2014 SUMMARY REPORT
of the
FOX CHAIN O'LAKES

Lake County, Illinois

Prepared by the

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Executive Summary

The Fox Chain O' Lakes is comprised of 13 lakes that are interconnected with the Fox River and various natural and manmade channels. Lake Catherine, Channel Lake, Grass Lake, Lake Marie, Fox Lake, Bluff Lake, Petite Lake, Nippersink Lake and Pistakee Lake are the primary lakes that make up the Fox Chain O' Lakes. Dunn's Lake, Spring Lake, Redhead Lake and Matthews Lake are connected to the primary lakes through natural or manmade channels and are also included within this report. In 2014, the Lake County Health Department – Ecological Services (LCHD-ES) monitored these 13 lakes within the Fox Chain O'Lakes waterway system for water quality sampling, beach sampling, and aquatic macrophyte surveys.

Water quality samples were collected on a monthly basis from May – September at the deep hole of each of the 13 lakes. In 2014, the water clarity was poor in the Fox Chain O' Lakes as determined by Secchi depth measurements. The average Secchi depth for the lakes' was 1.83 feet; this is well below the median Secchi depth of 2.95 feet for all lakes sampled in Lake County for water clarity between 2000 and 2014. Average Secchi depths recorded for the lakes' ranged from 0.9 feet (Lake Nippersink and Grass Lake) to 2.9 feet (Lake Catherine).

Total Suspended Solids (TSS) negatively impact water clarity. Dunn's, Fox, Grass and Nippersink lakes are considered impaired for TSS based on the concentrations of median surface non-volatile suspended solids being greater than or equal to 12 mg/L during the 2014 monitoring season. These are all shallow lakes therefore they are susceptible to having bottom sediments re-suspended from recreational boating activities; according to the Fox Waterway Agency, Grass Lake is also a known sink for sediment entering the Fox Chain 'O' Lakes due to the Fox River entering the lake on its northwestern shoreline.

Nutrient availability especially of phosphorus and nitrogen are of primary importance to the growth of plants and algae in lake systems. A ratio between total nitrogen and total phosphorus (TN:TP) is used to determine the limiting nutrient of a lake. The Fox Chain 'O' Lakes, like many of the lakes in Lake County, had plant and algal growth limited by phosphorus with a TN:TP ratio of 20:1. Lakes with TN:TP > 20 are considered limited by phosphorus, they are limited by nitrogen if there TN:TP ratio is <10; and both nutrients are limiting if the ratio is ≥10 TN:TP ≤20. Additionally, in 2014, all of the lakes' of the Fox Chain 'O' Lakes were considered impaired for phosphorus by exceeding the Illinois Environmental Protection Agency (IEPA) water quality standard of 0.05 mg/L TP any time during the growing season (May – October). The average TP concentration ranged from 0.061 mg/L in Redhead Lake to 0.118 mg/L in Lake Matthews. The 2014 average TP concentration in the epilimnion was 0.095 mg/L which was greater than the median epilimnetic TP concentration of 0.068 mg/L for all lakes in the county sampled for TP between 2000 and 2014.

There are 13 licensed beaches located in the Fox Chain O' Lakes that the LCHD-ES samples on a bi-weekly basis from Memorial Day through Labor Day. The beach waters are sampled at by submerging a bottle under the surface of the water, two samples are collected at each beach and tested for E-coli. During the summer of 2014, there were three beaches that

exceeded 235 E. coli/100 ml. out of the 13 beaches sampled. Highland Beach, located on a channel between Spring and Petite Lake, exceeded the limit sixteen times between June 13, 2014 and August 1, 2014. Stanton Bay (Fox Lake) and Vacation Village (Dunn's Lake) each had one sample that exceeded the maximum allowable limit.

While not part of the 2014 sampling, in 2013 at a subset of beaches, an additional water sample was collected to test for the presence of microcystin, a common toxin produced by cyanobacteria (blue-green algae). The sample was sent to an independent laboratory for enzyme linked immunosorbant assay (ELISA). In 2013, Channel Lake and Dunn's Lake each had microcystin concentrations above 20 ug/L on one occasion, at 259.11 ug/L and 26.63 ug/L respectively; which is above the recommended level for no contact by the World Health Organization.

In 2014, the LCHD-ES conducted surveys on the aquatic vegetation once during the peak growing season starting on June 20th finishing on September 1st. The presence of aquatic vegetation in aquatic systems is critical. Aquatic vegetation provides habitat and nesting sites, filters sediments from the water and competes with algae for nutrients which limit their growth. It is a delicate task for the lake manager to keep this system in balance. The results of the 2014 aquatic vegetation survey indicate that the balance is tipping towards an algal dominated system due to low plant abundance; as the average cover of vegetation at points sampled in the Fox Chain 'O' Lakes was 27.3%. The lake vegetation was diverse and in total 20 species were identified; however the plant diversity varied between lakes. Chara was counted as a plant species due to its structure; however, it is actually a macroalgal species found in high alkaline lakes and is known for its effects on water clarity. The lakes' were dominated by Coontail, American Lotus and White Water Lily. Two aquatic invasive species were detected in the surveys, Eurasian Water Milfoil and Curlyleaf Pondweed. The abundances of these species varied by lake, however they represented 15.6% and 2.0%, respectively, of the Relative Importance of the entire Fox Chain 'O' Lakes. Relative importance is the sum of the relative cover and relative frequency for each of the species detected in the survey. A floristic quality assessment was conducted on the aquatic vegetation found during the surveys. Floristic quality assessments are conducted in order to compare sites, identify natural areas, and for long term monitoring and monitoring of restoration activities. The assessment is geared towards terrestrial systems; however, it can be used to compare sites and to monitor success of management practices utilized on lakes. A FQI score is generated based upon the "conservativeness" or "weediness" of the plants comprising the vegetation. In 2014, the FQI score of the Fox Chain 'O' Lakes was 29.7, which is pretty good considering that terrestrial systems with FQI scores of 35 are considered to possess sufficient conservatism and richness to be of profound importance from a regional perspective.

