutrient loading reduction from tributaries which enter the lake. The increased developmental pressures and usage of aquatic ecosystems necessitate inland lake management practices to preserve and maintain balance within the Maple Lake immediate watershed. Lake management components involve within-lake (basin) and around-lake (watershed) solutions to protect and restore complex aquatic ecosystems. The multiple goals of a Lake Management Plan (LMP) are to increase water quality, favorable wildlife habitat, aquatic plant and animal biodiversity, recreational use, and lakefront property values. Regardless of the management goals, all management decisions must be site-specific and should consider the socio-economic, scientific, and environmental components of the LMP (Madsen 1997).

5.1 Maple Lake Aquatic Plant Management

The management of nuisance submersed, floating-leaved and emergent aquatic plants is necessary in nutrient-enriched aquatic ecosystems due to accelerated growth and distribution. Management options should be environmentally and ecologically sound and financially feasible. Options for control of aquatic plants are limited yet are capable of achieving strong results when used properly. Protection of favorable native aquatic plants (especially the submersed pondweeds and *Chara*) in Maple Lake to provide for a balanced fishery is strongly recommended. However, exotic aquatic plant species should be managed with solutions that will yield long-term results.

5.1.1 Aquatic Herbicides and Algaecides

The use of aquatic chemical herbicides is regulated by the MDEQ under Part 33 (Aquatic Nuisance) of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994, and requires a permit from the Michigan Department of Environmental Quality (MDEQ). The permit contains a list of approved herbicides for a particular body of water, as well as dosage rates, treatment areas, and water use restrictions. Furthermore, residents that reside within 100 feet of the proposed treatment area must be notified at least seven days, but not more than forty-five days prior to the initial treatment date. A certified herbicide applicator usually notices the residents in advance of the proposed treatment date, and during the day of treatment. Contact and systemic aquatic herbicides are the two primary herbicide types used in aquatic systems. Contact herbicides cause damage to leaf and stem structures; whereas systemic herbicides are assimilated by the plant roots and are lethal to the entire plant. Wherever possible, it is preferred to use a systemic herbicide for longer-lasting aquatic plant control. There are often restrictions with usage of some systemic herbicides around shoreline areas that contain shallow drinking wells. Systemic herbicides such as 2, 4-D and Triclopyr could be used to successfully treat localized or widely dispersed beds of Eurasian Watermilfoil. Triclopyr should be used with an adjuvant to increase its ability to adhere to the aquatic plants.

Fluridone (trade name, SONAR®) is a systemic whole-lake herbicide treatment that is applied to the entire lake volume in the spring. The objective of a fluridone treatment is to selectively control the growth of Eurasian Watermilfoil in order to allow other native aquatic plants to germinate and create a more diverse aquatic plant community. A whole-lake treatment of fluridone is not recommended for Maple Lake due to the localized areas of *M. spicatum* that would be best controlled with granular aquatic herbicides and also the low water retention time, which may flush liquid herbicides out of the system, thereby lowering the concentration available to the exotic plants. All herbicides should be applied during calm weather conditions to minimize drift of the chemical from the treatment site. Other systemic herbicide treatments may be needed throughout the growing season as new *M. spicatum* fragments may be introduced to the lake. Algae treatments through the use of algaecides should be limited to extremely dense filamentous algal blooms and efforts should be taken to reduce the nutrient loads that encourage algal blooms which may require treatments. Overuse of algal treatments may lead to the selection for non-preferred algal types, so these treatments should be used sparingly and only in canal and shallow beach areas.

5.1.2 Mechanical Harvesting

Mechanical harvesting involves the physical removal of nuisance aquatic vegetation with the use of a mechanical harvesting machine. The mechanical harvester collects numerous loads of aquatic plants as they are cut near the lake bottom. The plants are off-loaded onto a conveyor and then into a dump truck. Harvested plants are then taken to an offsite landfill or farm where they can be used as fertilizer. Mechanical harvesting is preferred over chemical herbicides when primarily native aquatic plants exist, or when excessive amounts of plant biomass need to be removed. Mechanical harvesting is usually not recommended for the removal of Eurasian Watermilfoil since the plant may fragment when cut and re-grow on the lake bottom. Due to the current infestation of *M. spicatum* throughout the littoral zone of Maple Lake, mechanical harvesting is not recommended until all of the *M. spicatum* has been effectively treated. This will allow for the removal of excess plant biomass, while avoiding the risk of milfoil fragmentation after the plants have been killed and are no longer viable. Mechanical harvesting does not require a permit from the Michigan Department of Environmental Quality (MDEQ); however, some counties require a launch site use permit from the Michigan Department of Natural Resources (MDNR) if a public access launch site is present.

5.1.3 Biological Control

The use of the aquatic weevil, *Euhrychiopsis lecontei* to control *M. spicatum* has become a popular option for many inland lakes. The weevil naturally exists in many of our lakes; however, the lack of adequate populations in many lakes requires that they be implanted and augmented for successful control of *M. spicatum*. The weevil feeds almost entirely on *M. spicatum* and will leave native aquatic species unharmed. The weevil burrows into the stems of *M. spicatum* and damages the vascular tissue, thereby reducing the plant's ability to store carbohydrates (Newman et al. 1996). Eventually, the *M. spicatum* stems lose buoyancy and the plant decomposes on the lake bottom.

Recent research has shown that the weevils require a substantial amount of aquatic plant biomass for successful control of *M. spicatum*. In addition, the weevils require adequate over-wintering habitat since they overwinter within shoreline vegetation. Lakes with sparse *M. spicatum* distribution and abundant metal and concrete seawalls are not ideal candidates for the milfoil weevil. If weevils are considered for Maple Lake, they a pilot evaluation project should be pursued before using them on a larger scale.

5.1.4 Laminar Flow Lake Aeration

A laminar flow aeration system utilizes diffusers which are powered by onshore air compressors. The diffusers are connected via extensive self-sinking airlines which help to purge the lake water of benthic carbon dioxide (CO_2), which is a primary nutrient necessary aquatic plant photosynthetic growth and productivity. In addition to the placement of the diffuser units, the concomitant use of bacteria and enzymatic treatments to facilitate the microbial breakdown of organic sedimentary constituents is also used as a component of the treatment. Although this is a relatively new area of research, recent case studies have shown promise on the positive impacts of laminar flow aeration systems on aquatic ecosystem management with respect to sediment organic matter reduction and algal and aquatic plant management in eutrophic ecosystems. The philosophy and science behind the laminar flow aeration system is to reduce a key source of food to aquatic plants (i.e. CO_2), rather than wait for the plants to grow in an abundance of the source and then treat the problem via aquatic herbicides. It must be realized though, that aquatic herbicides and other aquatic plant management strategies may still need to be used during early years of the laminar flow aeration system since it may take years for the system to show impacts on a large scale. It is also possible that exotic species may never be fully eradicated from the lake even after the aeration system has been implemented for a substantial length of time. This type of aeration system generally works best in littoral zone areas with densely rooted aquatic vegetation and high organic matter content. Maple Lake is the ideal candidate for this system, which dramatically reduce organic matter content and reduce algal blooms and potentially, nuisance rooted aquatic plant growth. Costs for the units vary and are dependent upon sediment thickness profiles. Annual operating electricity costs typically range between $2,500-$4,000 for most inland lakes and smaller treatment areas. If a pilot evaluation project is desired, the units should be placed at the south basin of the lake, where the organic matter and aquatic plant growth are the highest. If the water depth is adequate in Briggs Pond, then it may also be advantageous to place the laminar flow unit in that location to reduce organic loads as they would potentially enter Maple Lake.

5.1.5 Integrated Management

Integrated management involves the combined use of chemical, biological, mechanical, aeration, or other control methods for aquatic plant control or the combination of various methods for the management of nutrients, erosion, or other issues. Integrated management is becoming increasingly common since aquatic ecosystems are multi-dimensional and have different vegetation communities in certain lake areas and thus may show variable responses to specific treatments. The recommended use of systemic chemical herbicides for the *M. spicatum* and *P. crispus* within Maple Lake and the use of other watershed management methods (i.e. BMP's for the reduction of tributary nutrient inputs to the lake and laminar flow aeration), are indicative of an integrated management plan.

5.2 Maple Lake Watershed Management

In addition to the proposed treatment of *M. spicatum*, *P. crispus*, and *L. salicaria* around and within Maple Lake, it is recommended that watershed Best Management Practices (BMP's) be implemented to improve the water quality of the lake. The water quality of the lake can be improved through the use of these BMP's such as lakeside landscaping which emphasizes optimum lakeshore planting. The guidebook, Lakescaping for Wildlife and Water Quality (Henderson et al. 1998) may be ordered online at: http://web2.msue.msu.edu/bulletins/mainsearch.cfm. These guidelines include: 1) maintenance of brush cover on lands with steep slopes, 2) development of a vegetation buffer zone 25-30 feet from the land-water interface with approximately 60-80% of the shoreline bordered with vegetation, 3) limiting boat traffic to reduce wave energy and thus erosion potential, 4) avoiding the use of retaining walls and encouraging the growth of dense shrubs or rip-rap to control erosion, and 5) using only native genotype plants (those native to Maple Lake) around the lake since they are most likely to establish and thrive than those not acclimated to growing in the area soils, and 6) restricting boat access via the consideration of a township ordinance (i.e. carry-down access sites, or electric motor only at various launch sites).

5.2.1 Maple Lake Erosion and Sediment Control

The construction of impervious surfaces (i.e. paved roads and walkways, houses) should be minimized and kept at least 100 feet from the lakefront shoreline to reduce surface runoff potential. In addition, any wetland areas around Maple Lake should be preserved to act as a filter of nutrients from the land and to provide valuable wildlife habitat. Construction practices near the lakeshore should minimize the chances for erosion and sedimentation by keeping land areas adjacent to the water stabilized with rock, vegetation, or wood retaining walls. Increased erosion may lead to increased turbidity and nutrient loading to the lake (Figure 16). Seawalls should consist of rip-rap (stone, rock), rather than metal, due to the fact that rip-rap offers a more favorable habitat for lakeshore organisms, which are critical to the ecological balance of the lake ecosystem. If metal seawalls are currently used, then rip-rap should be installed in front of the seawall and extend into the water to create the presence of microhabitats for enhanced biodiversity of the aquatic organisms within Maple Lake. The emergent aquatic plant, *Scirpus* sp. (Bulrushes) offers satisfactory stabilization of shoreline sediments and assists in the minimization of sediment release into the lake.

