LAKE COUNTY, ILLINOIS

2014 SUMMARY REPORT LAKE MARIE

PREPARED BY THE

LAKE COUNTY HEALTH DEPARTMENT

Population Health-Ecological Services

Figure 1. Egret sitting on dead wood, Lake Marie, 2014

Lake Marie is one of the 12 glacial lakes sampled in the Fox Chain 'O' Lakes during 2014 by the LCHD-ES. Its maximum depth is 30 feet and it has a surface area of 595.82 acres. The lake elevation is influenced by the McHenry Dam which was built in 1939, therefore manipulations to the dam can affect the water depths in the lake. From June—September water levels were measured at a location on Lake Marie to track changes in water levels during the season, the lake experienced a decrease in water level during the monitoring season of 8.40 inches. Lake Marie is hydrologicaly connected to Channel and Catherine lakes to the north by a channel constructed between Marie and Channel in the early 1900's. Using data supplied by Southeastern Wisconsin Regional Planning Commission and Lake County Mapping Services, the watershed of Lake Marie was estimated at 23,084.95 acres, and encompassed the sub-watersheds of Trevor Creek and Sequiot Creek. The dominant land uses found in the watershed were agriculture, single family and water. However, the greatest percent runoff was generated from single family and transportation.

The lake is used for recreational boating, fishing and aesthetics. Lake Marie is well known by anglers and Barnacle Bob's and Sandbar are two public boat launches on

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SUMMARY (CONTINUED)

Lake Facts:

Major Watershed: Fox River

Sub-Watershed: Trevor and Sequoit Creek

Location: T43N, R9E, Section 11

Surface Area: 595.82 acres

Shoreline Length: 16.01 miles

Maximum Depth: 30.00 ft.

Average Depth: 16.7 ft.

Lake Volume: 5064.87 acre-ft

Watershed Area: 23,084.95 acres (WI and IL)

Lake Type: Glacial

Management Entity:

Fox Waterway Agency

State of Illinois

Homeowners Associations (various)

Current Uses: fishing, swimming, boating, aesthetics

Access: Barnacle Bob's and The Sandbar, private launches and additional public launches on other lakes of Fox Chain 'O' Lakes.

private property that provide access to the public within its shoreline, an additional two public launches are within property owned by the state at Chain 'O' Lakes and and Oak Point. Fishing by shoreline on Lake Marie is limited as nearly the entire shoreline of Lake Marie is under private ownership, therefore, fishermen usually access the lake from public launches on the Fox Chain 'O' Lakes.

In 2014, the LCHD-ES sampled the lakes for the water quality parameters discussed in this report. Once a month water chemistry samples were collected at the deep hole of the lake at 3 feet from the surface (epilimnion) and lake bottom (hypolimnion) by use of a Van Dorn sampler. A multi-parameter sonde was used to collect depth profile data. Additionally, a Secchi disc was lowered into the water column to measure the water clarity of the lake. Other environmental data was recorded including air temperature, water elevation and notes of wildlife in the area.

A vegetation survey was conducted utilizing a randomized grid generated by ARCGIS to determine points to sample within the lake footprint. Rake density was used to estimate the cover of vegetation on the lake bottom. The vegetation was estimated by scoring the amount of vegetation collected by a rake tossed at each grid point sampled. The data collected was entered into ARCGIS10 and vegetation maps and invasive species maps were created to indicate the location and density of vegetation within the lake.

The overall water quality of the Lake Marie is fair. The average water clarity as determined through the Secchi depth of 1.9 feet. This is below the median Secchi depth of 2.95 feet for lakes in the county whose water clarity has been monitored since 2000. Lake Marie ranked 131 for average Secchi depths of 158 lakes in the county kept since 2000. Like many of the lakes in our county, it is impaired for phosphorus based upon the Illinois Environmental Protection Agency's (IEPA) phosphorus standard for general use of $\geq$ 0.05 mg/L TP for lakes with surface area greater than 20 acres. It only takes one exceedance of the standard per season to be considered impaired. The average TP concentration in the epilimnion was 0.068 mg/L. This is well below the 2014 median TP concentration for all Fox Chain 'O' Lakes of 0.126 mg/L and is equivalent to the 2014 county median TP concentration. Marie ranked 116 out of 173 lakes in the county sampled for TP since 2000.

An analysis of vegetation was conducted using a modified Braun-Blanquet scale to determine species cover, frequency and relative importance. Relative importance is determined by summing the relative cover and relative frequency. The total average cover of vegetation in 2014 was 27.84%. This was about average for the Fox Chain 'O'Lakes this year. Dominant species were also determined by ranking the relative importance of the species, with the top 50% of the relative importance being considered dominant. There were four dominant species in Lake Marie in 2014, they were Coontail, Common Duckweed, Eurasian Watermilfoil, and White Water Lily. A map indicating the location and cover of Eurasian Watermilfoil was created. This map is designed to assist in locating areas where aquatic plant management is needed. The map as well as the morphometric table can be used by those charged with making decisions on aquatic plant management data to construct a detailed request for proposal (quote) for pesticide management.

SUMMARY (CONTINUED)

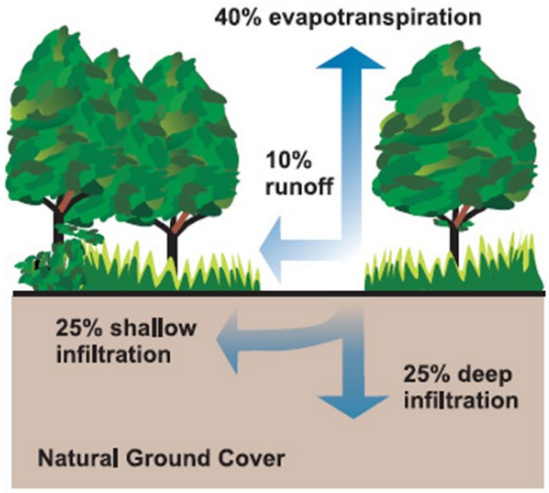
Fifteen species were recognized in Lake Marie during 2014. A floristic quality assessment was conducted on the vegetation resulting in a FQI score of 25.24. Floristic quality assessments are usually conducted on terrestrial systems, however they are useful for determining natural areas, site comparisons, and long term monitoring of natural areas and restoration projects. Lake Marie ranked Channel Lake ranked 22nd from 170 lakes in the county scored for FQI and was above the median score of 15.2.

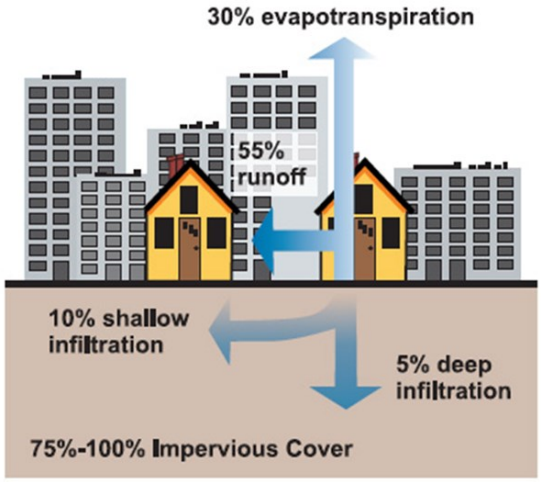
WATERSHED

A general definition of a watershed is an area of land defined by two or more high ridges. Watersheds however are usually much more complex than that and can extend across political boundaries. Most watersheds have had engineering of drainage areas to remove stormwater from the landscape which can make boundaries hard to decifer at times, other times you need cooperation from other agencies to get the entire dataset for the watershed. As a watershed is developed, the amount of impervious surface increases resulting in a greater influx of runoff entering our waters due to reduced infiltration of rainwater into the ground.

Lake Marie has an expansive watershed encompassing Trevor Creek and Sequiot Creek sub-watersheds which total approximately 23,084.95 acres (SEWRPC and Lake County Mapping Division). According to land use data, the watershed is dominated by Agriculture (25.5%), Water (14.2%) and Wetlands (12.2%). However, it is estimated that greatest percent of total runoff comes from Single Family and Transportation at representing 35.5% and 23.1% respectively (Appendix A, Table 1). It is recommended that the agencies and homeowners associations within the entire watershed work together to educate homeowners and municipalities of the important role that they play in the health of Lake Marie. They should promote management practices in the watershed that reduce nutrients both within residential and agricultural communities. The should also promote proper use of deicing materials by winter road maintenance crews during winter months. These practices can go along way in alleviating phosphorus pollution and maintain or reduce the chloride concentrations found in Lake Marie.

Within the Sequoit Creek watershed is a wastewater treatment facility, it appears to be taking measures to reduce it's nutrient load (phosphorus) into Sequiot Creek. This is important as Lake Marie is considered impaired for phosphorus by IEPA standards.





Water Clarity

Water clarity is important in a lake as it allows light to penetrate into the water column. This light is used by the primary producers (plants and phytoplankton) in the water. Water clarity is measured by lowering a Secchi disk into the water until it can no longer be seen by the naked eye. The resulting depth is recorded.