To improve the overall quality of the Fox Chain O' Lakes; the LCHD-ES has several recommendations. The development on an aquatic plant management plan that restores density and diversity of plant species is encouraged. The enforcement of no-wake zones can minimize re-suspension of sediment in the water column which will be beneficial for water clarity and

plant growth. The creation of an updated bathymetric map for individual lakes would aid lake management decisions by providing accurate morphometry for the lake. To minimize the amount of nutrients and sediment entering the lake from runoff and erosion, LCHD-ES recommends addressing areas of severe shoreline erosion and stone-refacing of vertical sea walls. Homeowners are encouraged to incorporate native plants in their landscaping through rain gardens or shoreland buffer strips to filter nutrients and sediment before reaching the lake as well as use phosphorus free lawn fertilizer. Inspecting septic systems regularly will also minimize the potential for harmful bacteria and beach closures in the Fox Chain O'Lakes. Homeowners are encouraged to participate in the Clean Waters Clean Boats Program and educate lake users on aquatic invasive species. For snow and ice management, use salt alternatives and proper application procedures for homeowners to reduce the amount of chlorides that runoff into the lakes. These recommendations will help improve water quality in the Fox Chain O'Lakes.

Introduction

The Fox Chain O'Lakes is one of the busiest inland recreational waterways per acre in the United States with weekend usage around 60,000 people, and up to 100,000 on holidays (Antioch Chamber of Commerce, 2015). Public boat launch access is restricted to launches within the Chain O'Lakes State Park on Grass Lake and the Fox River north of Grass Lake (Appendix A, Figure 1). Most shoreline access is private; and many homeowner associations have piers and beaches available for their residents. Once on the lake, there is public access to all of the lakes within the Fox Chain via channels. The Fox Chain O'Lakes is designated as public waters, which is defined as a navigable waterbody that is open or dedicated to the public use (DNR, Administrative Code, Part 895). Overall management of the Fox Chain O'Lakes falls under oversight of multiple agencies as well as private individuals or associations, who can have lake bottom ownership. The Chain O'Lakes and all navigable channels directly connected to these lakes are under jurisdiction of the Fox Waterway Agency, a regional body of government that was created by the State of Illinois in 1984 to manage the lakes'. Homeowner associations or individuals who wish to apply chemical or non-chemical treatment for the management of aquatic plants in the Fox Chain O'Lakes, must obtain a Letter of Permission (LOP) from the Illinois Department of Natural Resources (IDNR) and apply for a Notice of Intent as part of the NPDES permit process.

In 2014, the Lake County Health Department – Ecological Services (LCHD-ES) monitored 13 lakes within the Fox Chain O'Lakes waterway system on a monthly basis from May – September. These lakes included: Bluff, Channel, Catherine, Dunn's, Fox, Grass, Pistakee, Petite, Marie, Matthews, Nippersink, Redhead, and Spring. Water samples were collected at the deep hole of the lake and analyzed for a series of parameters at the Lake County Health Department's lab. Additionally, depth profiles measuring temperature, pH, conductivity and dissolved oxygen concentrations occurred at 1 ft. intervals (lakes ≤15ft) or 2 ft. intervals (lakes ≥15 ft.) throughout the water column. Aquatic plant surveys were conducted to better

assess the plant community and species populations on each lake. Results from the aquatic plant survey, beach sampling, and water quality sampling can provide valuable information to those who are in charge of management of the lakes. The following report will discuss the results from the 2014 monitoring period.

Watershed

The Fox Chain O'Lakes are located just south of the Illinois-Wisconsin border in Lake and McHenry County (Appendix A, Figure 2). The Chain O'Lakes are composed of nine main lakes and another four lakes that are interconnected by small canals and channels. Most of the Fox Chain 'O' Lakes are glacial in origin. The only lake that did not originate from glacial deposits is Grass Lake. Grass Lake was a large riparian marsh that cradled the Fox River channel and was renowned for its expansive lotus beds and was nearly impassible until the 1907 dam increased the water levels in the lake by 6 inches changing much of the wetland area into a shallow lake. Catherine and Channel lakes were historically two lakes separated by a gravel bar; today there is only remnant sandbar remaining and the lakes are entirely connected. They are the two deepest lakes on the Fox Chain 'O' Lakes registering depths of 35 and 36 feet, respectively. Lake Marie is the next deepest lake with a depth of 31 feet. Marie was always connected to Bluff Lake whose depth is 28 feet. Channelization between Channel, Catherine, Marie and Bluff occurred between 1905 and 1916 by the State of Illinois. A channel dredged between 1920 and the early 1950's connected the "northern lakes" from near Grass Lake Road through Spring Lake (10 feet) which eventually reached the northeast shoreline of Petite Lake whose maximum depth is 19 feet. Fox Lake whose maximum depth is 12 feet is the largest of the Fox Chain 'O' Lakes with a surface area of 1,881-acres. Pistakee Lake is the next largest lake along the Chain occupying 1,700-acres; followed only by Grass Lake (1,623.4 acres). Grass Lake is the shallowest of the primary lakes with a maximum depth of 6 feet. Although much of Pistakee is shallow with an average depth of 7.4 feet, its maximum depth is 30 feet. Redhead, Matthews and Dunn's are smaller lakes at 50-acres; 8.76-acres; and 68-acres, respectively. Redhead and Matthews are connected via channels to Pistakee Lake and Dunn's via channelization to Nippersink Lake.