Figure 16. Erosion of sand into Maple Lake (September, 2009).

5.2.2 Maple Lake Nutrient Source Control

Due to the finding that Maple Lake contains a substantially higher relative proportion of nitrogen to phosphorus (i.e. N: P > 15 and thus the system is P-limited), any additional inputs of phosphorus to the lake are likely to create further algal and aquatic plant growth throughout the lake. This is especially problematic given the high amount of nutrients which enter the lake from the east and south branches of the Paw Paw River. Thus, the following recommendations are advised to protect the water quality of Maple Lake:

1) Avoid the use of lawn fertilizers that contain phosphorus (P). P is the main nutrient required for aquatic plant and algae growth, and plants grow in excess when P is abundant. When possible, water lawns with lake water that usually contains adequate P for successful lawn growth.

2) If you must fertilize your lawn, assure that the middle number on the bag of fertilizer reads "0" to denote the absence of P.

3) Preserve riparian vegetation buffers around lake (such as those that consist of Cattails, Bulrushes, and Spike rushes), since they act as a filter to catch nutrients and pollutants that occur on land and may run off into the lake. As an additional bonus, Canadian geese (*Branta canadensis*) usually do not prefer lakefront lawns with dense riparian vegetation because they are concerned about the potential of hidden predators within the vegetation.

4) Do not burn leaves near the lake shoreline since the ash is a high source of P. The ash is lightweight and may become airborne and land in the water eventually becoming dissolved and utilized by aquatic vegetation and algae.

5.2.3 Maple Lake Waterfowl Management and Control

In addition to the contribution of *E. coli* from runoff sources, waterfowl populations should also be controlled since they may contribute bacteria and nutrients to the lake and also contribute to the problem of swimmer's itch. This is especially important in areas of Maple Lake where the soils are prone to ponding or saturation (i.e. the mucks). Such ponding could cause an overflow of *E. coli* directly into the lake during a strong runoff event. It is recommended that the residents of Maple Lake prevent the feeding of waterfowl that visit lakefront properties. In addition, since many of the geese were found on Maple Island (Figure 17), it is strongly recommended that a thick riparian vegetation buffer be placed around the perimeter of the island to deter geese and reduce their presence. Waterfowl populations may be controlled by following these guidelines:

Figure 17. Geese gathering on Maple Island (September, 2009).

- Do not feed the waterfowl as it only encourages them to reside on lakefront lawns. There is adequate food for them within the watershed area.
- Plant tall grasses near the shoreline or stop mowing the lawn in areas adjacent to shore. Geese in particular are less likely to visit a lawn with tall grasses due to the possibility of a potential predator residing there. In addition, the vegetation buffer may help to absorb some of the fecal matter (and consequently the *E. coli* bacteria and nutrients) and prevent it from leaching into the water at the shoreline-water interface. Since geese will likely not visit the edge of this buffer if it directly abuts the water's edge, they may visit the other side of the buffer and it may filter the fecal inputs from the geese.
- Contact the Michigan Department of Natural Resources (MDNR) for permit applications for egg-replacement strategies of Geese, which usually nest in March and April. The MDNR may also participate in nest destruction practices in selected areas.

- Purchase sound alarms, whistles, or loud devices to deter waterfowl from lakefront properties. Construction of a pyramidal configuration (designed with four strings attached to a central wooden stake) on swimming rafts along with the addition of reflective compact disks (CD's) tied
- Plastic birds of prey or predatory mammals (i.e. coyotes) may have some effects on the prevention of waterfowl from entering some beach areas.

5.3 Invasive Aquatic Species Prevention

An exotic species is a non-native species that does not originate from a particular location. When international commerce and travel became prevalent, many of these species were transported to areas of the world where they did not originate. Due to their small size, insects, plants, animals, and aquatic organisms may escape detection and be unknowingly transferred to unintended habitats. The first ingredient to successful prevention of unwanted transfer of exotic species to Maple Lake is awareness and education. Invasive species prevention signs are available from the Minnesota Department of Natural Resources, Exotic Species Program, 500 Lafayette Rd., St. Paul, MN 55155-4025, Phone: 612-296-2835, Fax: 612-296-1811, Email: debbie.hunt@dnr.state.mn.us. The signs (18"x24") are intended for posting at exits of public and private water accesses, and read: "Please stop and remove all aquatic plants and drain water from boat and trailer." They are free to water access owners in MN; however, a fee may apply for Michigan riparians.

5.3.1 Zebra Mussels

Zebra mussels (*Dreissena polymorpha*) were first discovered in Lake St. Clair in 1988 (Herbert et al. 1989) and likely arrived in ballast water or on shipping vessels from Europe (McMahon 1996). They are easily transferred to other lakes because they inherit a larval (nearly microscopic) stage where they can easily avoid detection. The mussels then grow into the adult (shelled) form and attach to substrates (i.e. boats, rafts, docks, pipes, aquatic plants, and lake bottom sediments) with the use of byssal threads. The fecundity (reproductive rate) of female zebra mussels is high, with as many as 40,000 eggs laid per reproductive cycle and up to 1,000,000 in a single spawning season (Mackie and Schlosser 1996). Although the mussels only live 2-3 years, they are capable of great harm to aquatic environments. In particular, they have shown selective grazing capabilities by feeding on the preferred zooplankton food source (green algae) and expulsion of the non-preferred blue green algae (cyanobacteria). Additionally, they may decrease the abundance of beneficial diatoms in aquatic ecosystems (Holland 1993). Such declines in favorable algae can decrease zooplankton populations and ultimately the biomass of planktivorous fish populations. Zebra mussels are viewed by some as beneficial to lakes due to their filtration capabilities and subsequent contributions to increased water clarity. However, such water clarity may allow other photosynthetic aquatic plants to grow to nuisance levels (Skubinna et al. 1995). The recommended prevention protocols for introduction of zebra mussels includes steam-washing all boats, boat trailers, jet-skis, and floaters prior to placing them into Maple Lake. Boat transom wells must always be steam-washed and emptied prior to entry into the lake. Excessive waterfowl should also be discouraged from the lake since they are a natural transportation vector of the microscopic zebra mussel larvae or mature adults. Fishing poles, lures, and other equipment used in other lakes (and especially the Great Lakes) should also be thoroughly steam-washed before use in Maple Lake. Additionally, all solid construction materials (if recycled from other lakes) must also be steam-washed.

5.3.2 Other Invasive Aquatic Plants

In addition to Eurasian Watermilfoil (*M. spicatum*), Curly-leaf Pondweed (*Potamogeton crispus*), and Purple Loosestrife (*Lythrum salicaria*), many other invasive aquatic plant species are being introduced into waters of the North Temperate Zone. The majority of exotic aquatic plants do not depend on high water column nutrients for growth, as they are well-adapted to using sunlight and minimal nutrients for successful growth. These species have similar detrimental impacts to lakes in that they decrease the quantity and abundance of native aquatic plants and associated macroinvertebrates and consequently alter the lake fishery. *Hydrilla* was introduced to waters of the United States from Asia in 1960 (Blackburn et al. 1969) and is a highly problematic submersed, rooted, aquatic plant in tropical waters. Recently, *Hydrilla* was found in Lake Manitou (Indiana, USA) and the lake public access sites were immediately quarantined in an effort to eradicate it. *Hydrilla* retains many physiologically distinct reproductive strategies which allow it to colonize vast areas of water and to considerable depths, including fragmentation, tuber and turion formation, and seed production. Currently, the methods of control for *Hydrilla* include the use of chemical herbicides, rigorous mechanical harvesting, and Grass Carp

(*Ctenopharyngodon idella* Val.), with some biological controls currently being researched. However, use of the Grass Carp in Michigan is currently not permitted by the Michigan Department of Natural Resources (MDNR

5.3.3 Viral Hemorrhagic Septicemia (VHS) Fish Virus

Viral Hemorrhagic Virus (VHS) is a fish disease caused by a rhabdovirus, which has spread to the Great Lakes region and has caused great harm to the fishery in the Great Lakes waters and a few inland lakes. The VHS virus is deadly to fish and once it has entered into a waterbody, there is no way to remove it. VHS is most active in colder waters (i.e. water temperatures < 15°C), which is why the virus is most active during the spring season. The virus has two possible ways of entering into an inland lake waterbody; 1.) attached to a vessel 2.) and/or through infected bait fish. The MDNR recommends that boats going from lake to lake be sprayed with a solution of Chlorox® or Virkon® prior to entering a waterbody. The solution of Chlorox® and water required to kill the virus is a very weak concentration (one-half ounce of Chlorox® per gallon of water). The MDNR has also been inspecting bait sellers and issuing virus-free bait permits. Live wells or bilge pumps should be drained prior to entering Maple Lake. Some lake associations throughout the state are supplying their boat launches with the proper gear to stop the spread of VHS. The recommended materials needed include instructions on how to disinfect your boat, safety goggles, rubber gloves, and a hand-held garden sprayer containing the Chlorox® water solution. Visit the Michigan Lake and Streams Association website at: http://www.mlswa.org for more information.

6.0 KEY FINDINGS AND OVERALL ASSESSMENT OF MAPLE LAKE

6.1 Maple Lake Key Watershed Findings

Based on the laboratory analyses (sediment and water),the watershed around Maple Lake has been impacted nutrient and pollutant loads from surrounding rivers and tributaries as well as nutrient and sediment loads from residential development around the lake shoreline. In addition, the lake has been impeded by *M. spicatum* fragments from recreational boats and thus an aggressive approach to the control of *M. spicatum* on Maple Lake or a preventative measure for the spread of *M. spicatum* fragments is highly recommended. The highly developed shoreline around Maple Lake emphasizes the need for riparians to follow sound land use management practices to protect the water quality of the lake. The low quantity of riparian vegetation at some shoreline areas allows for greater opportunities for nutrient and sediment (erosion) inputs from the land to the lake. Although there is still a fair abundance of forested lands in the extended watershed, the majority of the wetlands have been altered and thus nutrient filtering capacities have been dramatically reduced. As a result, it is critical that the riparians and residents around Maple Lake adopt sound watershed management strategies to improve and protect the water quality of the lake. The remaining forest land and wetlands should be preserved to the extent possible.