The average Secchi depth of in Lake Marie during 2014 was 1.9 feet. This is well below the county median of 2.95 feet for lakes measured between 2000 and 2014 for water clarity (Appendix A, Table 2). Although most of the lakes in the Fox Chain 'O' Lakes experienced decreased water clarity none suffered as much as that of Channel and Catherine Lakes (Figure 2).

The average water clarity in Lake Marie decreased 15.56% since 2002 when the average Secchi depth was 2.25 feet.

TSS and Secchi depth are inversely correlated. When TSS increases Secchi depth decreases. Many factors can influence TSS, wet vs. dry years, aquatic plant management, algal blooms, sediments, carp, recreational boating and dredging.

Precipitation events can also cause impaired water clarity. According to the Long Lake rain gauge (Lake County Stormwater Commission), two weeks prior to our June 2014 sampling event accumulatively only 1.01 inches of rain that fell in the region. May precipitation measurements at the station accumulated to a total of 3.77 inches of rainfall, which is comparable to the average May precipitation measurement of 3.21 inches. However, if there are areas in the watershed that are contributing sediments into the lake via stormwater this can adversely affect the

Figure 1. Comparison of Secchi depth measurements in Lake Marie, 2002 and 2014.

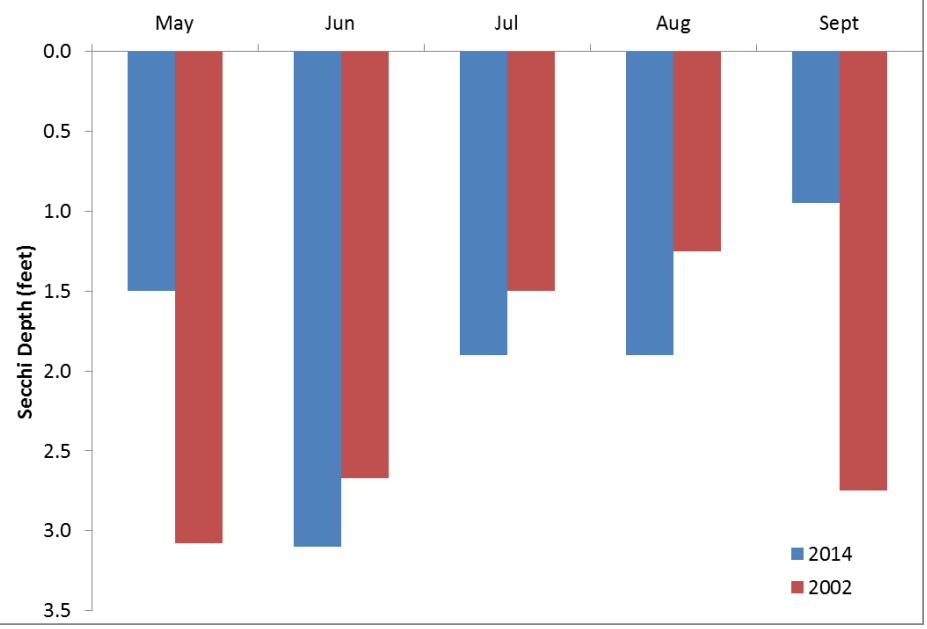


Figure 2. Secchi Depths from 2002 and 2014 for the Fox Chain'O'Lakes

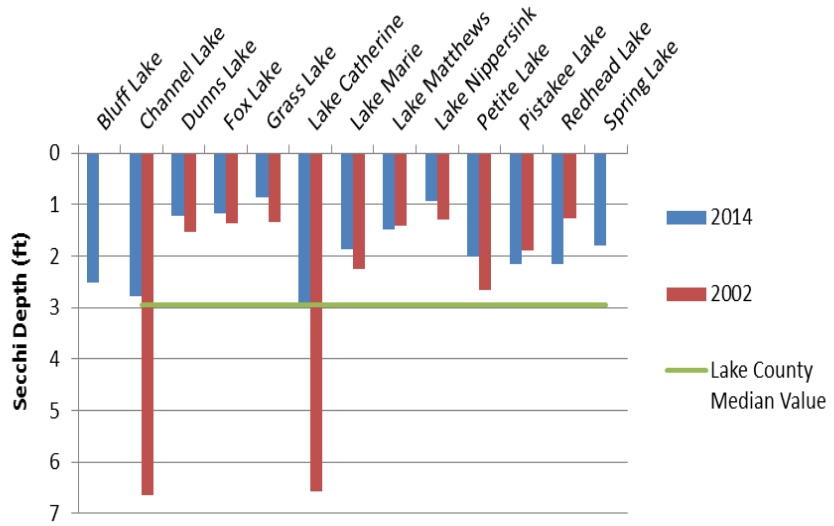
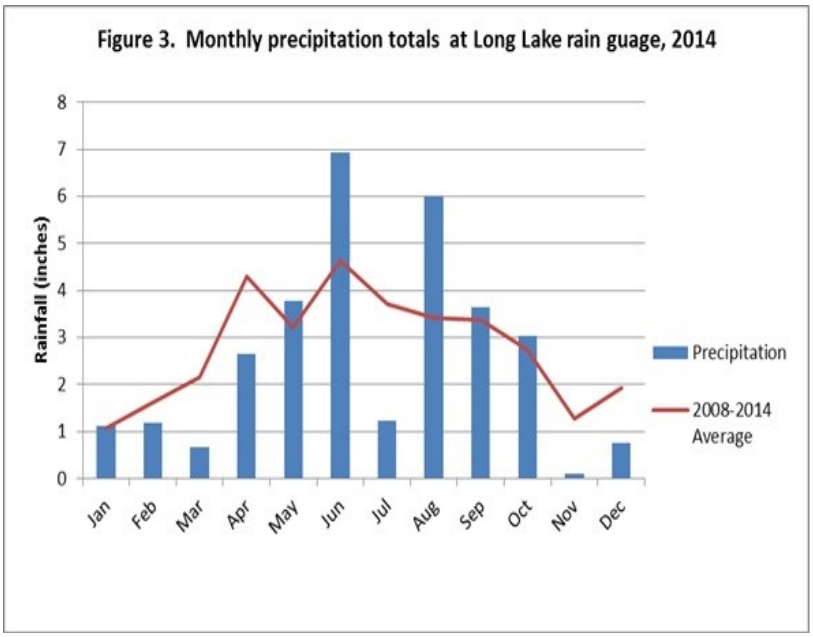


Figure 2. Secchi depths from 2002 and 2014 for all lakes' on the Fox Chain. Note the significant decreases in water clarity for Channel and Catherine lakes.

WATER CLARITY (CONTINUED)

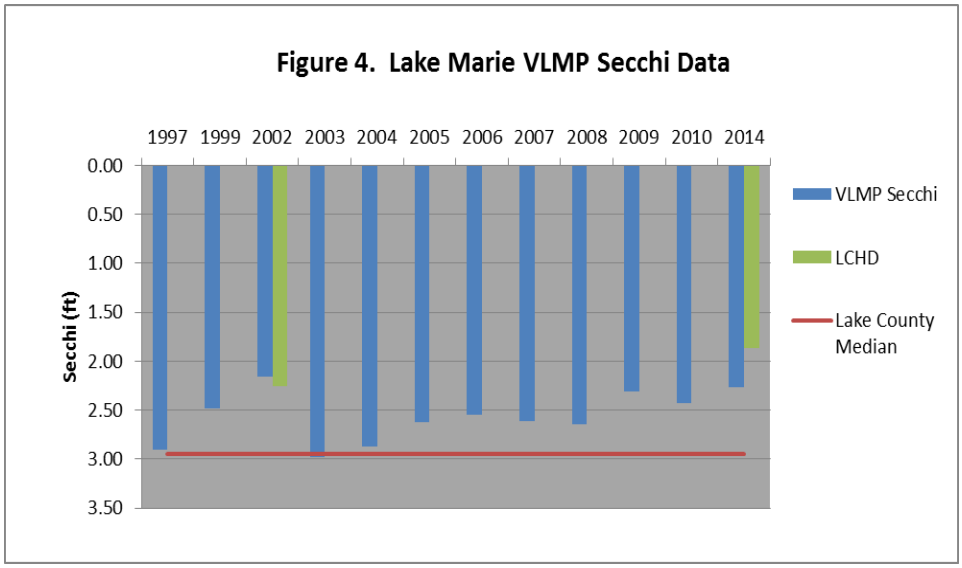


water clarity as is exhibited in the results of the May sampling. In June, precipitation was well above the 12 year average of 4.64 in., with a total of 6.93 in. recorded at Long Lake. This could explain the decrease in Secchi depth between June (3.1 ft.) and July (1.9 ft.).

Aquatic plants play an important role in water clarity as they compete with algae for resources such as phosphorus, nitrogen and light. Water clarity suffers in lakes with little or no vegetation. Algae gain the competitive edge, and plant abundance becomes further reduced due to the reduced light availability making it very difficult to improve water clarity. Lake Marie had an estimated average plant coverage of 27.84% on approximately 27.4% of the lake bottom. In May and September of 2014, a planktonic algal bloom was noted in Lake Marie, those two months had the lowest recorded Secchi depths of 1.5 feet and 1.0 feet respectively.