The Fox Chain is part of the Fox River Watershed that spans both Illinois and Wisconsin (Appendix A, Figure 2). The Fox River has its headwaters in Wisconsin and flows south into Illinois, entering the Fox Chain on the west side of Grass Lake. It flows south through Nippersink and Pistakee Lake and then exits south towards the town of Johnsburg (Lester, 2014). The Fox River eventually discharges into the Illinois River. The Wisconsin portion of the Fox River Watershed is approximately 600,000 acres (938 sq.-miles). The Illinois portion of the Upper Fox River Watershed drains land from McHenry and Lake Counties into the Fox Chain and is approximately 230,000 acres (362 sq.-miles) (AECOM,INC , 2009). Due to the large drainage basin and significant sources of water flow from the Fox River and its tributaries; the inflow of water can carry more nutrients and sediments into the lakes. The large watershed

makes it difficult to identify possible pollution sources, especially for nonpoint source pollution. The main tributaries into the Fox Chain O'Lakes include Nippersink Creek, Squaw Creek, Sequoit Creek, and Trevor Creek. Of those, Nippersink Creek is the largest tributary of the Fox River in Illinois at approximately 129,280 acres (202 sq.-miles), followed by Squaw Creek at 30,283 acres (47 sq.-miles), Sequoit Creek at 8,384 acres (13.1 sq.-miles) and Trevor Creek at greater than 10,110 acres. The Fox Chain O'Lakes is located in the flat gradient area of the Fox River, which means the deep glacial lakes and flat gradient can act as a sediment deposition area.

History

As far back as the 1870's the Fox Chain O' Lakes or as it was termed then, "The Pistaqua Lakes Region" was a popular get away destination by Chicagoans who used the area as a playground. At that time, the Fox Chain O' Lakes was a complex of marshland, meandering streams and shallow lakes, and were a sportsman's paradise as they were full of game, fish and waterfowl. The area was accessed by taking a train to McHenry and continuing to the lakes' by a steam paddle-wheeler called "The Steamboat Express". Today, the Fox Chain O' Lakes is known as "the world's busiest waterway on a per acre basis" currently registering 26,000 boats, either attached to weekend residents or the new breed of permanent residents (Fox Lake Chamber of Commerce, 2015). The area of the Fox Chain O' Lakes has transitioned from a tourist destination to being a recreational residential community.

Since 1850, dams constructed on the Fox River downstream of the Fox Chain 'O' Lakes, and at McHenry made access to the lakes possible. In 1906, the wooden dam structure at McHenry was replaced with an improved concrete structure, which was replaced in 1907 due to damage from ice and flooding of the newly constructed dam the year before. This damming resulted in a rise of 8 inches of water into Nippersink Lake and 6 inches measured at the north end of Fox Lake. In 1939, the McHenry dam was reconstructed once again due to the sheet pile dam being damaged by flooding in 1938. The 1939 dam raised the water elevation 3 feet which permanently inundated the marshlands of the Fox Chain 'O' Lakes and dramatically increased the amount of navigable water in the lakes'. The 1939 dam was improved in 1960 to include boat locks making the lakes, even more vulnerable to boating pressure (Lester, 2014; Ryder, 1998)

The lotus beds on Grass Lake were the number one attraction for tourists from 1870 until 1960 when they were nearly extirpated from the Fox Chain 'O' Lakes. The consensus blamed the raising of seasonal water levels (raising and lowering), increased motor boat traffic and water pollution coming from failing septic systems as contributing to the near elimination of the once prevalent lotus beds by 1960. It was only after the Fox River and Chain 'O' Lakes Waterway Agency enforced a "No Wake Zone" of 150 feet from the shorelines in 1993, that the lotus beds were documented as re-establishing in Grass Lake between 1992 – 1996.

Recreational boating is another pressure impacting the quality of the water and vegetation within the Fox Chain 'O' Lakes. In 1991, 18,555 motorboats were registered by the Fox River

and Chain 'O' Lakes Water Management Agency. Water studies conducted by the Army Corps of Engineers in 1991 -1992 identified boat propellers as a major contributor to the poor quality of aquatic habitat found on the Fox Chain 'O' Lakes. Boat races have continued to attract boating and racing enthusiasts to the Fox Chain 'O' Lakes since their inception in 1905 on Pistakee Bay.

Land use

The source of a lake's water supply is important in determining its water quality and for choosing appropriate management practices for the lake. The Fox Chain O'Lakes watershed extends significantly into Wisconsin and it is necessary to look at land use in both states to understand water quality in the Fox Chain. The Wisconsin portion of the watershed that drains into the Fox Chain is approximately 2.5 times larger than the portion of the watershed in Illinois. Land use data for Wisconsin was provided by the Southeastern Wisconsin Regional Planning Commission (SWRPC) in a geodatabase, which was then brought into ArcGIS10.1. Land use data for the Upper Fox River Watershed in Illinois was provided by Lake County and summarized from the 2009 Upper Fox River/Chain O'Lakes TMDL report.

The dominant land use for the entire watershed that drains to the Fox Chain O'Lakes, including Illinois and Wisconsin, is agriculture (42%) followed by residential (14.5%), wetlands (11.3%), and woodlands (9%). Table 1 lists percent land use within the Fox River Watershed that drains into the Fox Chain. While agricultural land is the most dominant in the watershed, there has been a progression of land use change from agriculture to residential uses over time in the region. The large portion of the watershed that is agriculture likely plays a significant role in the high concentrations of sediment and nutrients in the Fox Chain O'Lakes. Agricultural land use in Wisconsin is 48.4% of the watershed compared to 28.6% agricultural in Illinois. Near shore land use in the Fox Chain is primarily residential and wetlands/water – with municipalities also located near the lakes. Understanding dominant land uses can aid in the choosing appropriate management techniques for the watershed and individual lakes and help with targeting educational material.

Based on the amount of impervious surfaces each land use contributes varied amounts of runoff. Impervious surfaces (parking lots, roads, buildings, compacted soil) do not allow rain to infiltrate into the ground; a greater amount of runoff is generated than in more natural areas that allow water to infiltrate. Urbanized and built up areas account for approximately 24.5% of the watershed. The major sources of runoff for the Fox Chain is residential areas, which contribute approximately 32% of the runoff.