6.1.1 Maple Lake Soils and Land Use Implications

A few shoreline areas around Maple Lake contain soils that may compromise the water quality of the lake. The Morocco Loamy Sands located at the south shore and on Maple Island are poorly drained, and may experience saturation during periods of increased precipitation. Such increased saturation may cause bacteria (from waterfowl feces) or nutrients (from lawn fertilizers) to directly enter into the lake. The sands are substrates that are well-drained and are not likely to encounter ponding or saturation, yet many sites contain slopes that are prone to erodibility. Since not much can be done to change the properties of the soils surrounding the lake, it is recommended that waterfowl droppings be reduced by goose control methods (especially nest destruction as permitted) and soil erosion control methods. Such techniques will dramatically decrease the amount of bacteria and nutrients entering the lake from the immediate watershed.

6.2 Maple Lake Key Lake and Water Quality Findings

The overall quality of the Maple Lake aquatic ecosystem is fair to poor because it possesses moderate to high nutrient concentrations, low water clarity, elevated suspended solids and organic matter, and excessive growth of algae and aquatic plants. The lake remains susceptible to infestation by exotics such as Eurasian Watermilfoil, Curly-leaf Pondweed, and Purple Loosestrife. Below are the overall key findings from this study that ultimately lead to suggestions for the successful management and protection of Maple Lake.

6.2.1 Maple Lake Water Chemistry

Based on all of the water chemistry parameters, Maple Lake may be classified as eutrophic. Eutrophic lakes with abundant residential development and nutrient inputs are vulnerable to excessive nuisance aquatic plant growth if the nutrient loads are not decreased over time. The sediment nutrient concentrations (bottom phosphorus) around the lake are high, and are the dominant source of food for photosynthetic plants and algae. Concentrations of both phosphorus and nitrogen are likely to increase as nutrient inputs to the lake from the surrounding watershed continue.

6.2.2 Maple Lake Aquatic Vegetation.

Native submersed aquatic plants (i.e. Pondweeds and *Chara*) within Maple Lake are plentiful in shallow littoral zone areas (i.e. between 5-10 feet); however, these communities are currently stressed by the invasion of Eurasian Watermilfoil and Curly-leaf Pondweed which threatens to displace them. Furthermore, the presence of *M. spicatum* at depths of between 5-10 feet indicates the ability of this plant to colonize a vast majority of the Maple Lake littoral zone. Floating-leaved aquatic plants are rare in the Maple Lake due to the high sediment loads and inability to successfully grow under those environmental conditions. Emergent aquatic plants are plentiful around some undeveloped and riparian shoreline areas of Maple Lake and are critical habitats for insects and other lake biota. Additionally, they function as erosion guards by stabilizing beach sands that may wash into the lake.

7.0 PROJECT RECOMMENDATIONS, EXPECTATIONS, AND FINANCING

It is highly recommended that the municipalities and the residents around Maple Lake adopt the lake water quality and aquatic vegetation guidelines suggested in this management plan. To protect the biodiversity of native aquatic plants within Maple Lake, aquatic herbicides should be minimized and used primarily for exotic species. Additionally, an integrated management approach involving the use of other lake improvement strategies (i.e. nutrient-reducing BMP's and shoreline erosion reduction methods) for water quality improvement is recommended for the management of nuisance rooted aquatic plant growth and improvement of water quality in Maple Lake.

7.1 Recommendations and Expectations for the Municipalities and Riparians of Maple Lake

Every lake management plan should offer solutions that are ecologically sound, practical, and economically feasible. Since funds for the suggested management improvements and oversight are limited, it was suggested that the riparians around Maple Lake utilize a Special Assessment District (SAD) under P.A. 188 of 1954 to fund the suggested improvements. The SAD should include all riparian properties around Maple Lake and backlot properties which would derive benefit from the intended improvements mentioned in the management plan. Under P.A. 188 of 1954, it is critical that the formation of the SAD be equitable to properties within a particular category. The riparians around Maple Lake are encouraged to participate in regular water quality sampling of Maple Lake through the Cooperative Lakes Monitoring Program (CLMP) with the Michigan Lake and Streams Association (MLSA) and Michigan Department of Environmental Quality (MDEQ). In addition, cooperation with the Van Buren County Drain Commissioner is strongly encouraged for the implementation of BMP's in upstream areas of the Paw Paw River. Successful BMP strategies as listed in this study should reduce the amount of sediment loads to Maple Lake from tributary inputs and overflows of sediments from Briggs Pond. Reduced sediment loads should also decrease the amount of nutrients added to Maple Lake water and sediments. Water quality monitoring is continuously recommended to assess the nutrient status of the lake both prior to lake improvements and for years after to reassess water quality improvements from implemented management techniques. At this time, it is recommended that the local municipalities and riparians consider the implementation of an Integrated Management approach for the control of exotic species within Maple Lake, along with watershed management improvements. An integrated approach will utilize both the watershed and within-lake management practices. Since the extent of the *M. spicatum* and *P. crispus* infestations are both approximately 50 acres, it is imperative that a rigorous yet ecologically sound treatment program for both begin immediately. Additionally, the chemical herbicides should consist of systemics which offer long-term control by effectively killing the plant roots. If systemic aquatic herbicides are used accordingly, rooted exotic species should decline to low levels (i.e. less than 5 acres). In addition, reduction of nutrient and sediment loads to the lake will decrease algal blooms and minimize the need for copper sulfate algal treatments. All aquatic herbicides to be used in Maple Lake must be registered by the United States Environmental Protection Agency (EPA) and must be used according to the safety guidelines listed for that particular herbicide on the MSDS sheet. The aquatic herbicide registration process requires that intense studies on human exposure and health, effects on fisheries and wildlife, biopersistance, and analysis of chemical breakdown products all be assessed to determine if these substances are safe to use in aquatic habitats for the control of nuisance aquatic vegetation.

Furthermore, a professional limnologist/aquatic botanist should perform regular GPS-guided whole-lake surveys each spring and fall to monitor the growth and distribution of *M. spicatum*, and other exotics that significantly disrupt the ecological stability of Maple Lake. The lake manager should oversee all management activities and would be responsible for the creation of aquatic plant management survey maps, direction of the harvester or herbicide applicator to target-specific areas of aquatic vegetation for removal, implementation of watershed best management practices, administrative duties such as the processing of contractor invoices, and the education of lakefront owners through an educational newsletter and through attending local municipality meetings. The educational newsletter should contain educational tips for residents to recognize and prevent the transfer of invasive species to the lake and watershed management methods.

The installation of a laminar flow aeration unit may decrease the organic matter sediment thickness and need for great amount of chemical herbicides; however, a pilot project is highly recommended to evaluate the efficacy on a small scale before utilizing the technology on a whole-lake scale. When additional microbes are used in conjunction with the aeration unit, a decline of >10 inches of organic matter within a single season has been recorded on other lakes which have installed laminar flow units with microbial adjuvants (Clean-Flo, 2009).

7.1.1 Cost Estimates for Maple Lake Improvements

The proposed Integrated Management treatment program for the control of exotic species and sediment and organic matter reduction in Maple Lake would begin during the spring of 2010. A breakdown of costs associated with Maple Lake improvements is presented in Table 10. It should be noted that proposed costs are estimates and may change in response to changes in environmental conditions (i.e. increases in aquatic plant growth or distribution, or changes in herbicide costs).

Proposed Maple Lake Improvement Item	Estimated 2010 Cost	Estimated 2011 Cost[4]	Estimated 2012-2014[5]
Herbicides (Triclopyr OTF for *M. spicatum*[1] for 50 acres@ $485 per acre; $1,500 MDEQ permit fee; Algal treatments	$28,000	$21,000	$12,000
Laminar Flow Aeration for south basin (includes installation, lease, and operation); Note: Estimate for future year contingent upon South Basin pilot project results.	$25,000	$25,000	$55,000[6]
Professional Services (limnologist surveys, sampling, oversight, processing, education, newsletter)[2]	$8,000	$8,000	$8,000
Contingency[3]	$6,100	$5,400	$7,500
Total Annual Estimated Cost	$67,100	$59,400	$82,500

Table 10. Maple Lake proposed lake improvement program costs (2010-2014).

[1] Herbicide treatment scope may change annually due to changes in the distribution and/or abundance of aquatic plants.

[2] Professional services includes two annual GPS-guided, aquatic vegetation surveys, pre and post-treatment surveys for aquatic plant control methods, oversight and management of the aquatic plant control program, processing of all invoices from contractors and others billing for services related to the improvement program, education of local riparians through the development and publication of a high-quality, scientific newsletter, and attendance at up to four annually scheduled Maple Lake Improvement meetings.

[3] Contingency is 10% of the total project cost, to assure that extra funds are available for unexpected expenses. Note: Contingency may be advised and/or needed for future treatment years. Contingency funds may also be used for other water quality improvements and watershed management.

[4] Cost estimates for 2011 based on 75% of the herbicide treatment costs for 2010. Note: Herbicide unit costs given for 2012 are the same as for 2011.

of living adjustments for the contractor services and/or products.

[5] Costs of the proposed program for years 2012-2014 are estimates only and may change based on the distribution and/or abundance of nuisance aquatic vegetation, implementation of a laminar flow aeration system, and costs of products and contractor services.

[6] Estimated cost of laminar flow aeration for whole-lake, after 2-year pilot project in south basin.