Lake Marie ranked 131 out of the 158 lakes measured for water clarity; this is based upon Secchi depth measurements taken in the county since 2000 (Appendix A, Table 4).

VOLUNTEER LAKE MONITORING PROGRAM



Volunteer Lake Monitoring Program

The Volunteer Lake Monitoring Program was established in 1981 to assist in gathering water quality information on Illinois lakes and to provide an educational program for citizens interested in lake water quality. The primary measurement taken by all volunteers in the program is Secchi disk (water clarity). Other observations such as algal blooms, vegetation, water color, and wildlife, plus any observations that the VLMP feels noteworthy are recorded. The sampling season is May through October, two visits a month are required under the program.

Lake Marie was in need of a lake volunteer, however, Norm Kleber and Bonnie Bakutis recently agreed to monitor Marie beginning in 2015. The historical VLMP data for Lake Marie is presented in Figure 4, the water clarity has been nearly constant with depths averaged across all sites on the lake ranging from 2.16 feet to 2.98 feet in 2002 and 2003, respectively. VLMP data assists managers identify when impacts have occurred to a lake as well as provide a continuous dataset to supplement data collected when the lake is being actively monitored by agencies such as LCHD-ES and others.

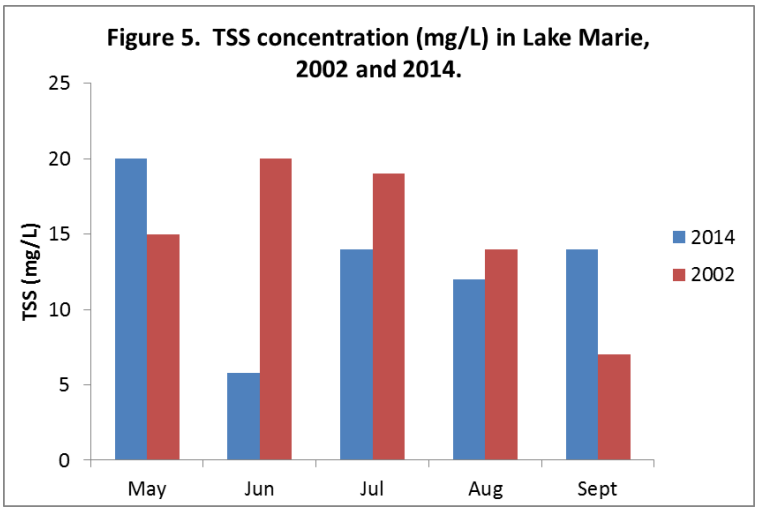
Differences in average Secchi depths between VLMP and LCHD-ES data occur due to an increased number of samples and frequency of sampling that occurs under the VLMP program.

Total Suspended Solids

Total suspended solids (TSS) are comprised of volatile (organic) materials and nonvolatile (inorganic) materials within the water column. Total suspended solids reduce water clarity and can impact both flora and fauna in a lake when TSS are prevalent. Examples of volatile solids are plankton and plant material as well as small macroinvertebrates. Non-volatile solids are sediments. TSS concentrations are inversely correlated to water clarity, hence when TSS concentrations are elevated, water clarity is diminished.

In 2014, TSS concentrations in Channel Lake ranged from 6 mg/L in June to 20.0 mg/L in May (Figure 5; Appendix A, Table 3). The average TSS concentration of 13.0 mg/L was greater than median TSS concentration of 8.2 mg/L for lakes in the county measured for TSS since 2000. The 2014 average TSS was slightly less than the 2002 average TSS concentration of 15.0 mg/L .

Total volatile solids (TVS) in the epilimnion during 2014 ranged from 110 mg/L in July to 146 mg/L in May. The 2014 average TVS concentration measured in the epilimnion in 2014 was 127 mg/L, this is greater than the county median concentration of 121 mg/L for county lakes measured for TVS since 2000. In 2002, TVS concentrations ranged from 4 mg/L to 17 mg/L. The large differences between TVS concentrations in 2014 and 2002 are likely due to analytical differences and are not comparable.



However, nutrients likely played a role in the algal blooms that was noted in May and September, both phosphorus and nitrogen were elevated in those months. Organic nitrogen (TKN) was especially elevated, this is nitrogen that is tied up in cells such as algae and could account for the increased TSS during those months.

In 2014, non-volatile suspended solids (NVSS) in the form of sediments ranged from 9.05 mg/L in May to 1.11 mg/L in June. Non volatile solids were elevated throughout the entire water column in May with concentrations in the hypolimnion of 9.33 mg/L. Elevated NVSS is likely due to spring rains flushing the system and waters remaining well mixed.

Activities in the watershed can contribute to the increases in TSS found in Lake Marie, however, recreational boating, algal blooms, dredging and eroding shorelines can also play a role.

It is recommended to educate residents, businesses and the agriculture community on best management practices that they can incorporate into their daily lives that can reduce sediments from enter-

Total Suspended Solids

ing into waters that eventually discharge into Channel Lake. Additionally, Channel Lake residents should promote a long term aquatic plant management plan on the Fox Chain 'O' Lakes to allow for expansion of vegetation in sensitive areas as aquatic vegetation can filter sediments and other pollutants out of the water column as well as provide competition to algae.

Sediments

Sedimentation naturally occurs in our environment, however, human activities can increase the amount of sediment that ends up in our streams and subsequently our lakes. Sediments are usually fine grained sands, silts and clays that can cover up the coarser bottom sediments and the spaces between rocks and cobbles that provide habitat for aquatic life.

In the Midwest region, sediments entering into our lakes and stream through erosion are laden with phosphorus and is a major source of eutrophication of our lakes and streams. It also reduces water clarity which reduces the amount of light penetrating into the water which impacts plants ability to photosynthesize and plant propagules (seeds) to reestablish, this can subsequently impact fish and macro-invertebrate habitat. Additionally, sediments bury and suffocate fish eggs and gravel nests. Sediment particles in the water absorb warmth from the sun resulting in increased water temperatures. This can cause problems with dissolved oxygen and cause stress to fish.

The Fox Waterway Agency provides the service of removing sediments deposited from the Fox River and other tributaries to the lakes within the Fox Chain 'O' Lakes. The sediment load coming from all tributaries has been calculated to be steady at approximately 100,000 yds^3/year. Of that sediment, 12%, or approximately 12,000 yds^3/year enter the Fox Chain 'O' Lakes through Lake Catherine from Trevor Creek.

In 2014, an approximate area of 38 acres was dredged near the outlet of Lake Marie which enters into Grass Lake (Figure 6 and Figure 7). According to the Fox Waterway Agency, Grass Lake is the main recipient of the sediment load for the Fox Chain 'O' Lakes and is at or near capacity. Therefore much of the 2014 dredging efforts were focused in Grass Lake, Fox Lake and Lake Marie. The Fox River Waterway Agency is not supported through tax revenues but by annual sticker fees required by boaters using the lakes of the Fox Chain 'O' Lakes. Sediment that is dredged is used to construct islands that provide habitat to birds navigating and nesting in and among the Fox Chain 'O" Lakes. There are threatened and endangered bird species who utilize the islands and other areas of the Chain; however, recently we have observed increased gull activity on the islands as well. The Fox Waterway Agency frequently tests the dredged soils

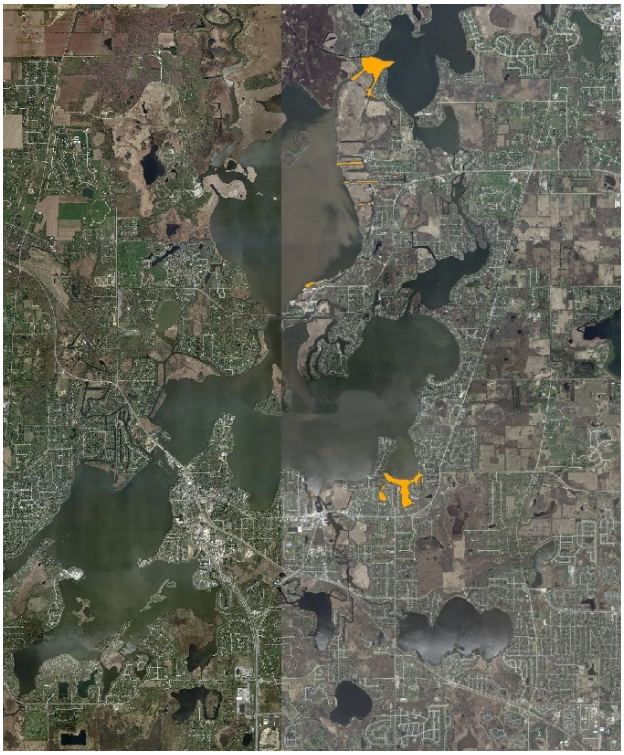


Figure 6. Location of dredging activities on the Fox Chain 'O' Lakes, 2014.