Table 1: Percentage of land use in the Fox River watershed that drains to the Fox Chain.

Land Use	Percentage of Land use in Wisconsin	Percentage of Land Use in Illinois	Total Percentage of Land use in Watershed
Agricultural	48.4	28.6	41.8
Disturbed Land	0.8	0.9	0.8
Forest and Grassland	8.7	9.6	9.0
Government and Institutional	0.8	1.3	1.0
Industrial	0.8	1.8	1.2
Residential (Multi and Single Family)	13.3	16.9	14.5
Public and Private Open Space	2.0	14.7	6.2
Retail and Commercial	0.9	1.3	1.1
Transportation, Utilities & Waste Facilities	6.4	4.9	5.9
Water	4.6	12.3	7.2
Wetlands	13.2	7.5	11.3
Total	**100.0**	**100.0**	**100.0**

Point Sources: NPDES Permits

As per the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waterbodies, including treated municipal effluent, treated industrial effluent and stormwater. Industrial, municipal, and other facilities are required to obtain an NPDES permit if their discharge goes directly into surface waters. Discharge from these facilities, including sewage treatment plants (STPs) and wastewater treatment plants (WTPs) play an important role in flow and nutrient dynamics into the lakes. Discharge can increase levels of nutrients (phosphorus and nitrogen) available in the water column. Total suspended solids, temperature, and flow amounts of the discharged waters can also impact the receiving waterbodies. STPs and WTPs are a large source of nutrient loading to tributaries that connect to the Fox Chain O'Lakes.

The discharge monitoring report (DMR) for three sewage treatment plants in the Illinois portion of the Upper Fox River Watershed are of interest due to their proximity to the Fox Chain O'Lakes. These include the Village of Fox Lake-Tall Oaks STP which discharges into an unnamed tributary to Dunn's Lake, Village of Spring Grove STP which discharges into

Nippersink Creek, and the Village of Antioch STP which discharges in Sequoit Creek. The Village of Fox Lake – Tall Oaks STP has a maximum allowable load of 3,650 lbs./yr of phosphorus and 4,752 lbs./yr of Ammonia as N. In 2014, their total loads were 184 lbs./yr of phosphorus and 156 lbs./yr of ammonia as N. The Village of Antioch STP has a maximum allowable load of 28,105 lbs./yr of phosphorus and 39,123 lbs./yr of ammonia as N. In 2014, the total loads were 3,053 lbs./yr of phosphorus and 728 lbs./yr of ammonia as N. Lastly, the Village of Spring Grove STP maximum allowable load is 487 lbs./yr. of ammonia as N and discharged 130 lbs./yr in 2014. All of the STPs remained below their maximum allowable load, but are still a significant source of nutrients to the watershed. For additional detailed information on these STPs and other NPDES permits in the watershed, refer to Appendix B and use the discharge monitoring report pollutant loading tool on the Environmental Protection Agency's website at http://cfpub.epa.gov/dmr/facility_search.cfm.

Lake Levels

Wide fluctuations in lake levels can create problems for lakeside residences, marinas, businesses, and impact near shore habitat for lake organisms. Changes in water level are typically associated with shifts in weather patterns, such as extended periods of unusually high or low precipitation. It may also be associated with human activities such as withdrawals for water use and dams that control water levels.

The main inflow into the Fox Chain lakes is the Fox River with Sequoit, Nippersink, Trevor and Squaw Creek being other significant tributaries. There is a minimal change in the stream gradient of the Fox River as it moves through the Chain O'Lakes. The elevation of the Fox River when it enters Illinois is 732 feet does not change as it leaves the Chain O'Lakes (AECOM, INC., 2009). The Stratton Dam in McHenry also helps artificially maintain these water levels.

There are three USGS gage stations in the Chain O'Lakes that measure real-time data of water levels (Appendix A, Figure 3). Water levels for the Fox Chain were compiled from these three gage stations, located at Johnsburg at Fox River, Nippersink Lake at Fox Lake, and Fox Lake near Lake Villa. These stations provide a decent lake level estimation of the Chain O'Lakes. Lake level is also artificially regulated by the McHenry Lock and Dam that is required to keep water levels between 3.8 – 4.2 feet (Fox Waterway Agency, 2015). During the monitoring season (May-September), lake levels fluctuated between 0.39 -0.53 ft. with Fox Lake near Lake Villa showing the largest lake fluctuation (0.53 ft.) and Johnsburg at Fox River station showing the least (0.39 ft.). September had the lowest water level consistently at all stations. The month of May had the highest water levels at Nippersink Lake at Fox Lake and Fox Lake near Lake Villa station, but June was the highest for the Johnsburg at Fox River station. Figure 1 depicts lake levels at the three stations for the monitoring station.

Retention time is the amount of time it takes for water entering the lake to flow out of it. Retention time for the Fox Chain O'Lakes varies by lake, but is relatively short as the Fox River flows through most of the lake systems. Retention times range from 4.3 days for Grass Lake

(directly connected to the Fox River) to 6 months for Channel and Lake Catherine (not connected to the Fox River) (AECOM,INC., 2009).

Precipitation

Heavy precipitation events can be a significant contributor to sediment and nutrients to the overall lake system and can sometimes explain water quality data. Precipitation data was obtained from the Lake County Stormwater Management Commission which has several climate monitoring stations throughout Lake County. Long Lake, just south-east of the Fox Chain was used to determine monthly precipitation totals. In 2014, May, June, and August were wetter-than-average months, with rainfall for June and August totaling greater than 6 inches in precipitation. The 2014 precipitation data was compared against the average precipitation amounts from 2008-2014, which were years that had daily precipitation data recorded at the Long Lake station (Figure 2).