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APPENDIX A

MAPLE LAKE HISTORICAL WATER QUALITY AND FISHERIES DATA

Surface Water Information Management System
Department of Environmental Quality • Department of Natural Resources

Michigan.gov
The Official State of Michigan Website

Click to Export to Excel: Export

800275 DEQ Sampling Station Information

Description	MAPLE LAKE NORTH BASIN, PAW PAW TOWNSHIP SECTION 1
Type	Lake
Depth	15
Latitude	42.233337
Longitude	-85.887505
USGS HUC Code	04050001

DEQ Water Chemistry Sampling Results

Characteristic	Result Value	Units	Project Name	Sample Date	Value Type	Depth	Depth Units	Sample Time
Temperature, water	21.5	deg C	LWQA	8/15/2006	Actual	8	ft	1307
Total Dissolved oxygen (DO)	12.2	mg/l	LWQA	8/15/2006	Actual	5	ft	1304
Total Dissolved oxygen (DO)	3	mg/l	LWQA	8/15/2006	Actual	11	ft	1311
Total Dissolved oxygen (DO)	5.9	mg/l	LWQA	8/15/2006	Actual	8	ft	1307
Total Dissolved oxygen (DO)	7.8	mg/l	LWQA	8/15/2006	Actual	6	ft	1305
Total Nitrogen, ammonia (NH3)+ organic	0.61	mg/l	LWQA	8/15/2006	Actual	9	ft	1325
Total Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.006	mg/l	LWQA	8/15/2006	Actual	6	ft	1320
Total Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.096	mg/l	LWQA	8/15/2006	Actual	9	ft	1325
Total pH	8.7		LWQA	8/15/2006	Actual	3	ft	1302
Total Specific conductance	453	umho/cm	LWQA	8/15/2006	Actual	2	ft	1301
Temperature, water	21	deg C	LWQA	8/15/2006	Actual	10	ft	1309
Temperature, water	24	deg C	LWQA	8/15/2006	Actual	4	ft	1303
Total pH	8.7		LWQA	8/15/2006	Actual	4	ft	1303
Temperature, water	21.5	deg C	LWQA	8/15/2006	Actual	7	ft	1306
Total Chlorophyll a (composite)	14	ug/l	LWQA	8/15/2006	Actual	8	ft	1310
Total Dissolved oxygen (DO)	12.2	mg/l	LWQA	8/15/2006	Actual	3	ft	1302
Total Dissolved oxygen (DO)	2.4	mg/l	LWQA	8/15/2006	Actual	10	ft	1309
Total Nitrogen, ammonia (NH3)+ organic	0.65	mg/l	LWQA	8/15/2006	Actual	3	ft	1315
Total Nitrogen, ammonia as N	0.026	mg/l	LWQA	8/15/2006	Actual	9	ft	1325
Total pH	8.6		LWQA	8/15/2006	Actual	5	ft	1304
Secchi disk depth	1.2	m	LWQA	8/15/2006	Actual			1315
Temperature, water	24	deg C	LWQA	8/15/2006	Actual	2	ft	1301
Total Specific conductance	527	umho/cm	LWQA	8/15/2006	Actual	8	ft	1307
Total Specific conductance	529	umho/cm	LWQA	8/15/2006	Actual	10	ft	1309
Temperature, water	21	deg C	LWQA	8/15/2006	Actual	9	ft	1308
Temperature, water	24	deg C	LWQA	8/15/2006	Actual	3	ft	1302
Total Dissolved oxygen (DO)	12.4	mg/l	LWQA	8/15/2006	Actual	2	ft	1301
Total Nitrogen, ammonia as N	0.004	mg/l	LWQA	8/15/2006	Actual	3	ft	1315
Total Nitrogen, ammonia as N	0.004	mg/l	LWQA	8/15/2006	Actual	6	ft	1320
Total pH	7.6		LWQA	8/15/2006	Actual	10	ft	1309
Total pH	7.7		LWQA	8/15/2006	Actual	9	ft	1308
Total pH	8.7		LWQA	8/15/2006	Actual	2	ft	1301
Total Specific conductance	453	umho/cm	LWQA	8/15/2006	Actual	3	ft	1302
Total Specific conductance	488	umho/cm	LWQA	8/15/2006	Actual	6	ft	1305
Temperature, water	21	deg C	LWQA	8/15/2006	Actual	11	ft	1311
Total Nitrogen, ammonia (NH3)+ organic	0.6	mg/l	LWQA	8/15/2006	Actual	6	ft	1320
Total pH	7.7		LWQA	8/15/2006	Actual	11	ft	1311
Total pH	7.9		LWQA	8/15/2006	Actual	8	ft	1307
Total Phosphorus	0.031	mg/l	LWQA	8/15/2006	Actual	6	ft	1320

Total Phosphorus	0.034	mg/l	LWQA	8/15/2006	Actual	9	ft	1325
Total Specific conductance	458	umho/cm	LWQA	8/15/2006	Actual	5	ft	1304
Total Specific conductance	528	umho/cm	LWQA	8/15/2006	Actual	11	ft	1311
Total Specific conductance	529	umho/cm	LWQA	8/15/2006	Actual	9	ft	1308
Total Dissolved oxygen (DO)	3.8	mg/l	LWQA	8/15/2006	Actual	9	ft	1308
Total Dissolved oxygen (DO)	6.6	mg/l	LWQA	8/15/2006	Actual	7	ft	1306
Total pH	8		LWQA	8/15/2006	Actual	7	ft	1306
Total pH	8.1		LWQA	8/15/2006	Actual	6	ft	1305
Total Specific conductance	453	umho/cm	LWQA	8/15/2006	Actual	4	ft	1303
Temperature, water	23	deg C	LWQA	8/15/2006	Actual	6	ft	1305
Temperature, water	23.5	deg C	LWQA	8/15/2006	Actual	5	ft	1304
Total Dissolved oxygen (DO)	12.2	mg/l	LWQA	8/15/2006	Actual	4	ft	1303
Total Phosphorus	0.036	mg/l	LWQA	8/15/2006	Actual	3	ft	1315
Total Specific conductance	523	umho/cm	LWQA	8/15/2006	Actual	7	ft	1306

Characteristic	Result Value	Units	Project Name	Sample Date	Value Type	Depth	Depth Units	Sample Time
Temperature, water	7	deg C	LWQA	3/29/2006	Actual	3.5	ft	751
Temperature, water	7	deg C	LWQA	3/29/2006	Actual	6.5	ft	757
Total Chloride	27	mg/l	LWQA	3/29/2006	Actual	6	ft	815
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	7.5	ft	759
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	8	ft	800
Total pH	8.5		LWQA	3/29/2006	Actual	6.5	ft	757
Total Phosphorus	0.023	mg/l	LWQA	3/29/2006	Actual	6	ft	815
Total Specific conductance	581	umho/cm	LWQA	3/29/2006	Actual	3.5	ft	751
Total Specific conductance	581	umho/cm	LWQA	3/29/2006	Actual	4.5	ft	753
Temperature, water	7	deg C	LWQA	3/29/2006	Actual	4	ft	752
Temperature, water	7	deg C	LWQA	3/29/2006	Actual	6	ft	756
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	4.5	ft	753
Total pH	8.5		LWQA	3/29/2006	Actual	4	ft	752
Total pH	8.5		LWQA	3/29/2006	Actual	6	ft	756
Total Phosphorus	0.023	mg/l	LWQA	3/29/2006	Actual	3	ft	810
Total Specific conductance	577	umho/cm	LWQA	3/29/2006	Actual	9	ft	802
Total Specific conductance	579	umho/cm	LWQA	3/29/2006	Actual	6.5	ft	757
Total Specific conductance	581	umho/cm	LWQA	3/29/2006	Actual	5.5	ft	755
Temperature, water	6.5	deg C	LWQA	3/29/2006	Actual	8	ft	800
Temperature, water	7	deg C	LWQA	3/29/2006	Actual	4.5	ft	753
Total Chlorophyll a (composite)	11	ug/l	LWQA	3/29/2006	Actual	11.5	ft	805
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	8.5	ft	801
Total Magnesium	24.2	mg/l	LWQA	3/29/2006	Actual	6	ft	815
Total pH	8.5		LWQA	3/29/2006	Actual	4.5	ft	753
Total pH	8.5		LWQA	3/29/2006	Actual	7	ft	758
Total Total Hardness	280	umho/cm	LWQA	3/29/2006	Actual	6	ft	815
Temperature, water	6.5	deg C	LWQA	3/29/2006	Actual	7.5	ft	759
Temperature, water	7	deg C	LWQA	3/29/2006	Actual	5.5	ft	755
Total Calcium	70.4	mg/l	LWQA	3/29/2006	Actual	6	ft	815
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	6.5	ft	757
Total Nitrogen, ammonia (NH3)+ organic	0.31	mg/l	LWQA	3/29/2006	Actual	6	ft	815
Total Nitrogen, ammonia (NH3)+ organic	0.32	mg/l	LWQA	3/29/2006	Actual	3	ft	810
Total Nitrogen, ammonia as N	0.02	mg/l	LWQA	3/29/2006	Actual	3	ft	810
Total pH	8.5		LWQA	3/29/2006	Actual	7.5	ft	759
Total Phosphorus	0.022	mg/l	LWQA	3/29/2006	Actual	9	ft	820
Total Specific conductance	577	umho/cm	LWQA	3/29/2006	Actual	7.5	ft	759
Total Specific conductance	577	umho/cm	LWQA	3/29/2006	Actual	8	ft	800
Total Specific conductance	578	umho/cm	LWQA	3/29/2006	Actual	7	ft	758
Total Specific conductance	581	umho/cm	LWQA	3/29/2006	Actual	3	ft	750
Total Dissolved oxygen (DO)	13.7	mg/l	LWQA	3/29/2006	Actual	5.5	ft	755
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	4	ft	752
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	6	ft	756
Total Nitrogen, ammonia as N	0.016	mg/l	LWQA	3/29/2006	Actual	9	ft	820
Total Nitrogen, ammonia as N	0.02	mg/l	LWQA	3/29/2006	Actual	6	ft	815