Figure 7. Fox Waterway Agency dredging a channel in Lake Marie, 2014.

SEDIMENTS

and results from a 2005 sampling by conducted by Hey and Associates shows that sediment concentrations for most parameters (total phosphorus as P, Arsenic, Cadmium, Chromium, copper, Lead, Manganese, Nickel, Zinc, and Mercury) fall within the "Low" or "Normal" classification based on the IEPA's Illinois Lake Sediment Classification, therefore sediments are also recycled. The McDonald classification for these indicate that adverse effects pollutants are either not expected or would be rarely observed in the majority of the sediment dwelling organisms.

Table 1. Most of the pollutants sampled in dredging sediments by Hey and Associates compared to IEPA and Mac-

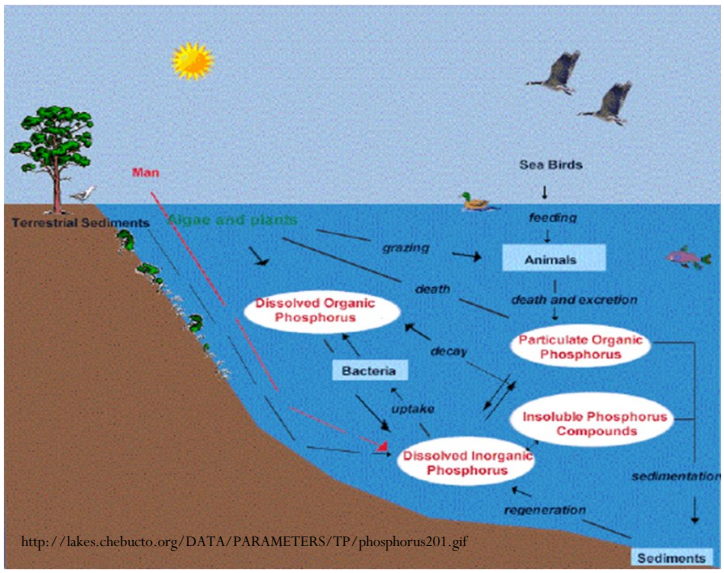
Metal	Value (Hey & Associates)	IEPA Illinois Lake Sediment Classification	MacDonald et al. Sediment Guidelines
Arsenic	12 mg/kg	Normal (4.1 to <14)	Below ERL
Cadmium	<0.5 mg/kg	Normal (<5)	Below LEL
Chromium	20 mg/kg	Normal (13 to <27)	Below LEL
Copper	14 mg/kg	Low (<16.7)	Below LEL
Lead	18 mg/kg	Normal (14 to <59)	Below LEL
Mercury	0.11 mg/kg	Normal (<0.15)	Below LEL
Nickel	14 mg/kg	Low (<14.3)	Below LEL
Zinc	51 mg/kg	Low (<59)	Below LEL

ERL: Effect range-low: represents the chemical concentration below which adverse effects would be rarely observed

LEL: Sediments are considered to be clean to marginally polluted. No effects on the majority of sediment dwelling organisms are expected below this concentration

NUTRIENTS

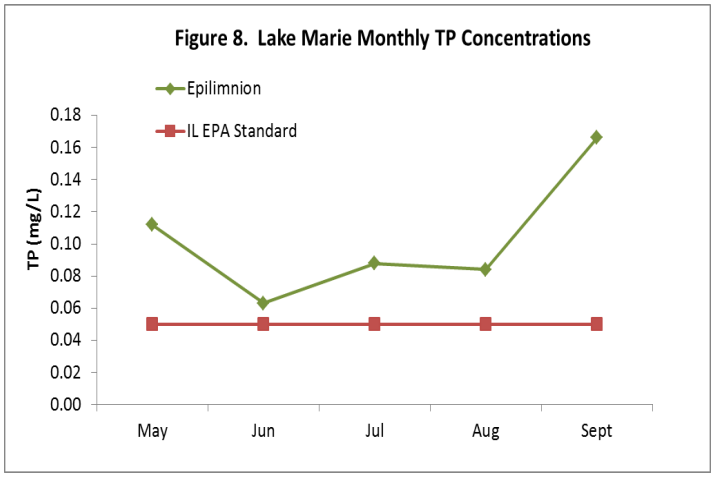
Phosphorus and nitrogen are essential, naturally occurring nutrients needed for plant growth, however when in excess they can impair water quality in lakes. Phosphorus is usually the nutrient which causes water quality problems in lakes. Phosphorus can come from both internal and external sources, and in general is the easiest of the limiting nutrients (those mainly responsible for plant growth) to manipulate due to the ability of plants and some algae species to fix nitrogen, and additional nitrogen inputs by catalytic converters on automobiles. High phosphorus levels in lakes can lead to excessive algae and aquatic plant growth which can harm aquatic life and impair recreational use. It can promote algal blooms, reduce water clarity, and deplete oxygen levels. External sources are those that occur in the watershed, however, in deep lakes such as



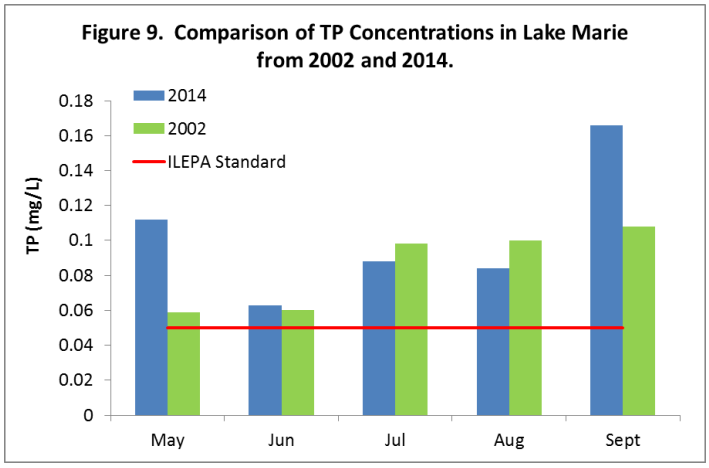
http://lakes.chebucto.org/DATA/PARAMETERS/TP/phosphorus201.gif

Nutrients

Marie, anoxic bottom sediments can also be a contributing factor as they release phosphorus into the waters of the hypolimnion. In fall, phosphorus from the hypolimnion mix with those of the epilimnion causing spikes in TP (Figure 8). Neither phosphorus nor nitrogen are limiting the growth of plants or algae in Lake Marie, so there is plenty of nutrients in the water to support nuisance plant and algal growth throughout the growing season. Lake Marie has elevated phosphorus in its waters and therefore when fall turnover begins and phosphorus from the hypolimnion begin to mix in September the excess phosphorus is utilized by algae and results in fall algal blooms.



Lake Marie has been impaired for total phosphorus dating back to at least our 2002 monitoring year. Lakes are considered impaired for total phosphorus (TP) under the Illinois Environmental Protection Agency (IEPA) standard when concentrations in the water column exceed 0.05 mg/L the lake is considered impaired. TP concentrations are presented in Figure 9 for both 2002 and 2014. TP concentrations in 2014 ranged from 0.063 mg/L in June to 0.166 mg/L in September (Appendix A, Table 3). The average TP concentration in Lake Marie was 0.103 mg/L during the monitoring season (May—Sept), this is 50% higher than the median TP concentration of lakes within the county during the period of 2000—2014 of 0.068 mg/L.



A ratio between total nitrogen and total phosphorus (TN:TP) is another tool utilized to determine which nutrient is limiting plant or algal growth in a lake. Ratios of less than 10:1 indicate a system limited by nitrogen, while lakes with ratios greater than 20:1 are limited by phosphorus. The TN:TP ratio calculated for Lake Marie in 2014 was 20., therefore neither nutrient was limiting the growth of plants or algae, this was true for Lake Marie in all months except June, when the TN:TP exceeded 20, at that time plant and algal growth was limited by phosphorus.

Trophic State Indeces

OLIGOTROPHIC:

Lakes are generally clear, deep and free of weeds or large algae blooms. Though beautiful, they are low in nutrients and do not support large fish populations.

MESOTROPHIC:

Lakes lie between the oligotrophic and eutrophic stages. Devoid of oxygen in late summer, their hypolimnions limit cold water fish and cause phosphorus cycling from sediments.