Precipitation data was also compared to data from the southeast Wisconsin Climatology Office. Precipitation upstream in the watershed will greatly affect sediment and nutrients that is entering the Chain O'Lakes through overland flow and runoff. Compared to the Long Lake station, the Wisconsin data for south-east Wisconsin showed slightly higher amounts of precipitation for every month, except August 2014 in the Wisconsin data.

Figure 1: Lake Levels from USGS Gage Stations on the Fox Chain O'Lakes

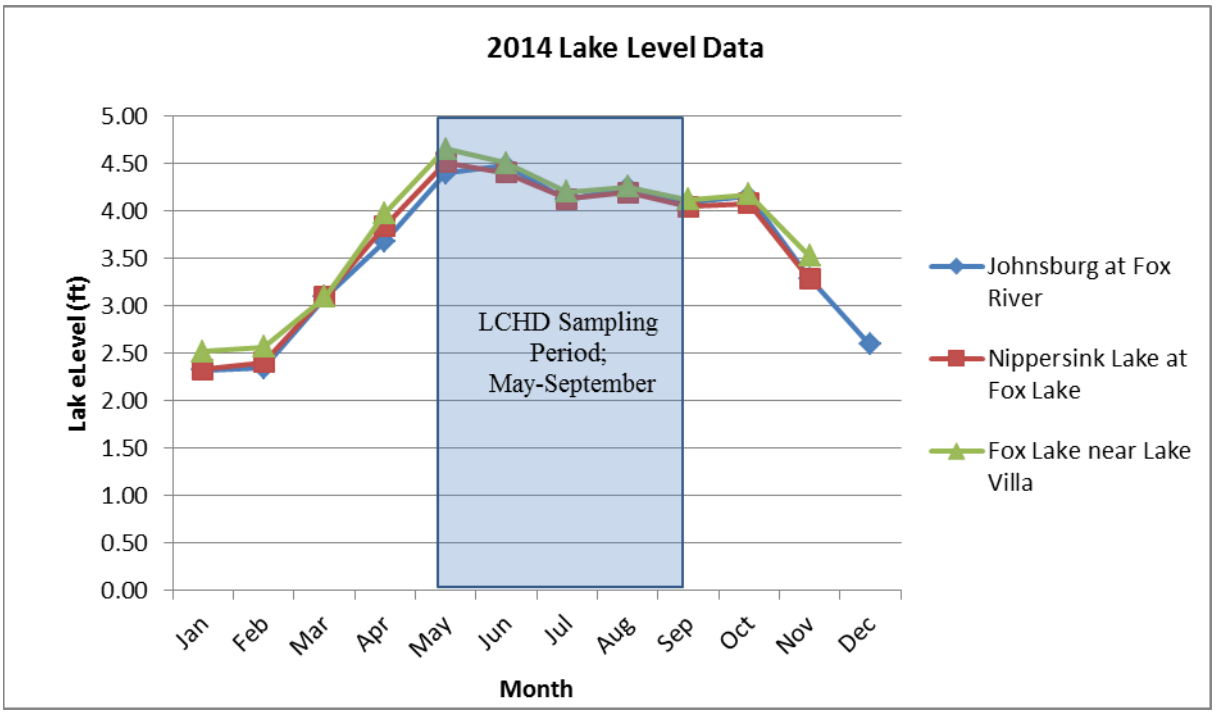
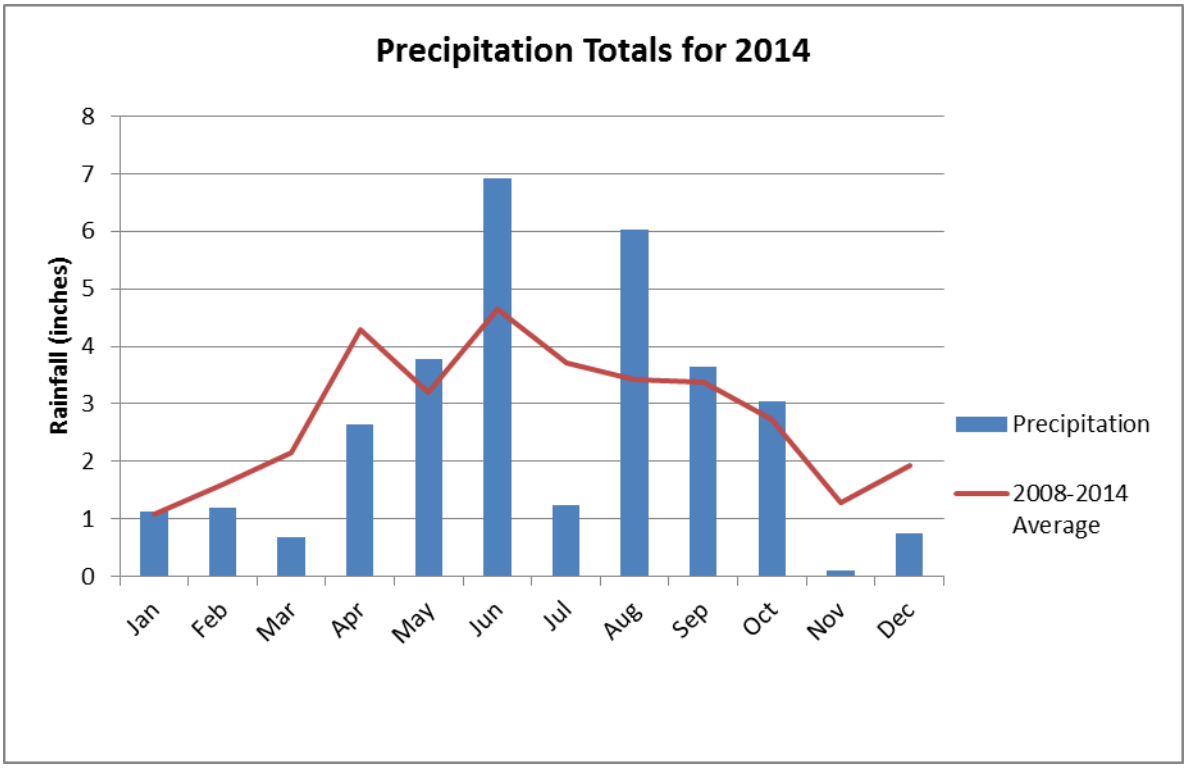


Figure 2: Monthly precipitation data for 2014 based on Long Lake station in Lake County, IL



Sediment

Sediment is a naturally occurring phenomenon that happens 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 are a major source of eutrophication of our lakes and streams. It also reduces water clarity, reducing 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 and thus water temperatures increase. This can cause problems with dissolved oxygen and some fish species become stressed.