Total Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.06	mg/l	LWQA	3/29/2006	Actual	6	ft	815
Total Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.07	mg/l	LWQA	3/29/2006	Actual	3	ft	810
Total pH	8.5		LWQA	3/29/2006	Actual	5	ft	754
Total pH	8.5		LWQA	3/29/2006	Actual	5.5	ft	755
Total Sulfur, sulfate (SO4) as SO4	49	mg/l	LWQA	3/29/2006	Actual	6	ft	815
Temperature, water	6.5	deg C	LWQA	3/29/2006	Actual	8.5	ft	801
Temperature, water	6.5	deg C	LWQA	3/29/2006	Actual	9	ft	802
Temperature, water	7	deg C	LWQA	3/29/2006	Actual	5	ft	754
Total Acid Neutralizing Capacity (ANC)	210	mg/l	LWQA	3/29/2006	Actual	6	ft	815
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	7	ft	758
Total pH	8.5		LWQA	3/29/2006	Actual	3	ft	750
Total pH	8.5		LWQA	3/29/2006	Actual	3.5	ft	751
Total pH	8.5		LWQA	3/29/2006	Actual	8.5	ft	801
Total pH	8.5		LWQA	3/29/2006	Actual	9	ft	802
Total Sodium	14	mg/l	LWQA	3/29/2006	Actual	6	ft	815
Total Specific conductance	577	umho/cm	LWQA	3/29/2006	Actual	8.5	ft	801
Temperature, water	6.5	deg C	LWQA	3/29/2006	Actual	7	ft	758
Total Dissolved oxygen (DO)	13.7	mg/l	LWQA	3/29/2006	Actual	5	ft	754
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	3	ft	750
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	3.5	ft	751
Total Nitrogen, ammonia (NH3)+ organic	0.32	mg/l	LWQA	3/29/2006	Actual	9	ft	820
Total Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1.05	mg/l	LWQA	3/29/2006	Actual	9	ft	820
Total pH	8.5		LWQA	3/29/2006	Actual	8	ft	800
Total Specific conductance	581	umho/cm	LWQA	3/29/2006	Actual	4	ft	752
Secchi disk depth	1.8	m	LWQA	3/29/2006	Actual			810
Temperature, water	7	deg C	LWQA	3/29/2006	Actual	3	ft	750
Total Dissolved oxygen (DO)	13.8	mg/l	LWQA	3/29/2006	Actual	9	ft	802
Total Potassium	1.9	mg/l	LWQA	3/29/2006	Actual	6	ft	815
Total Specific conductance	580	umho/cm	LWQA	3/29/2006	Actual	6	ft	756
Total Specific conductance	581	umho/cm	LWQA	3/29/2006	Actual	5	ft	754

Characteristic	Result Value	Units	Project Name	Sample Date	Value Type	Depth	Depth Units	Sample Time
Total Chlorophyll a (probe)	27	ug/l	GLEC	7/9/2001	Actual	1	ft	
Total Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	.37	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Phosphorus	.029	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Phosphorus	.032	mg/l	GLEC	7/9/2001	Actual	15	ft	
Total Nitrogen, Nitrite (NO2) as NO2	.013	mg/l	GLEC	7/9/2001	Actual	15	ft	
Total Nitrogen, Nitrite (NO2) as NO2	.013	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Nitrogen, Kjeldahl	.53	mg/l	GLEC	7/9/2001	Actual	15	ft	
Total Phosphorus	.024	mg/l	GLEC	7/9/2001	Actual	1	ft	
Total Phosphorus, orthophosphate as P	.008	mg/l	GLEC	7/9/2001	Actual	15	ft	
Total Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	.32	mg/l	GLEC	7/9/2001	Actual	15	ft	
Total Nitrogen, Nitrite (NO2) as NO2	.012	mg/l	GLEC	7/9/2001	Actual	1	ft	
Total Phosphorus, orthophosphate as P	.006	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Total Suspended Solids (TSS)	14	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Nitrogen, ammonia (NH3) as NH3	.103	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	.189	mg/l	GLEC	7/9/2001	Actual	1	ft	
Total Phosphorus, orthophosphate as P	.005	mg/l	GLEC	7/9/2001	Actual	1	ft	
Total Total Suspended Solids (TSS)	20	mg/l	GLEC	7/9/2001	Actual	15	ft	
Total Nitrogen, Kjeldahl	.46	mg/l	GLEC	7/9/2001	Actual	1	ft	

Total Nitrogen, ammonia (NH3) as NH3	.006	mg/l	GLEC	7/9/2001	Actual	1	ft
Total Nitrogen, ammonia (NH3) as NH3	.064	mg/l	GLEC	7/9/2001	Actual	15	ft
Total Nitrogen, Kjeldahl	.53	mg/l	GLEC	7/9/2001	Actual	30	ft
Total Total Suspended Solids (TSS)	6	mg/l	GLEC	7/9/2001	Actual	1	ft

800510 DEQ Sampling Station Information

Description	MAPLE LAKE, SOUTH BASIN
Type	Lake
Depth	0
Latitude	42.21903
Longitude	-85.89505
USGS HUC Code	04050001

DEQ Water Chemistry Sampling Results

Characteristic	Result Value	Units	Project Name	Sample Date	Value Type	Depth	Depth Units	Sample Time
Total Chlorophyll a (probe)	8	ug/l	GLEC	7/9/2001	Actual	1	ft	
Total Nitrogen, ammonia (NH3) as NH3	.035	mg/l	GLEC	7/9/2001	Actual	1	ft	
Total Nitrogen, ammonia (NH3) as NH3	.045	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Nitrogen, Kjeldahl	.32	mg/l	GLEC	7/9/2001	Actual	1	ft	
Total Nitrogen, Kjeldahl	.61	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	.82	mg/l	GLEC	7/9/2001	Actual	1	ft	
Total Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	.93	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Nitrogen, Nitrite (NO2) as NO2	.012	mg/l	GLEC	7/9/2001	Actual	1	ft	
Total Nitrogen, Nitrite (NO2) as NO2	.012	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Phosphorus	.023	mg/l	GLEC	7/9/2001	Actual	1	ft	
Total Phosphorus	.075	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Phosphorus, orthophosphate as P	.007	mg/l	GLEC	7/9/2001	Actual	1	ft	
Total Phosphorus, orthophosphate as P	.009	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Total Suspended Solids (TSS)	17	mg/l	GLEC	7/9/2001	Actual	30	ft	
Total Total Suspended Solids (TSS)	7	mg/l	GLEC	7/9/2001	Actual	1	ft	

Land and Water Management Division

Flood Discharge Request Record 20000053

10/18/2009

Discharge Information

Watercourse: SOUTH BRANCH PAW PAW RIVER
Location: Briggs Mill Dam # 2020
Basin Name: 34A - Paw Paw
County: Van Buren
Township: Paw Paw
Quad Name: Paw Paw
Quad ID: V19NW
Requested By: Village of Paw Paw
Request Type: Dam
File Number: 20000053

Drainage Area: 58.2 mi^2
Contributing Area: 55.9 mi^2
Tn/Rng/Sec: 03S14W/12
Latitude: 42.218333
Longitude: -85.895

Received Date: 2/14/2000
Issued Date: 2/23/2000
Reference Number: D-02020

Discharge Frequencies:

10%: 700 cfs
2%: 1200 cfs
1%: 1600 cfs
0.5%: 1800 cfs
0.2%: 2300 cfs

Volume Frequencies:

1%:
0.5%:

Access to the Flood Flow Database is provided as a service to allow you to check the status of your flood flow requests or to view discharges from previous requests for preliminary design purposes. The discharges values are only valid for the original requestor and for one year after the original request date. To obtain discharge information from the Land and Water Management Division's Hydrologic Studies Unit (HSU), a flood flow discharge request form may be submitted electronically to the HSU. A written or email response to your request will be returned to you and must accompany your permit application.

Department of Environmental Quality

Michigan.gov

Land and Water Management Division

Flood Discharge Request Record 20030520-2

10/18/2009

| Home | Water Management | Lowflows | Discharge Requests | Watersheds Map |

Discharge Information

Watercourse: SOUTH BRANCH PAW PAW RIVER

Location: Briggs Mill Dam

Basin Name: 34A - Paw Paw

County: Van Buren

Township: Paw Paw

Quad Name: Paw Paw

Quad ID: V19NW

Requested By: A R Blystra, Ltd

Request Type: Dam

File Number: 20030520-2

Drainage Area: 58.2 mi^2

Contributing Area: 55.9 mi^2

Tn/Rng/Sec: 03S14W/12

Latitude: 42.218333

Longitude: -85.895

Received Date: 9/3/2003

Issued Date: 9/16/2003

Reference Number: 2020

Discharge Frequencies:

10%: 700 cfs

2%: 1200 cfs

1%: 1600 cfs

0.5%: 1800 cfs

0.2%: 2300 cfs

Volume Frequencies:

1%:

0.5%:

Access to the Flood Flow Database is provided as a service to allow you to check the status of your flood flow requests or to view discharges from previous requests for preliminary design purposes. The discharges values are only valid for the original requestor and for one year after the original request date. To obtain discharge information from the Land and Water Management Division's Hydrologic Studies Unit (HSU), a flood flow discharge request form may be submitted electronically to the HSU. A written or email response to your request will be returned to you and must accompany your permit application.

DEQ Department of Environmental Quality | michigan.gov

Land and Water Management Division

Flood Discharge Request Record D-02020

10/18/2009

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Discharge Information

Watercourse: SOUTH BRANCH PAW PAW RIVER
Location: Briggs Mill Dam # 2020
Basin Name: 34A - Paw Paw
County: Van Buren
Township: Paw Paw
Quad Name: Paw Paw
Quad ID: V19NW
Requested By: PAW PAW VI
Request Type: Dam
File Number: D-02020

Drainage Area: 58.2 mi^2
Contributing Area: 55.9 mi^2
Tn/Rng/Sec: 03S14W/12
Latitude: 42.218333
Longitude: -85.895

Received Date: 2/10/1992
Issued Date: 2/25/1992
Reference Number: D-02020

Discharge Frequencies:

10%: 700 cfs
2%: 1200 cfs
1%: 1600 cfs
0.5%: 1800 cfs
0.2%: 2300 cfs

Volume Frequencies:

1%:
0.5%:

Access to the Flood Flow Database is provided as a service to allow you to check the status of your flood flow requests or to view discharges from previous requests for preliminary design purposes. The discharges values are only valid for the original requestor and for one year after the original request date. To obtain discharge information from the Land and Water Management Division's Hydrologic Studies Unit (HSU), a flood flow discharge request form may be submitted electronically to the HSU. A written or email response to your request will be returned to you and must accompany your permit application.