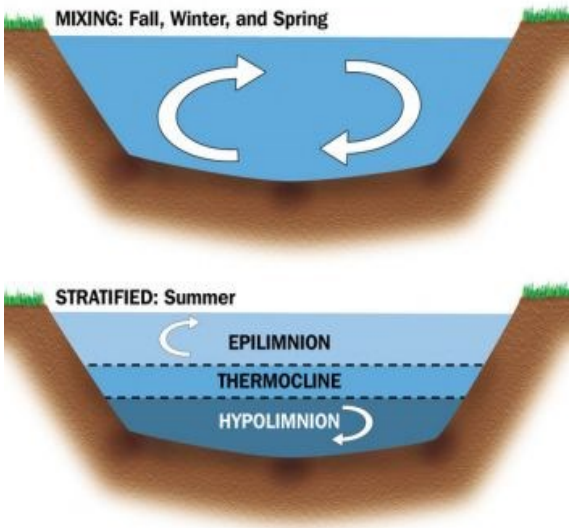
EUTROPHIC:

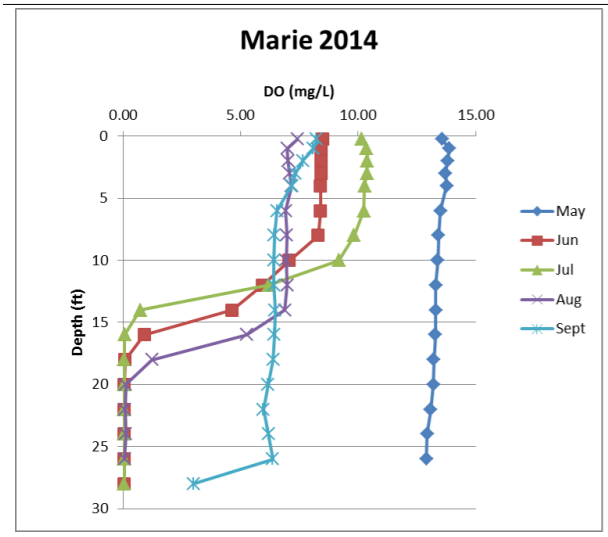
Lakes are high in nutrients, they are usually either weedy or subject to frequent algae blooms, or both. Eutrophic lakes often support large fish populations, but are also susceptible to oxygen depletion.

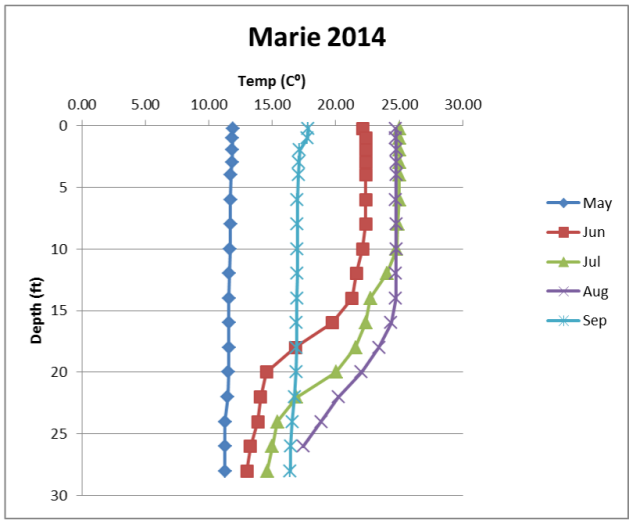
Another way to look at phosphorus levels and how they affect lake productivity is to use a Trophic State Index (TSI) based on phosphorus (TSIp). TSIp values are commonly used to classify and compare lake productivity levels (trophic state). Excessive phosphorus entering a lake can accelerate the rate of eutrophication. Eutrophication is a natural process of a lake aging where lake eventually is increasingly enriched with nutrients. Lakes start out with clear water and few aquatic plants and over time become more enriched with nutrients and vegetation, until the lake becomes a wetland. This process normally takes thousands of years, however, human activities that supply lakes with additional phosphorus speeds up the eutrophication process significantly. The TSIp index classifies the lake into one of four categories: oligotrophic (nutrient-poor, biologically unproductive) mesotrophic (intermediate nutrient availability and biological productivity), eutrophic (nutrient-rich, highly productive), or hypereutrophic (extremely nutrient-rich, productive). In 2014 Lake Marie was considered hypereutrophic with a TSIp score of 70.93. The TP phosphorus concentrations measured in Lake Marie caused it to be ranked 116 of 173 lakes in the county whose TP concentrations have been ranked (Appendix A, Table 5).

STRATIFICATION

Thermal stratification occurs in a lake when the lake separates into an upper layer (epilimnion) and a lower layer (hypolimnion). Stratification usually takes place in deep lakes where the wind and water currents are not strong enough to continually mix warmer waters with the cooler bottom waters and waters of the hypolimnion eventually experience anoxic conditions (where dissolved oxygen concentration fall <1 mg/L). Conditions in the hypolimnion during stratification can have profound effects on water quality. DO and temperature profiles are a good visual of stratification taking place in a lake. The depth profiles presented in Figure 10 a and 10b below were from data collected at the deep hole of Lake Marie. A multi-parameter sonde was used to record data. Measurements were recorded at every foot from the surface to 4 ft below the surface and every foot thereafter until the lake bottom was reached. The temperature and DO measurements are used to determine the depth of relative thermal resistance or where in the water column that lake stratification has set up (Appendix A, Table 6). In 2014, Lake Marie stratified between 12 feet and 16 feet from June through August. Fall turnover had completed by the end of our monitoring season (September).







Dissolved Oxygen

Dissolved Oxygen (DO) is essential for the survival of fish and invertebrates in a lake and influences many different biological and chemical processes in lakes (Indiana Department of Environmental Management, 2011).

The concern in many lakes is that DO concentrations become anoxic or too low to support fish (<1.0 mg/L). Fish become stressed as DO concentrations fall below 5 mg/L. Anoxic conditions did occur in Lake Marie during 2014 upon lake stratification as demonstrated in Figure as the lake stratified, and is expected in deep lakes, however, concerns do arise in the summer when strong thermal stratification develops near the surface of the lake where water temperatures are prohibitive for most fish species. In 2014, Channel Lake became anoxic at in June, July and August at approximately 15'. In September, DO concentrations were less than 5.0 mg/L by 14 feet, it should be noted that some species of fish become stressed at DO concentrations of 5.0 mg/L. The fisheries biologist from the IDNR suggests that as long as anoxic conditions do not expand above 14', there is a sufficient volume of oxygenated water for fish to utilize. However, in a year of extreme drought like what was experienced in 2012, the expansion of anoxic zones higher into the water column due to low water levels can become problematic.

Concerns arise when DO saturation levels becomes supersaturated (DO >100%) due to respiring algae. Although rare, excess DO can cause "gas bubble disease", this is where oxygen bubbles or emboli block the flow of blood in the blood vessels of fish. Lake Catherine exhibited excess DO in waters of the epilimnion to 18' in May, and to 10 feet below the surface in July. DO concentrations are considered saturated when the percent DO is 100%, or is equivalent to the ambient oxygen concentration and can become supersaturated due to algae and plants producing oxygen more rapidly than it can escape into the atmosphere.

While most water quality parameter concentrations increase in the hypolimnion, DO tends to get used up by detrivores in the bottom sediments causing anoxic conditions both in the water and bottom sediments. As DO concentrations approach 2 mg/L near the lake bottom, bottom sediments become anoxic, this allows for phosphorus to release from sediments. As indicated in Figures (8 and 9) above, Channel Lake stratified from June through September. By September the average TP concentration in the hypolimnion of Channel Lake was 1.16 mg/L setting up a conditions conducive for fall algal blooms.

Dissolved Oxygen

Dissolved Oxygen (DO) is essential for the survival of fish and invertebrates in a lake and influences many different biological and chemical processes in lakes (Indiana Department of Environmental Management, 2011).

The concern in many lakes is that DO concentrations become anoxic or too low to support fish (<1.0 mg/L). Fish become stressed as DO concentrations fall below 5 mg/L. Anoxic conditions did occur in Lake Marie in 2014, as is expected in deep lakes. A strong thermal stratification can develop near the surface of lakes, this can cause problems for many fish species especially as the temperatures rise is the waters of the epilimnion during the summer months. There were no DO problems observed in the waters of Lake Marie during 2014 as the lake anoxic zone fluctuated between 14 feet and 20 feet during the monitoring period.

Concerns arise when DO saturation levels becomes supersaturated (DO >100%) due to respiring algae producing oxygen more rapidly than it can escape into the atmosphere. Although rare, excess DO can cause "gas bubble disease", this is where oxygen bubbles or emboli block the flow of blood in the blood vessels of fish. Lake Marie did exhibit supersaturated DO throughout the entire water column in May and to at least 10 feet in July.in waters of the epilimnion to 18' in May, and to 10 feet below the surface in July.

While most water quality parameter concentrations increase in the hypolimnion, DO tends to get used up by detrivores in the bottom sediments causing anoxic conditions both in the water and bottom sediments. As DO concentrations approach 2 mg/L near the lake bottom, bottom sediments become anoxic, this allows for phosphorus to release from sediments. As indicated in Figures (8 and 9) above.

Algae

Algal blooms have historically occurred on Lake Marie during our monitoring years and planktonic blooms were noted again in Lake Marie during 2014. Algae, like plants utilize dissolved phosphorus and nitrogen for their growth. Like, plants they can have balanced populations or they can become imbalanced and a bloom can occur usually because of excess nutrients. Increased phosphorus concentrations have been demonstrated to cause algal blooms. Nitrogen especially if it occurs in late Spring (May), can cause summer algal blooms. HABs can gain the competitive advantage over other algal species due to their ability to fix nitrogen from the atmosphere as well as to assimulate it from the water column as many other algae.