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. The sediment load coming from all tributaries has been calculated to be steady, at approximately 100,000 cu.yds/year with

approximately 72% comes from the Fox River, 12% from Trevor Creek with the remaining 16% coming from Sequiot and Squaw Creeks (Fox River Waterway Agency, 2015). The Fox River Waterway Agency removes approximately 128,000 cu.yds. annually from the Fox Chain. Grass Lake is the main recipient of the sediment load. The Fox River Waterway Agency determines areas to be dredged on a rotational schedule, with some areas needing dredging every three to five years where other areas can be maintained with dredging occurring once every twenty years. Dredging occurred at select locations in 2014 (Appendix A, Figure 4). The Fox River Waterway Agency is not supported through tax revenues but by annual sticker fees required by boaters using the Fox Chain. Some of the sediment that is dredged is used to construct islands that provide habitat to birds navigating and nesting in and among the Fox Chain. There are threatened and endangered bird species who utilize the islands; however, recently LCHD-ES has observed increased gull activity on the islands as well. Additionally, some of the sediment that is dredged is made available for reuse.

The Fox Waterway Agency frequently tests the dredged soils and a 2005 sampling 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 (Appendix C: Lake and River Sediment Quality). Compared to sediment guidelines from MacDonald et. Al (2000), metal concentrations analyzed in the 2005 sampling by Hey and Associates are below the lowest effect level – meaning sediments are considered to be clean to marginally polluted and there are no effects expected on the majority of sediment dwelling organisms at these concentrations.

Water Quality

Water samples were collected once per month at 13 lakes within the Fox Chain O'Lakes. Samples were collected during the sampling season (May through September) at the deepest location in the lake (Appendix A, Figures 5-6). In deeper lakes, two water samples were collected one at three feet below the surface and one at 3 feet above the bottom. In shallow lakes, only one sample was collected at approximately 3 feet below the surface. Samples were collected with a horizontal Van Dorn water sampler. Approximately three liters of water were collected for each sample for all lab analyses. After collection, all samples were placed in a cooler with ice until delivered to the Lake County Health Department lab, where they were refrigerated. Field data collection and lab methods are described further in Appendix D. The following section describes water quality parameters for the Fox Chain O'Lakes. A complete list of water quality data is provided in Appendix B.

Water Clarity

Table 2: 2014 mean summer average Secchi depth by lake.

Lakes	Average Secchi Depth (ft.)
Bluff Lake	2.5
Channel Lake	2.8
Dunns Lake	1.2
Fox Lake	1.2
Grass Lake	0.9
Lake Catherine	2.9
Lake Marie	1.9
Lake Matthews	1.5
Lake Nippersink	0.9
Petite Lake	2.0
Pistakee Lake	2.1
Redhead Lake	2.2
Spring Lake	1.8

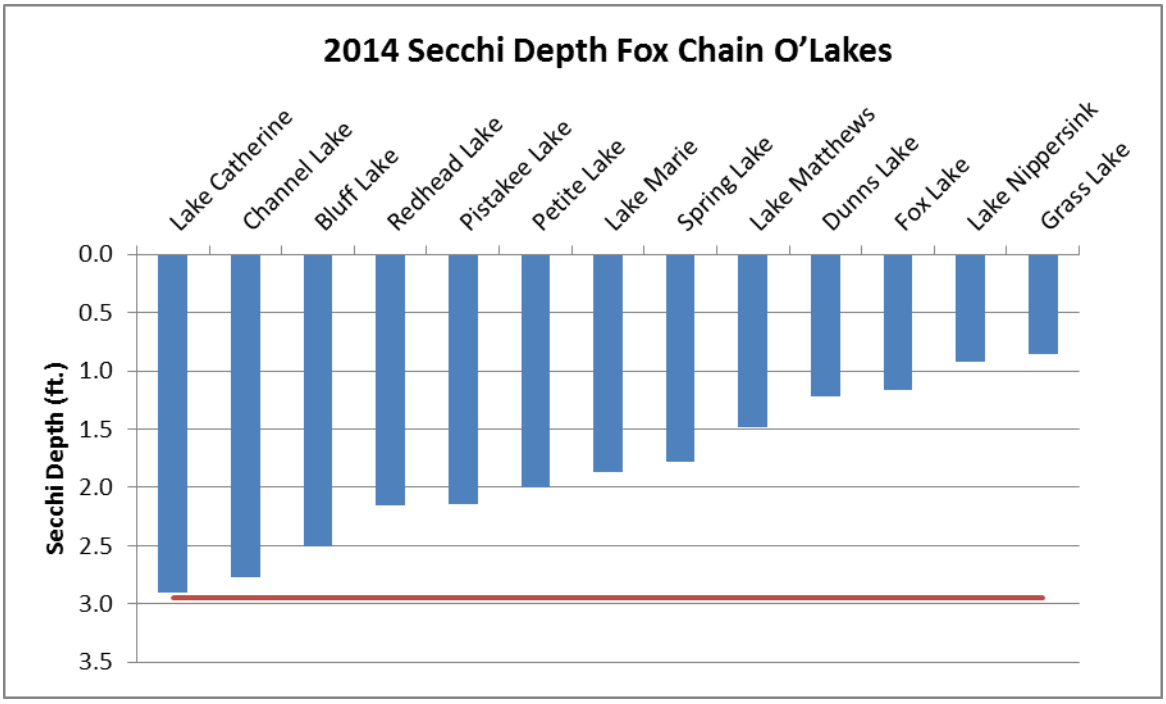
Water clarity, or water transparency, is an indicator of water quality related to chemical and physical properties. Water clarity is typically measured with a Secchi disk and indicates the amount of light penetration into a body of water. It can also provide an indirect measurement of the amount of suspended material in water. A number of factors can interfere with light penetration and reduce water transparency. This includes: algae, water color, re-suspended bottom sediments, and eroded soil. Generally the lower the water clarity or Secchi depth, the poorer the water quality. A decrease in Secchi depth during the summer can occur as a result of an increase in suspended solids (algae or sediment) in the water column.