DEQ Department of Environmental Quality | Michigan.gov

Land and Water Management Division

Flood Discharge Request Record D-02020A

10/18/2009

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Discharge Information

Watercourse:	SOUTH BRANCH PAW PAW RIVER
Location:	Briggs Mill Dam # 2020
Basin Name:	34A - Paw Paw
County:	Van Buren
Township:	Paw Paw
Quad Name:	Paw Paw
Quad ID:	V19NW
Requested By:	PAW PAW VI
Request Type:	Dam
File Number:	D-02020A

Drainage Area:	58.2 mi^2
Contributing Area:	55.9 mi^2
Tn/Rng/Sec:	03S14W/12
Latitude:	42.218333
Longitude:	-85.895
Received Date:	2/6/1996
Issued Date:	3/18/1996
Reference Number:	D-02020

Discharge Frequencies:

10%:	700 cfs
2%:	1235 cfs
1%:	1560 cfs
0.5%:	1840 cfs
0.2%:	2300 cfs

Volume Frequencies:

1%:	
0.5%:	

Access to the Flood Flow Database is provided as a service to allow you to check the status of your flood flow requests or to view discharges from previous requests for preliminary design purposes. The discharges values are only valid for the original requestor and for one year after the original request date. To obtain discharge information from the Land and Water Management Division's Hydrologic Studies Unit (HSU), a flood flow discharge request form may be submitted electronically to the HSU. A written or email response to your request will be returned to you and must accompany your permit application.

Fish Stocking Database

County	Water Site (Town Range Section)	Species *Strain*	Date	Number	Avg. Length (in.)	Operation	Fin Clips, Marks, Tags
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Largemouth bass	5/1/1991	309	6.6	Transplant of Wild Fish	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye	4/25/1980	160,000	0.68	State Plant	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye	8/3/1980	85	0	State Plant	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye	4/13/1984	407	4.16	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye	6/15/1986	4,076	1.92	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye	4/12/1987	75	21.92	State Plant	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye	6/24/1988	3,502	1.52	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye	6/15/1991	8,943	2.04	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Bay De Noc*	7/18/1983	1,750	0	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	11/2/1982	2,000	0	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/17/1985	3,550	0	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/21/1987	3,552	1.92	Transplant of Wild Fish	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/19/1989	3,555	1.72	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/19/1990	9,306	1.4	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/21/1990	4,352	1.68	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/8/1992	10,806	1.92	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE	Walleye *Muskegon*	6/8/1994	4,296	1.72	Marsh & Rearing Pond	none

	(03S 14W 12)					Release	
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/9/1994	4,950	1.72	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/8/1995	8,655	1.52	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/10/1996	303	1.32	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/12/1996	355	1.52	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/14/1996	8,931	1.6	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/11/1997	8,816	1.24	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/5/1998	15,476	0.48	State Plant	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	5/28/1999	17,265	1.08	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	5/31/2001	10,111	1	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/1/2001	8,647	1	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/3/2003 2:00:00 PM	9,966	0.92	Marsh & Rearing Pond Release	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	6/7/2005 12:00:00 PM	13,365	1.148	Marsh & Rearing Pond Release	oxytetracycline
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *Muskegon*	11/1/2006 8:00:00 PM	172	16.544	State Plant	none
Van Buren	Maple Lake MAPLE LAKE (03S 14W 12)	Walleye *New York*	4/15/1981	160,000	0.32	State Plant	none

New Search

Michigan Department of Natural Resources
Status of the Fishery Resource Report 2000-10, 2000.

MAPLE LAKE

Van Buren County (T3S, R14W, Sec. 1, 12) and (T3S, R13W, Section 6)

Surveyed September 1995

James L. Dexter, Jr.

Environment

Maple Lake is a small reservoir on the South Branch of the Paw Paw River. Located in east central Van Buren County, it is found in the Village of Paw Paw.

The South Branch of the Paw Paw River upstream of the lake drains over 60,000 acres (94 square miles). Rolling hills and sandy soils characterize the geography of the area. The soils of the immediate lake area are primarily loamy sands, which are very well drained. The basin of the South Branch is characterized by Adrian and Houghton muck soils. Most of the watershed is agricultural (54%); of less importance are forested land (20%), urban land (11%), open field (9%), water bodies (4%), and wetland (2%). The East Branch of the Paw Paw River is another tributary, entering the South Branch just prior to entering Maple Lake. Both branches are designated trout streams. Ackley Lake (62 acres) is connected to Maple Lake via a 10-foot arch culvert under M-40 located at the northeast corner of Maple Lake. The outlet for Maple Lake is blocked by a retired hydropower dam 27-feet high (17-foot head), originally constructed in 1907 on the north side of the lake. It is owned by the Village of Paw Paw.

Maple Lake is 172 acres in size and has a maximum depth of about 15 feet (Figure 1). Depths can vary over time because the flow-through system acts as a sediment basin. The deepest areas are associated with the old river channel. *Chara* is common in the lake, and little if any emergent vegetation is present. Floating vegetation is sparse. Submergent vegetation (milfoil and coontail) is quite thick in most areas.

Bottom substrates are made up of primarily sand and organic material. The south end of the lake contains a thick organic bottom that is mostly deposition from the inlet. It is sufficiently deep to allow some boat traffic in the very south end. That area is currently being hydraulically dredged.

Water quality parameters were measured August 29, 1995. Secchi disc readings were 6.0 feet. Dissolved oxygen levels were greater than 3 ppm from the surface to 12 feet, the deepest spot found. Alkalinity ranged from 158 ppm at the surface to 178 ppm at the bottom, while pH was 8.8-9.0. These parameters indicate the water is hard and well buffered, and have not changed since the 1991 survey (Dexter 1993). Temperature varied from 78^{o}F at the surface to 68^{o}F at the bottom. The lake does not stratify because of the flow-through system and shallow depth. The water retention time of the lake is very short, about 7 days (Southwest Regional Planning Commission 1978).

Overall water quality in Maple Lake is rated as fair to poor. While there have been no problems with fish kills, the environment of the lake is far from good. Phosphorus loading of the lake has been estimated at 11,900 pounds annually. This is an excessive amount, but detrimental effects are reduced by the very short retention time of the impoundment. In addition to the heavy nutrient loading, the physical characteristics of the lake (many channels, bays, peninsulas, and shallow depths) make it highly susceptible to eutrophication.

Residential development around Maple Lake is almost total. It sits in the middle of an urban area and has practically no undeveloped shoreline left. A cement boat launch (township-owned) is located on the north shore off M-40 and can handle 20-30 vehicles and trailers. Shore-fishing access (and parking) is available at the dam and at Maple Isle (a small city-owned island with pedestrian bridge access, beach house, and picnic facilities). The Village has also installed a shore fishing access with piers at the south end of the lake off of Red Arrow Highway.

Fishery Resource

According to historical records, Maple Lake has been actively managed by the State since at least 1934. Between 1934 and 1945, combinations of bluegill, largemouth bass, yellow perch, and black crappie were stocked. No additional stocking occurred until 1954 when walleye fingerlings were introduced. Between 1954 and 1956 about 21,200 walleye fingerlings were stocked. Walleyes were not stocked between 1957 and 1979, but stocking was re-initiated in 1980 on an annual basis (Appendix 1). Stocking rates in the 1980s were about 20/acre. Stocking rates were increased to 50/acre, minimum, starting in 1990 to meet statewide walleye stocking guidelines.

On December 8, 1937 the dam and hydroelectric plant at the north end of the lake washed out, draining both Maple and Ackley lakes. This allowed access to the lake by carp and they gained a strong presence. In 1945 the first documented angler complaint on Maple Lake was received. Anglers complained of poor fishing for everything except carp. An abundance of carp continued to plague the lake through the 1960s.

The first fishery investigations on Maple Lake occurred in 1955 and 1956. Gill net surveys were conducted to evaluate the success of walleye introduction. Gamefish captured included bluegill, largemouth bass, black crappie, yellow perch, and walleye. Unexpectedly, nine net lifts took only one carp. All gamefish were growing at or above state average growth rates.

A follow-up survey in 1962 did show a large number of carp (43% of the total weight collected). All gamefish were, however, still exhibiting average to good growth rates. Though the gamefish population (which included holdover walleye) appeared to be in good shape, the extreme abundance of carp led to a management proposal to eradicate the fishery and start anew. A public hearing was held regarding the proposal, and it was soundly defeated by a lack of public support.

In the spring of 1972, the Village of Paw Paw drew the lake down for maintenance of the dam and to allow riparians to clean their beaches. The Village tried to set up a schedule of fall drawdown every 3 years to provide for dam and shore maintenance. Apparently this never occurred, for the hydroelectric plant at the dam was retired in the mid-1970s, and no further references were made regarding drawdown until 1979.

An electroshocking survey was conducted in 1974 to evaluate the status of the fishery. At that time the gamefish population was still in good shape, but there were many carp and white suckers.

In 1980, concern mounted over the poor spring fishery. The cause of the poor fishing may have been the fall 1979 drawdown for dam repairs that left levels low throughout the winter. Since walleye had grown and survived well in the lake from stocking in the 1950s, it was recommended to restock walleye. It was thought that under the circumstances of prolonged drawdown (and loss of fish over the dam) that walleye would have a good chance to succeed. A 1984 electroshocking survey, targeting only walleye, evaluated the success of walleye stocked in 1980-1984. Only three walleye were collected. Hundreds of white suckers and "lots" of carp were observed in that survey.

As early as 1990 the Maple Lake Association began a campaign to convince riparian owners that it was time to dredge out the lake. The Lake Association took the lead and over a several-year period obtained required permits, procured funding, and purchased a hydraulic dredge. Portions of the south end of Maple Lake are currently (2000) being dredged to remove sediment that is being transported into the lake by the South Branch of the Paw Paw River. This is an ongoing project, which started in 1997 and continues each year as money becomes available.

In 1993 the Village drew Maple Lake down for 2 months to build docks at the south end of the lake and remove sediments with a bulldozer. Concern about the effects of the drawdown on the fishery prompted the most fish recent survey, on September 18-20, 1995. This was the same week the 1991 survey had been conducted.