Recently, increased awareness in Harmful Algal Blooms (HABs) has initiated an effort to track such blooms in lakes within Lake County as well as statewide. In 2013, the LCHD-ESU chose a subset of beaches that would be sampled for HABs on a regular basis. Harmful algal blooms appear as either a pea green color throughout the water column, or can appear as a blue-green slime on the surface of the water, Channel Lake did have a HAB present in2013 at one of the beaches that were chosen as a regular sampling site. While there are no licensed beaches present on Lake Marie, recreational boaters do congregate at sandbars near the shorelines. The LCHD-ES does encourage shoreline owners and associations that have unlicensed beaches to license their beach to protect themselves from any consequences that might occur due to either a HAB or e-coli contamination of recreational users at their beach areas. Regardless of whether or not there is a beach present, if it suspected that a HAB is present in Lake Marie, it should be reported. A water sample will be collected and an Abraxis test performed to determine if toxin is present. If the results of Abraxis indicate that toxin was present at >10ppb, the contact person will be advised and it will be recommended that people and their pets remain out of the water until the bloom subsides. The sample will also be sent to an independent laboratory to have an enzyme-linked immunosorbent assay (ELISA) performed. The results will be reported back to the LCHD-ES. The World Health Organization recommends no contact for concentration ≥20 ug/L toxin.

CHLORIDES/CONDUCTIVITY

Conductivity measures the amount of ions contained in a volume water. The more ions or salts that a volume of water contains the higher it's conductivity. Conductivity can be used to estimate both total dissolved solids (TDS) and chloride concentrations due to a strong correlation between these parameters. It has been decided in recent years to analyze chloride concentrations in lakes due to a strong relationship discovered between road salt usage (which contains 40% chloride) and the trend of increasing chloride concentrations in lakes. Even more recently, water softeners have been identified as an important source of increasing chlorides in waters. It only takes 1 teaspoon of salt (chloride) to pollute 5 gallons of water (230 mg/L). Once chlorides are in the water they remain there indefinitely, unless the water is diluted or treated by a reverse osmosis system, which is a very costly and not very practical for most surface water applications.

It only takes1 teaspoon of salt to pollute 5 gallons of water.

In 2014, the average chloride concentration in Lake Marie was 91 mg/L. Chloride was not a parameter tested for in 2002. It is estimated that there was a slight increase of 4.5% between 2002 and 2014 occurring in waters of the epilimnion based upon the strong relationship between chloride and conductivity ($R^2 = 0.94$). Conductivity, was a parameter tested for in both monitoring years; and it exhibited only a negligible increase (1.2%) in the waters of the epilimnion and a 4.9% increase in the hypolimnion between 2002 and 2014.

The chloride concentrations in 2014 ranged from 87.0 mg/L to 94.0 mg/L. This is well below the critical concentration of 230 mg/L (USEPA). Adverse impacts to the lake ecosystem and it's inhabitants are known to occur if the critical concentration is maintained for prolonged periods. However, certain species can be affected at concentrations lower than the critical concentration. Although chloride concentrations were not highly elevated in 2014, single family and transportation were estimated to be the two highest contributors of total percent runoff, and therefore as homeowners and those responsible for winter road maintenance should consider salt usage. Increased chloride concentrations have been linked to a shift in algal populations to blue green algae, and many invasive aquatic plant species are more tolerant of high chloride levels than are our native plant species. This can cause challenges to those responsible for lake management issues.

The LCHD-ES and Lake County Stormwater Management Commission (LCSMC) have been holding annual training sessions targeting deicing maintenance personnel for both public and private entities. This is an attempt to educate winter road maintenance crews on the recommended application rates for applying deicers and hopefully reduce the amount of chloride being introduced into our environment while maintaining safe passageways. Almost all deicing products contain chloride so it is important to read and follow product labels for proper application. For instance, at 10° Fahrenheit, rock salt is not at all effective in melting ice and will blow away before it melts anything. Additionally calling your local township office to ask them if they are taking any actions to minimize deicers on their properties or supporting changes in their deicing policy to minimize salt usage is encouraged.

Pavement Temp. °F	**One Pound of Salt (NaCl) melts**	**Melt Times**
30	46.3 lbs of ice	5 min.
25	14.4 lbs of ice	10 min.
20	8.6 lbs of ice	20 min.
15	6.3 lbs of ice	1 hour
10	Dry salt is ineffective and will blow away before it melts anything	

AQUATIC PLANTS

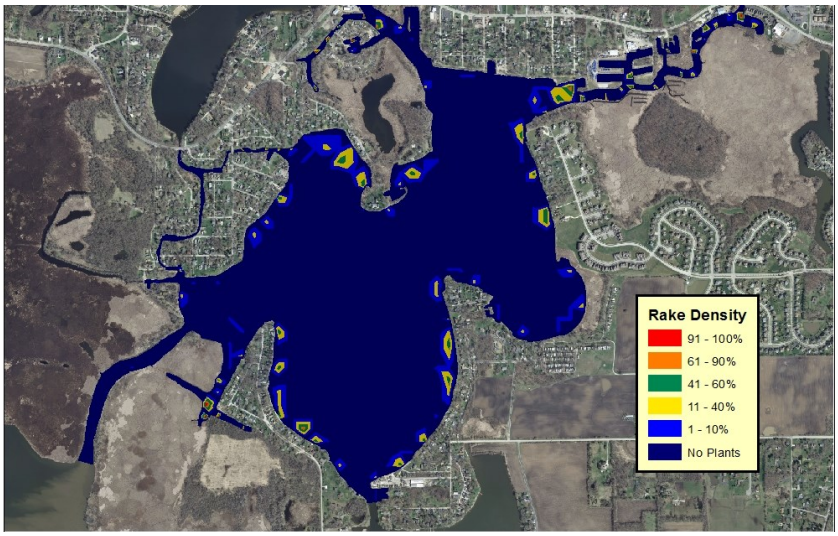


Figure 12. Status of vegetation in Lake Marie, July, 2014.

Aquatic plants are a critical component in lakes as they; contribute to the uptake of available nutrients such as phosphorus from the water column making it unavailable for use by algae, filter sediments and other pollutants from the water, and stabilize bottom substrates. They also provide habitat for nesting and nursery for fish and other aquatic organisms. At times, nuisance growth has been encountered by lake managers due to invasive species and eutrophication. Good data allows lake managers to be more efficient and environmentally sound when managing lake vegetation.

In August 2014, an point intercept survey was conducted on the aquatic vegetation in Lake Marie. In order to accomplish this a randomized 60-meter grid was overlaid on an aerial photo of Lake Catherine using ARCGIS10. A total of 669 points fell within the lake footprint. Above the 12 ft depth, which is the average depth that plants are likely to be detected given a 3—5 ft. Secchi depth, every point was sampled regardless of whether plants were detected or not, if plants dropped out of the littoral zone after 12 ft. depth, points lying at greater depths were not sampled. To sample the vegetation, a rake was lowered into the water and then scored from 1—5 (Appendix A, Table 7). Each species was scored from a modified scale. The scales were then converted to a percentage value using the midpoint of a percentage range which was associated with each score. The midpoint was used to establish species cover. A total of 297 points were sampled and species cover, relative cover, frequency, relative frequency and relative importance were quantified using a modified Braun- Blanquet scale (Mueller-Dombois, Ellenberg, 2002) Appendix A, Table 7 presents the estimated cover, frequency and relative importance for each species detected in the August, 2014 survey. A ranking of relative importance determined dominant species in the lake.

In 2014, vegetation was found at 58% of the 297 points in the lake with an estimated cover of 14.6%. Twelve plant species and Chara, a macro-algae were detected. Three plants were co-dominant; Coontail, Common Duckweed and Eurasian Watermilfoil. Coontail, is a native submerged aquatic species, and is tolerant of low light conditions, so it is not surprising that given the low water clarity measured during most of the 2014 monitoring season that it would be a member of the dominants. Eurasian Watermilfoil is a non-native invasive species that is known for its aggressive growth. Areas of aquatic vegetation are presented in Figure 12.(Appendix A, Figure 6).

An floristic quality assessment was performed using the aquatic plant species found in Lake Marie. A floristic quality index (FQI) is generated from the assessment estimating the "weediness" or "conservativeness" of native species in a system. A floristic quality assessment is commonly used in four applications; identification of natural areas, comparisons among sites, long term monitoring and monitoring habitat restoration. Since Lake Marie is actively managed through dredging and aquatic plant management activities, the FQI can be a tool to lake managers or home owner associations (HOA's) determine the extent that management occurring in the lake is affecting the quality of the vegetative community. The FQI in 2014 was 25.2 which was not bad considering that FQI scores of 35 or greater in terrestrial systems are of significance from a natural area perspective.

AQUATIC PLANTS (CONTINUED)

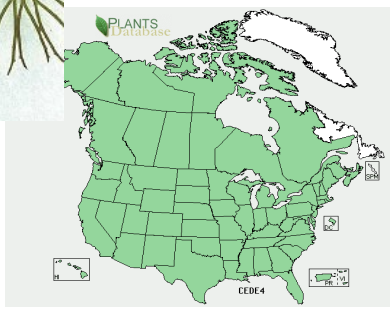
Lake Marie ranked 22nd out of 179 lakes in the county assessed for floristic quality (Appendix A, Table 8).