Aquatic plants play an important role in the level of water clarity. Plants increase water clarity by competing with algae for nutrients and stabilizing sediments to prevent re-suspension of bottom sediments. A lake with a healthy plant community tends to have a higher Secchi depth and better water clarity. Presence of carp can also affect the water clarity of a lake. The feeding behaviors of common carp stir up bottom sediment and can reduce water clarity significantly in shallow lakes. Additionally, in the Fox Chain, recreational boating was observed to have a statistically significant correlation with turbidity (which reduces water clarity) on weekly and

daily basis (USACE, 1994).

The average Secchi depth for the Fox Chain O'Lakes is 1.83 ft., which is significantly below the Lake County median of 2.95 ft. The lakes with the poorest water clarity within the Fox Chain O'Lakes are Nippersink and Grass which had a mean summer average Secchi depth below 1.0 ft. Poor water clarity correlates with high total suspended solids (TSS) concentrations and Grass Lake has the highest TSS concentration in the Fox Chain and is a known sink for sediment entering the lake system from its tributaries. The low Secchi depth reading and poor water clarity is related to this the influx of sediment and how easily the sediment can be resuspended in the water column, due to the lake's shallow morphology.

Figure 3: Secchi depth during the 2014 monitoring season for each lake in the Fox Chain O'Lakes compared to the Lake County median Secchi depth (2.95 ft.).

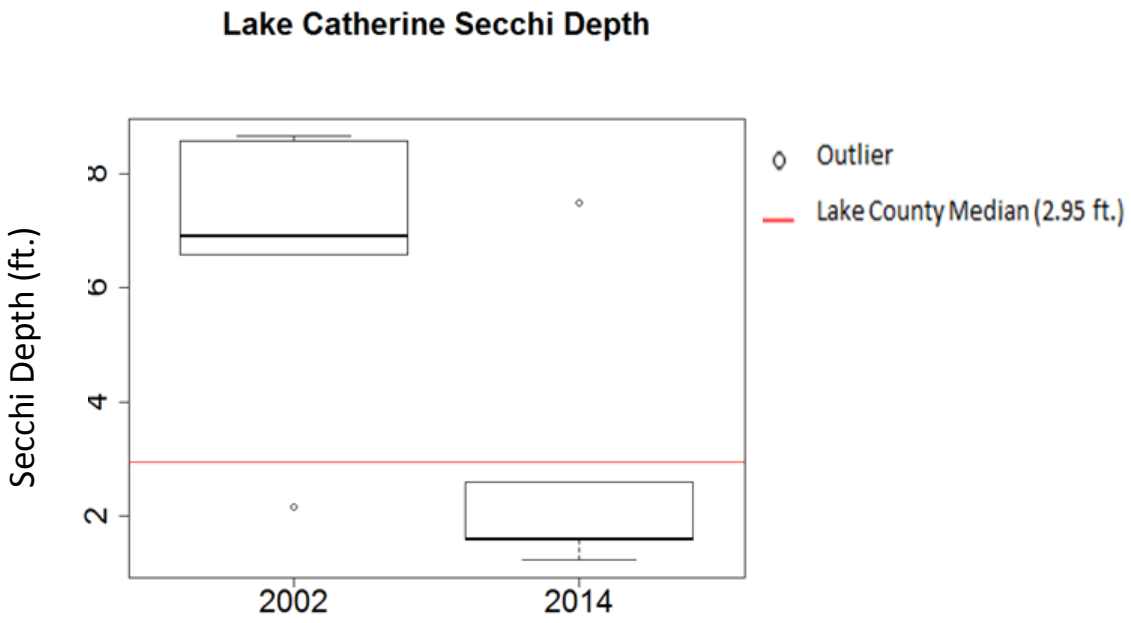


Lake Catherine, Channel Lake, and Bluff Lake have Secchi depths greater than 2.5 ft. (Figure 3). Catherine, Channel, and Bluff are part of the Fox Chain that the Fox River does not flow through and instead the greatest sediment input is from Trevor Creek. For the 2014 monitoring season, June had the deepest Secchi depth in Bluff, Catherine, and Channel with Secchi depths of 4.92, 7.5 ft., and 6.9 ft., respectively. Low water clarity occurred in September in these lakes when Secchi depths dropped to 1.0 ft., 1.23 ft., and 1.25 ft. in Bluff, Catherine and Channel, respectively. The decrease in Secchi depth and water clarity in September is most likely attributed to the increase in TSS observed in the water quality data. These lakes all thermally stratified in the summer and the thermocline began to weaken in September. With the weakening of the thermocline, particles are re-mixed throughout the water column increasing TSS and decreasing water clarity. Algae were also noticed during the September sampling, likely a result

lake mixing creating an influx of nutrients available in the epiliminion.