The most recent survey used four standard trap nets (6'x3'x 1.5"), four experimental gill nets (125 feet long), and 2.6 hours of nighttime boomshocking (250-V DC). Only 0.60 hours of the boomshocking were used for the general survey, while the remaining 2.0 hours were used strictly for conducting a SERNS walleye index (Serns 1982).

The fish community of Maple Lake appeared little different from that of almost 50 years ago. It is interesting to note that with the exact same effort as the 1991 survey, the 1995 survey collected more of practically every species except walleye. Catches of bluegill, perch, and crappie were double.

Bluegill were most numerous fish in the catch by number and weight (Table 1). Over 2,500 bluegills were sampled. Their length ranged from 1.4 to 8.5 inches. Forty percent of the bluegill catch was considered to be acceptable size (>6 inches). Schneider (1990) developed five criteria for ranking bluegill populations from survey catches in Michigan. Using trap net catch and growth rates from this survey, this bluegill population ranked 4.6 (good) on a scale of 1 (poor) to 7 (excellent). This is a decline in population size structure compared to 1991 when bluegill ranked a 6, which at that time was one of the highest rankings recorded for southwest Michigan. Growth rates were similar to 1991, again above state average rates (Table 2). Age frequency analysis (Table 3) shows that the 1992 year class was practically missing (as was true at most area lakes), apparently due to the very cool year resulting from the Mt. Pinatubo eruption in the Philippines.

Black crappie were collected from 1.0 to 10.6 inches in length. A total of 330 were captured using all gear (Table 1). Thirty-three percent were of acceptable size. Black crappie were growing at the State average (Table 2), which was down slightly from the 1991 growth pattern. The 1993-year class was poor (Table 3). Crappie populations in turbid reservoirs often have weak year classes. Mt. Pinatubo appeared to have no effect on crappie recruitment in 1992.

A total of 271 largemouth bass were sampled (Table 1). Largemouth were growing at the State average rate (Table 2), but significantly slower than in 1991. No legal size (>14") bass were collected. Recruitment levels appeared to be poor for the 1992 and 1993 year classes, again, not an uncommon occurrence for this type of waterbody. The lack of bigger bass may also have been caused by some fish going over the dam during the drawdown.

Over 250 yellow perch were collected that ranged in length from 1 to 11 inches. Acceptable size yellow perch accounted for 44 % of the catch. The growth rate of yellow perch also had declined compared to 1991, going from well above average (+1.2 inches) to just above average (+0.7 inches).

Recruitment appeared variable with a very strong 1991year class.

Fifty-three walleye were collected that ranged from 6 to 21 inches. Twenty-eight percent were legal size. Growth rates for walleye were well above the state average, but still had declined somewhat compared to 1991. Age groups 0, 1, 3, and 4 were present. No walleye were stocked in 1993 (age group 2, Appendix 1) due to the drawdown.

Additional electroshocking was done to estimate the abundance of young-of-year walleye. A total of 17 young-of-year walleye were collected per mile of shoreline electrofished. Based on the SERNS index methodology, this equates to 1.17 young-of-year walleye per surface acre. Age-1 walleye were estimated at 0.28 per surface acre. These results are low compared to most previous SERNS indexing at Maple Lake (Appendix 2).

Management Direction

Maple Lake should continue to be stocked with spring fingerling walleyes at the rate of 50 – 100 per acre. Over the past 20 years the lake has received annual stockings. Stocking should occur annually, and if time permits fall SERNS indexing should be continued. Past experience on this lake and others seem to indicate that if two "good" year classes in a row are found, that it is not necessary to stock the third year. In many instances walleye fisheries are carried by one or two strong year classes.

The remainder of the gamefish population is in excellent shape at this time. Fishing in Maple Lake is as good as can be expected of any lake in the District. However, there are some recruitment problems that may effect fishing in the future. Gamefish populations in Maple Lake exhibit wide fluctuations in recruitment rates. Fluctuations in yearly recruitment levels are to be expected because this is a turbid reservoir with frequently changing environmental conditions (Bennett 1962).

It should be noted that there was a lot of apprehension regarding the extended drawdown and its potential effects on the fishery. The results of this survey indicate that numbers of fish were not strongly affected. Based on these results, and positive results at another local impoundment (Pine Creek Impoundment, Allegan County), extended drawdown of small impoundments should not cause undue concern regarding fish populations. Breeding populations remain and can re-populate impoundments in a couple of years.

The goal of management should be to at least maintain, if not improve, the fishery. This should be possible because of the good growth of fish and the continued high nutrient loading of Maple Lake. The major goals presented in the Management Plan for Maple Lake (Dexter 1993) have been accomplished. It is not necessary for an additional plan at this time.

Twenty-five years from now Maple Lake may be significantly changed. The lake may be deeper, have less organic sediment, and probably will have improved water quality. Since Maple Lake is located in a fairly densely populated area, it will continue to receive significant use by the public and will require our attention to monitor the fishery.

Report completed: May 19, 2000.

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Serns, S.L. 1982. Relationship of walleye fingerling density and electrofishing catch per effort in northern Wisconsin lakes. North American Journal of Fisheries Management 2:38-44.

Southwest Regional Planning Commission. 1978. Water quality document. St. Joseph, Michigan.

Table 1.-Number, weight, and length (inches) of fish collected from Maple Lake with trap nets, gill nets, and DC boomshocker, September 18-20, 1995.

Species	Number	Percent by number	Weight (Pounds)	Percent by weight	Length range (inches)[1]	Average length	Percent legal size[2]
Bluegill	2574	53.7	169.8	30.2	1-8	4.8	40 (6")
Pumpkinseed	116	2.4	15.3	2.7	2-7	5.2	25 (6")
Black crappie	330	6.9	83.6	14.9	1-10	7.0	53 (7")
Green sunfish	2	0.0	0.2	0.0	3-6	5.0	50 (6")
Rock bass	1	0.0	0.5	0.1	8-8	8.5	100 (6")
Warmouth	11	0.2	2.7	0.5	4-8	6.6	73 (6")
Largemouth bass	271	5.6	54.7	2.7	2-13	6.4	0 (14")
Walleye	53	1.1	42.6	7.6	6-21	12.2	15 (15")
Yellow perch	254	5.3	40.1	7.1	1-11	6.2	48 (7")
Bullhead species	73	1.5	0.0	0.0	7-13	11.1	...
White sucker	86	1.8	144.2	25.6	10-20	15.9	...
Common carp	1	0.0	6.8	1.2	24-24	24.5	...
Bluntnose minnow	1,000	20.8	0.0	0.0	...	...	...
Golden shiner	25	0.5	2.3	0.4	3-8	6.5	---
Total	4,797	100.0	563.0	100.0			

[1] Note some fish were measured to 0.1 inch, others to inch group: e.g., "5"=5.0 to 5.9 inch; "12"=12.0 to 12.9 inches: etc.

[2] Percent legal size or acceptable size for angling. Legal size or acceptable size for angling is given in parentheses.

Table 2.-Average total weighted length (inches) at age, and growth relative to the State average, for fish sampled from Maple Lake with trap nets, gill nets, and DC boomshocker, September 18-20, 1995. Number of fish aged is given in parentheses.

Species	Age 0	1	2	3	4	5	6	7	8	Mean growth index[1]
Black crappie	2.3 (7)	5.5 (37)	7.7 (1)	8.4 (7)	9.1 (18)					-0.1
Bluegill	1.9 (14)	4.2 (25)	6.1 (13)	6.9 (1)	7.8 (21)	6.9 (1)				+0.8
Largemouth bass	4.0 (32)	7.8 (35)	8.8 (7)	11.3 (4)	12.8 (16)					+0.1
Walleye	7.3 (18)	13.3 (26)	...	17.3 (3)	20.2 (5)					+2.2
Yellow perch	2.9 (19)	6.4 (7)	7.2 (2)	7.8 (6)	9.0 (34)	...	...	10.0 (1)	9.3 (1)	+0.7

1 Mean growth index is the average deviation from the state average length at age.

Table 3.-Estimated age frequency (percent) of fish caught from Maple Lake with trap nets, gill nets, and DC boomshocker, September 18-20, 1995.

Species	Age 0	1	2	3	4	5	6	7	8	Number aged
Black crappie	10	53	1	10	26					70
Bluegill	19	33	17	1	28	1				75
Largemouth bass	34	37	7	4	17					94
Walleye	35	50		6	10					52
Yellow perch	27	10	3	9	49			1	1	70

Appendix 1.-Walleye stocking history of Maple Lake, Van Buren County.

Year	Number	Age/size
1954	5,000	Spring fingerlings
1955	14,000	Spring fingerlings

1956	2,200	Spring fingerlings
1980	85	
1980	160,000	Fry
1981	160,000	Fry
1982	2,000	Spring fingerlings
1983	1,750	Spring fingerlings
1984	407	Adults
1985	3,550	Spring fingerlings
1986	4,076	Spring fingerlings
1987	3,552	Spring fingerlings
1988	3,502	Spring fingerlings
1989	3,555	Spring fingerlings
1990	13,658	Spring fingerlings
1991	8,943	Spring fingerlings
1992	10,806	Spring fingerlings
1993	0	Spring fingerlings
1994	9,246	Spring fingerlings
1995	8,655	Spring fingerlings
1996	9,589	Spring fingerlings
1997	8,816	Spring fingerlings
1998	15,476	Spring fingerlings
1999	17,265	Spring fingerlings

Appendix 2.-History of SERNS index results from Maple Lake.

Year	Estimated population of walleye per acre Young of year	Age 1
1989	0	0
1990	5.5	0.1
1991	9.0	2.1
1992	0.7	0
1994	6.3	0.3
1995	1.2	0.3

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Back to List by Waterbody

Web Author: *Tina M. Tincher, Librarian*

Questions, comments and suggestions are always welcome! Send them to tinchert@michigan.gov

Michigan Department of Natural Resources
Status of the Fishery Resource Report 2000-4, 2000.