Eurasian Watermilfoil, is a non-native aquatic invasive plant species was detected at 25.25% of the points assessed. The other common invasive non-native aquatic plant found in Lake Marie was Curlyleaf Pondweed, its abundance at the time of our samling was low, representing 0.88% of the aquatic vegetation. However, the life history of Curlyleaf Pondweed has its growth peaking in June, and dying back by mid-July so the true abundance of this species may not have been captured.

The LCHD-ES is recommending that Lake Marie adopts a long term aquatic plant management plans that is developed by all stakeholders of the lake (lake associations, citizens, townships, park districts etc.). The plan would provide a template that describes the goals of aquatic plant management in Lake Marie and assists in determining what objectives need to be defined to help attain those goals. If a plan is not developed it is recommended that areas within the lake be identified to allow for native plant expansion, if chemical treatments are used to control invasive species, they should occur in when water temperatures are not too warm; as water o accelerate breakdown of chemical as well as to ensure that chemicals have minimal if any impact to native plant populations. Also, to consider when managing plants with chemicals are what type of plants are present. Aquatic plants like terrestrial plants are of two types monocots and dicots. Monocots contain all pondweeds, duckweeds, naiads, elodeas and others. Dicots include the watermilfoils, white water lily, spatterdock, Coontail, white water crowfoot and water marigold.

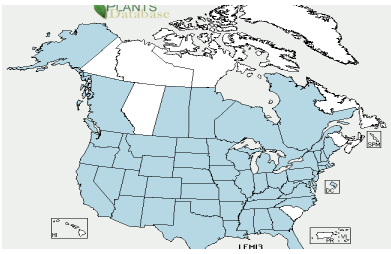
COONTAIL (DICOT

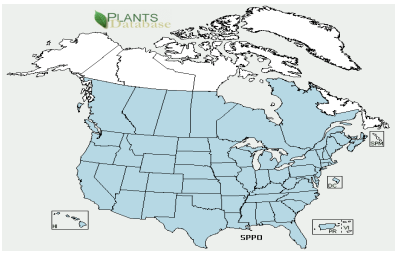
Coontail (*Ceratophyllum demeserum*) is a widespread native in and around the United States and Canada. It is identified by its forked whorl of leaves which extends the length of the stem. Early in the season, plants can be confused with Chara, a macroalgae.



DUCKWEEDS (MONOCOT)

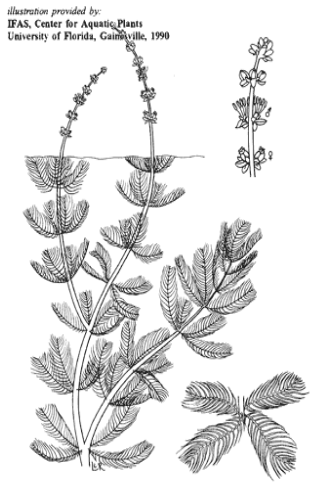
Common duckweed (Lemna minor) and Giant Duckweed (Spirodela polyrhiza) are two widespread natives . Common duckweed has invasive tendencies and under eutrophic conditions has been found to cover entire water surfaces. Giant Duckweed has a red pigment on bottom with multiple roots coming from a cluster of leaves (pictured on bottom left).





Eurasian Watermilfoil

Illustration of Eurasian Watermilfoil



Eurasian Watermilfoil (EWM) is a feathery submerged aquatic plant that can quickly form thick mats in shallow areas of lakes and rivers in North America. These mats can interfere with swimming and entangle propellers, which hinders boating fishing, and waterfowl hunting. Matted milfoil can displace native aquatic plants, impacting fish and wildlife. Since it was discovered in North America in the 1940's (Couch & Nelson), EWM has invaded nearly every US state and at least three Canadian Provinces. Milfoil spreads when plant pieces break off and float on water currents. It can cross land to new waters by clinging to sailboats, personal watercraft, powerboats, motors, trailers, and fishing gear.

EWM was found at 25.25% of the points sampled with an average cover of 4.37%. In 2014 chemical applications were applied in May and June, targeting EWM populations. LCHD-ES did not conduct an early season sampling in 2014, however the results of our August survey indicate that EWM remained a dominant in the aquatic plant community.

Recently hybrids of a cross between EWM and the native Northern Watermilfoil have been encountered. The hybrid milfoil has proven to be less sensitive than either parental species to certain herbicides. Therefore, it is important to know whether the hybrid is present or to occasionally switch chemicals used to treat EWM to reduce the chance of chemical sensitivity being reduced in the future.

Eurasian watermilfoil was a Member of the dominant species in Lake Marie during August, 2014.

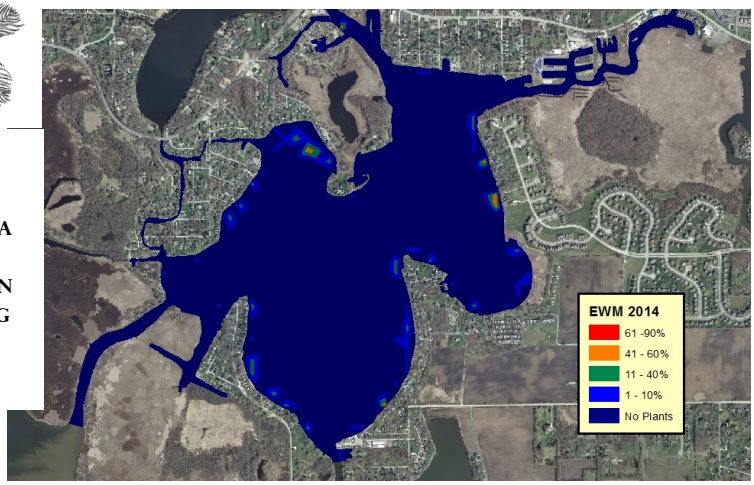


Figure 11. Status of EWM on Lake Marie, July, 2014.

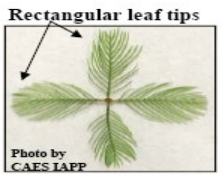
Myriophyllum spicatum Exotic*

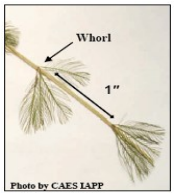
Common Names:
Eurasian watermilfoil

Origin: EXOTIC
Europe and Asia. Found throughout lake county and Illinois

Importance:
This invasive plant spreads rapidly, crowding out native species, clogging waterways, and blocking sunlight and oxygen from underlying waters.

Look alikes:
Northern watermilfoil; Hybrid Milfoil Which has fewer than 12 leaflet pairs per leaf, and generally has stouter stems.





Key Features:

Leaf: leaves are rectangular with ≥12 pairs of leaflets per leaf and are dissected giving a feathery appearance, arranged in a whorl, whorls are 1 inch apart.

Flower: Small pinkish male flowers that occur on reddish spikes, female flowers lack petals and sepals and 4 lobed pistil.

Aquatic Plant Management

For full details of Part 895 see:

http://www.ilga.gov/commission/jcar/admincode/017/01700895sections.html

Herbicide application is a tool utilized by home owner associations, individual residents and lake managers for the control of aquatic plants in Lake Marie. Targeted species are usually non-native invasive species; however our records indicate that there are areas treated that are additionally colonized by native species.

By Administrative Code, applying herbicides on Lake Marie or any other lake in the Fox Chain 'O' Lakes requires a permit by the Illinois Department of Natural Resources (IDNR) In order to obtain the permit an application needs to be filed with the IDNR requesting a permit for pesticide application, the application can be filled out by the applicant or their representative (which is usually the pesticide consultant). It should minimally document the location and area of treatment, species targeted, pesticide and application rate as well as an estimated time when pesticide will be applied. There is an exemption for needing the letter of permit (LOP) if you are treating an area less than 0.25 acres. However, exempt individual are responsible to abide by other applicable laws or ordinances. Any pesticide application into the Fox Chain 'O' Lakes needs to be done by an applicator licensed under the Illinois Department of Agriculture. The application can be obtained at the Fox Waterway Agency through its website at or its website (www.foxwaterway.com). The IDNR has 45 days to issue or deny the permit. The Fox Waterway agency has the right to review all applications and can recommend denial of a permit if it feels that it could cause harm to the environment. Chemicals should only be used if they are labelled and registered with the Illinois Environmental Protection Agency. More information is available at the link to Part 895 of the Administrative Code which covers management of aquatic plants on the Fox Chain 'O' Lakes.

A NPDES permit is required before applying pesticides over or near waters of the state. A notice of intent to apply pesticides needs to be filed with the state and can be found at the following website: http://www.epa.state.il.us/water/permits/pesticide/forms/noi.pdf.

Lake Name	Max. Depth (ft)	# points sampled	#points	Total# Species	Total # Native Species	Floristic Quality Index	Average Density
Column1	**Column2**	**Column3**	**Column4**	**Column5**	**Column6**	**Column7**	**Column8**
Bluff	28	50	108	6	4	11	14.5
Catherine	35	87	178	13	11	21.8	14.6
Channel	36	227	413	11	8	18.8	31.2
Dunn's	7.5	56	79	9	7	17	21.4
Fox	18	221	2087	11	10	20.2	17.5
Grass	6	469	1880	12	11	22.2	43.0
Matthews	5	19	19	5	4	15.5	27.1
Marie	31	297	669	14	12	23.5	27.8
Nippersink	10.2	391	761	13	12	23.2	20.4
Petite	19	190	230	10	8	18.7	6.6
Pistakee	30	450	1978	14	13	23.5	25.1
Redhead	4.56	57	57	9	8	18.7	88.6
Spring	10	41	42	7	6	15.2	29.6
Fox Chain	36	2555	8501	20	18	23.7	27.3

AQUATIC PLANT MANAGEMENT (CONTINUED)

There is a 14 day public notice period and additional information may be requested so plan ahead. Either the homeowner or its representative can apply for the permit. Once issued the permit is good for 5 years. If your treatments exceed 80 acres annually additional reporting is required. Additional documentation is required in the cases where adverse affects due to a spill or overdosing occur.

The LCHD is encouraging homeowner associations and individuals and agencies to formulate a long-term Aquatic Plant Management Plan (APMP) for the Fox Chain 'O' Lakes that can be used as a template by any entity or homeowner applying pesticides into the lake. Developing the plan should consider all stakeholders that utilize the lake. The plan should describe all methods of control and select the best management tool for the lake, explain why it was chosen. The plan should consider timing of pesticide application, targeted species, and pesticide selection. Distributing information on pesticides that are approved for aquatic use should be included so that the person(s) responsible for lake management decisions are knowledgable about the pesticides being applied to the lake and any risks associated with those chemicals. This allows them to formulate a clear concise Request for Proposal (RFP) that addresses the key considerations, sets reasonable goals and the objectives for achieving those goals. The APMP could also require monitoring of the lake vegetation to ensure that the goals are being met. This would allow for tweaking of the APMP if goals are not met. The vegetation coverage in Lake Marie was above the estimated average cover of 27.3% calculated for the Fox Chain 'O' Lakes during 2014; management decisions should consider increasing native plant populations as well as invasive species control.

FISH

The Illinois Department of Natural Resources continuously monitors the fish populations in the Fox Chain 'O' Lakes through biennial fish surveys. The IDNR conducted surveys in 2005 and 2014 on Lake Marie. In 2005 they used a different method (trap net) than they did in 2014 (day electroshocking). Therefore the data are not comparable. In 2014, 21 fish species were detected during the day of electroshocking on Marie. Bluegill was the most abundant fish caught (300 individuals). However, Carp (8), Channel Catfish (19), and Carp (7) were the fish having the greatest average weight, 8.4 lbs. and 7.6 lbs., respectively.

The Fox Chain 'O' Lakes is annually stocked with 243,000 2"walleye fingerlings, 2 million walleye fry, and at least 2000 muskie fingerlings. Sixty-five thousand 4" to 6" largemouth bass fingerlings are stocked every other year. Natural reproduction maintains all other species.

FISHING REGULATIONS – Includes the Fox River from the Illinois State line to the Algonquin Dam. Trout line fishing is permitted.

Species	Daily Creel Limit	Minimum Length Limit
Largemouth Bass and **Smallmouth Bass**	**6**	**14"**
Walleye	**4**	**14" to 18"** (18" to 24" protected slot limit, no possession) **only 1 fish can be >24"**
Muskie	**1**	**48"**
Northern Pike	**3**	**24"**

(No more than 3 fish can be smallmouth bass, smallmouth must be released immediately between April 1 to June 15, no possession)

(see current Illinois Fishing Information booklet or IFISHILLINOIS website: http://www.ifishillinois.org/ for specific details).

Fish Species in Lake Marie, 2005 and 2013.

Species	Apr 2005	Sept 2013
Black Crappie	0	2
Blue Gill	0	300
Brook Silverside	0	10
Carp	0	8
Channel Catfish	0	19
Emerald Shiner	0	46
Freshwater Drum	0	30
Golden Shiner	0	9
Green Sunfish	0	6
Gizzard Shad	0	65
Large Mouth Bass	0	24
Logperch	0	10
Muskellunge	14	1
Northern Pike	5	0
Pumpkinseed	0	5
Small Mouth Bass	0	5
Spottail Shiner	0	6
Quillback	0	5
Walleye	286	15
Hybrid Bluegill	0	12
Yellow Perch	0	3
Yellow Bass	0	10

Zebra Mussels

Figure 12. Results of zebra mussel invasion in Lake Marie, November 2008, photo taken by Marietta Kappel.

STOP AQUATIC HITCHHIKERS!™

Prevent the transport of nuisance species.
Clean all recreational equipment.
www.ProtectYourWaters.net

When you leave a body of water:

- Remove any visible mud, plants, fish or animals before transporting equipment.
- Eliminate water from equipment before transporting.
- Clean and dry anything that comes into contact with water (boats, trailers, equipment, clothing, dogs, etc.).
- Never release plants, fish or animals into a body of water unless they came out of that body of water.

In the late 1990's, the presence of zebra mussels (Dreissena polymorpha) was confirmed in the Fox Chain O Lakes. These mussels are believed to have been spread to this country in the mid 1980's by cargo ships from Europe that discharged their ballast water into the Great Lakes. The mussels spread throughout the Great Lakes and by 1991 had made their way into the Illinois and Mississippi Rivers. In 1999, the first sighting of the mussel in Lake County (besides Lake Michigan and the Chain of Lakes) occurred. Currently there are 35 inland lakes in the county are known to be infested with the zebra mussel, but this number could be much higher, since the zebra mussel has probably gone unnoticed in many lakes.

In Lake Marie, like many of the northern lakes of the Fox Chain 'O' Lakes, the zebra mussel population seemed to have peaked in approximately 2008 and 2009, in recent years however, zebra mussels have not been observed on the lakes (personal observation Frank Jacobesik, IDNR).

The zebra mussel's reproductive cycle allows for rapid expansion of the population. A mature female can produce up to 40,000 eggs in a cycle and up to one million in a season. Zebra mussels can live as long as five years and have an average life span of about 3.5 years. The adults are typically about the size of a thumbnail but can grow as large as 2 inches in diameter. Colonies can reach densities of 30,000 - 70,000 mussels per square meter. Due to their quick life cycle and explosive growth rate, zebra mussels can quickly edge out native mussel species. Negative impacts on native bivalve populations include interference with feeding, habitat, growth, movement and reproduction.

The impact that mussels have on fish populations is not fully understood. However, zebra mussels feed on phytoplankton (algae), which is also a major food source for planktivorous fish, such as minnows and shad and young of the year bluegill. These fish, in turn, are a food source for piscivorus fish (fish eating fish), such as largemouth bass and northern pike.

Studies on the transport of the zebra mussel have shown that they can be found in any area of a boat that holds water and mussel larvae were being transported via aquatic plants that were taken from one lake to another on boats and trailers. Therefore, it is important that all boats and trailers entering or leaving the Fox Chain O' Lakes are inspected for aquatic plants, zebra mussels and all water from the bilge and motors are drained.

LakeCounty
Health Department and
Community Health Center

ENVIRONMENTAL SERVICES

Senior Biologist: Mike Adam

madam@lakecountyil.gov

Population Health Services
500 W. Winchester Road
Libertyville, Illinois 60048-1331

Phone: 847-377-8030
Fax: 847-984-5622

For more information visit us at:

http://www.lakecountyil.gov/Health/want/BeachLakeInfo.htm

Protecting the quality of our lakes is an increasing concern of Lake County residents. Each lake is a valuable resource that must be properly managed if it is to be enjoyed by future generations. To assist with this endeavor, Population Health Environmental Services provides technical expertise essential to the management and protection of Lake County surface waters.

Environmental Service's goal is to monitor the quality of the county's surface water in order to:

- Maintain or improve water quality and alleviate nuisance conditions
- Promote healthy and safe lake conditions
- Protect and improve ecological diversity

Services provided are either of a technical or educational nature and are provided by a professional staff of scientists to government agencies (county, township and municipal), lake property owners' associations and private individuals on all bodies of water within Lake County.

RECOMMENDATIONS

LCHD-ES recommends the following actions for improving the water quality and overall health of Lake Catherine:

- Develop an aquatic plant management plan for the Fox Chain 'O' Lakes that can be used as a template for lake managers, homeowners and other entities charged with aquatic plant management on Lake Catherine.
- Encourage groups within the Trevor Creek watershed to incorporate best management practices to reduce the nutrient load (especially phosphorus) into Lake Catherine and the Fox Chain 'O' Lakes.
- Encourage municipalities within the watershed to use chloride products efficiently in their winter road maintenance programs while they still maintain safe passageways.
- Seek a citizen volunteer to become involved in the Volunteer Lake Monitoring program, it allows lake managers to address problems occurring in their lake during times when the LCHD-ES is not out actively monitoring.