EAST BRANCH PAW PAW RIVER

Kalamazoo County (T3S, R12W, Section 31)
Van Buren County (T3S, R13W, Sections 17, 18, 20-22, 25-27, 36 and T3S, R14W, Section 13)

Surveyed August 14-16, 1995

James L. Dexter, Jr.

Environment

The East Branch of the Paw Paw River is one of many larger tributaries to the main stream of the Paw Paw River. A second-order designated trout stream with a water quality designation of top-quality cold, the East Branch flows in a westerly direction until it flows into Maple Lake in the Village of Paw Paw.

Most of the East Branch flows through nearly level, very poorly drained soils which have moderate water capacity and slow surface runoff. These soils fall into the categories of either Houghton muck or Glendora sandy loam. The surrounding area of the stream is mostly small wooded lots, fallow farmland, and new residential home sites. Land around the East Branch is becoming very popular for new homes.

Estimated to be 8.4 miles long, the East Branch has two main sources: Little Paw Paw Lake in Kalamazoo County and Mattawan Creek in the Village of Mattawan. This small creek starts in a swampy area just to the southeast of the Village. Both the creek and the East Branch pick up considerable amounts of ground water. Total fall for both of the streams is about 150 feet from the sources to the confluence at Maple Lake.

The East Branch ranges from 11 to 24 feet wide, averages 16.8 feet wide, and has an average depth of 1.3 feet. Discharge measurements made during various seasons in the 1960s showed that flows ranged from 2-8 cfs in the upper reaches to 15-30 cfs in the lower reaches before entering Maple Lake. Habitat is good, with overhanging brush, undercut banks, pools, riffles, and logs all being common throughout many sectors of the river. Gravel and rock occur throughout the river bottom, but average 36% and 5% of the available substrate, respectively. Sand predominates (47%), silt accounts for 10% of the substrate, and some traces of clay occur in the lower reaches. Comparing these estimates of bottom substrate composition to those estimated in a 1967 survey, it appears that up to ½ of the gravel substrate has been buried by an increase in sand bed load. No large sources of sand input are known to exist.

No land is owned by the State along the banks of the East Branch. Some bridge locations where access is possible are posted "No trespassing" but landowners allow access to anglers upon request. Two small dams exist in the middle reaches of the East Branch and there is another dam at the lower end. Development in the watershed is mostly limited to residential home sites, and these are not excessive at this time.

Fishery Resource

The East Branch has been managed for trout since at least 1934 when brook trout were stocked. No trout stocking took place in 1965-1968 and 1970. For most years between 1939 and 1965, combinations of brook, brown, and rainbow trout were stocked. Since 1971, only brown trout have been stocked.

Anglers have been attracted to the East Branch for decades. Records from the 1950s indicate intense pressure. Trout as large as 20 inches have been captured during surveys, and anglers have reported brown trout as large as 27.5 inches (7 pounds, in 1985). Carryover of stocked trout has always been good, and natural reproduction has been evident since surveys began.

During a 1990 survey (Dexter 1991), brown trout were found at four of six lower locations on the East Branch. Seventy-nine percent of these trout were 8 inches or longer. They were judged to be mostly wild fish based on size (young-of-the-year at 2 to 3 inches) and fin characteristics. Hatchery browns are easily distinguished by eroded fins or regenerated crooked fins. Growth was very good, with age groups 1-3 growing well above the State average rate for this species.

No trout were found at the upper two stations that are strongly influenced by Little Paw Paw Lake. Water temperatures at these two sites are most likely too warm to support trout. A temperature survey needs to be conducted to verify that.

When comparing the results of the 1990 survey on the East Branch with past surveys (1962, 1966 and 1975), a very interesting history was revealed (Dexter 1991). Relative abundance of brown trout declined after each sampling period. Catch per hour of electrofishing was highest in 1962 (59.5), followed by 1966 (29.5) and 1975 (19.5), and was lowest in 1990 (13.7). What is interesting here is that no brown trout were stocked from 1958 through 1967, so the high numbers of brown trout collected in 1962 and 1966 all originated from natural reproduction. Legal-size browns were stocked at an average rate of 1,150 per year between 1947 and 1957. These were stocked in conjunction with an average of 2,300 legal-size brook trout and 800 legal-size rainbow trout. Surveys during the 1960s took only one 6-inch brook trout, no rainbow trout, and many brown trout. This may have been indicative of poor survival of brooks and rainbows in this environment.

Bachman (1982) found that when hatchery trout were stocked into a wild population, many agonistic encounters took place between the two. Most often, larger hatchery trout chased smaller wild trout out of their territories. When these hatchery trout encountered larger wild trout, they would not chase the wild trout out, but they did cause severe stress to the wild fish.

Based on this information, it seemed possible that the stocking schedule of the 1970s, 1980s and 1990s was reducing the potential to create a better wild trout fishery. A management plan was adopted to stop all stocking of trout for a 4-year period, 1992 - 1995 (Dexter 1991). The objective was to determine if the trout population could be maintained by natural reproduction. Results were to be evaluated by a spot check in 1993 and a population estimate in 1995.

The survey in 1993 was conducted at the three lowermost stations. The catch per hour of brown trout was 16.0, a 15% increase compared to the 1990 survey. Brown trout were collected from 3 to 18 inches in length, but the average size of trout collected was large, indicative of low recruitment. At the same time anglers were complaining about the lack of small trout (file data). In 1995, we surveyed six sites (repeat of 1990 effort), and conducted population estimates of trout at two sites.

The fish community found in 1995 was virtually unchanged from that of 35 years ago (Table 1). It is strikingly familiar to the 1990 survey. Brown trout remain the primary game fish. One brook trout was collected. A few warmwater species were present, but not in significant numbers.

However, trout caught per hour of electrofishing was down to 8.8, a 36% decrease from 1990 (the catch-per-hour computation is only based on stations where trout were caught). Mark and recapture population estimates (Bailey method) were conducted at 28th and 30th Avenues, the only sites that had enough trout. For this section of river, brown trout were present at an average of 22 pounds/acre, but only 38 fish per acre. The majority of the biomass was larger trout. Brown trout age groups 0-4 were identified. Growth rates were well above State average at +1.9 inches (Table 2). Age-frequency analysis appeared normal based on the small sample (Table 3).

Management Direction

Data collected from the 1995 survey showed that the East Branch of the Paw Paw River can sustain a wild fishery, but not at the level that anglers have come to expect. Just 2 years after stocking ceased anglers began noticing the lack of small fish, but not of larger fish. Given that four of the six sites have suitable habitat and water quality for trout survival, and we found most trout at only two stations, it would appear that limited successful natural reproduction produces an average for the entire river of about 10 pounds per acre of brown trout. This is very low for a productive stream in this area of the state.

Stocking efforts previous to 1992 were at levels approaching 200 spring yearlings per acre. Strain availability from the hatcheries was inconsistent. Our management direction in 1996 was directed at lowering stocking rates to supplemental levels (100 per acre), and obtaining consistent strains for stocking. Seeforellen strain brown trout have been used since 1996 and should be used through the year 2000. After that another new strain should be available if a change is needed. The Gilchrist Creek strain will be coming into full production and should be available about 2001. It is very wild in character compared to the somewhat domesticated and lucustrine (i.e., lake-preferring) Seeforellen.

Our management goal into the next century should be to maintain and improve upon the existing fishery. We have received several comments since 1996 regarding the excellent fishing since low level stocking was started. Anglers appear very satisfied. However, a better management strategy would be to eliminate the need for stocking by enhancing reproduction. This stream used to produce more wild trout. Further investigation regarding sand bedload could be beneficial, but due to low staffing levels the cost of investigation would exceed the cost of continued low-level stocking.

Report completed May 15, 2000.

References

Dexter, J.L. Jr. 1991. East Branch of the Paw Paw River (and Mattawan Creek). Michigan Department of Natural Resources Status of the Fishery Resource Report 91-16, Ann Arbor.

Table 1.-Species, relative abundance, and length of fish collected by stream electrofishing at six sites on the East Branch of the Paw Paw River, August 14 and 16, 1995.

Species	Number	Percent by number	Weight (pounds)	Percent by weight	Length range (inches)	Percent legal size

Blacknose dace	25	3.4	0.3	0.9	1-3	100
Bluegill	2	0.3	0.0	0.1	2-3	0
Bluntnose minnow	6	0.8	0.1	0.3	2-3	100
Brook trout	1	0.1	0.2	0.5	7-7	0
Brown trout	20	2.7	11.1	36.1	2-19	46
Bullhead catfishes (family)	2	0.3	0.0	0.0	6-8	100
Central mudminnow	11	1.5	0.1	0.3	1-4	100
Common shiner	66	9.1	1.5	4.9	2-6	100
Creek chub	177	24.3	3.6	11.6	1-7	100
Green sunfish	21	2.9	1.1	3.4	2-5	0
Horneyhead chub	77	10.6	1.7	5.5	1-5	100
Johnny darter	14	1.9	0.0	0.1	1-2	100
Lamphreys (Family)	1	0.1	0.0	0.0	5-5	100
Largemouth bass	5	0.7	0.1	0.4	1-5	0
Mottled sculpin	219	30.1	1.8	5.8	1-3	100
Northern brook lamprey	1	0.1	0.0	0.0	4-4	100
Northern hog sucker	2	0.3	0.2	0.8	3-8	100
Rainbow darter	21	2.9	0.1	0.4	1-2	100
Rock bass	4	0.5	0.3	0.9	2-6	17
White sucker	52	7.1	8.5	27.7	1-15	100
Yellow perch	1	0.1	0.0	0.1	4-4	0
Total	728					

Table 2.-Average length (inches) by age group of brown trout from the East Branch of the Paw Paw River. The number aged is in parenthesis. More trout were aged than appear in Table 1 because unmarked brown trout from recapture runs were included in the age analysis.

Species	Age 0	1	2	3	4	Mean growth index
Brown trout	4.2 (10)	8.4 (6)	11.7 (8)	14.1 (4)	19.5 (1)	1.9

Table 3.-Estimated age frequency (percent) of brown trout from the East Branch of the Paw Paw River, August 1995.

Species	Age 0	1	2	3	4	Number aged

Brown trout	34	21	28	14	3	29

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Questions, comments and suggestions are always welcome! Send them to tinchert@michigan.gov