Lake Catherine and Channel Lake have seen significant drops in Secchi depth since the 2002 sampling period (Figure 4). Channel Lake and Lake Catherine have had a Volunteer Lake Monitoring Program (VLMP) volunteers since 2011 that collected Secchi data twice a month during May- October. The VLMP data shows a significant decrease in Secchi depth after 2011 in both of these lakes (Figure 5). This shows the importance of lakes participating in the VLMP program so that yearly data can be collected. Yearly data on water clarity can then be used to observe anomalies or changes within the lake and can help with lake management decisions. It is difficult to determine the reason for the decrease in water clarity. Low abundance of native aquatic plants and increased boating activities since 2002 may have contributed to higher TSS values in the water column, decreasing water clarity

Figure 4: *Boxplots show a significant decrease in Secchi depths from 2002 to 2014 sampling on Lake Catherine and Channel Lake*



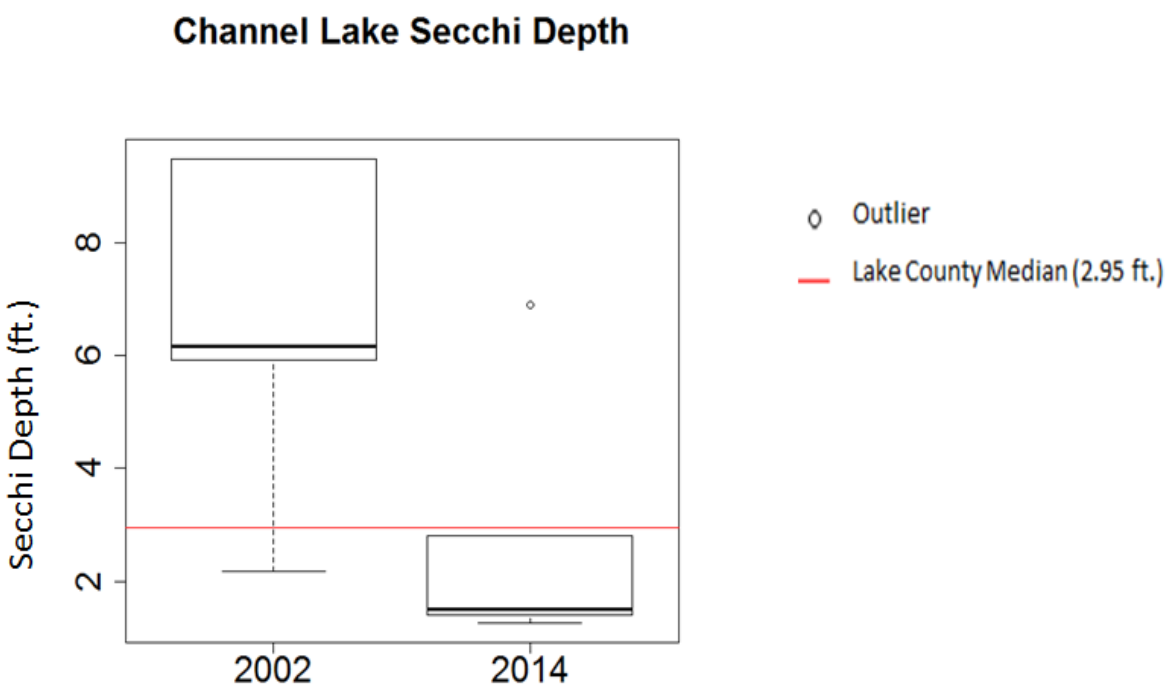
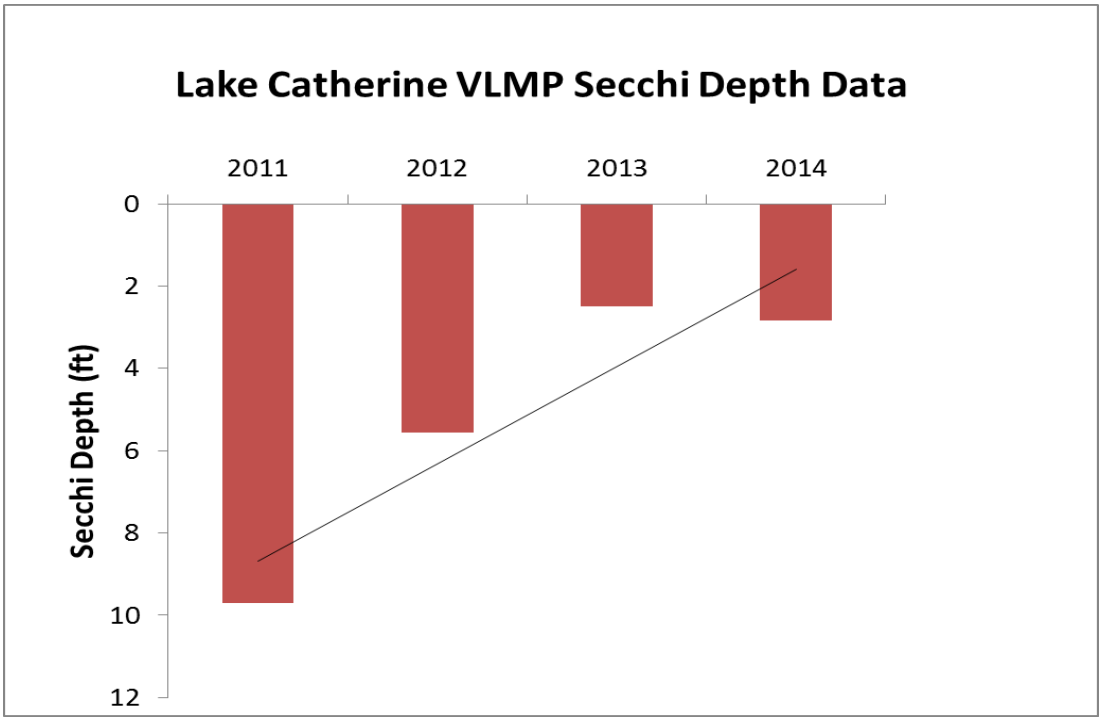
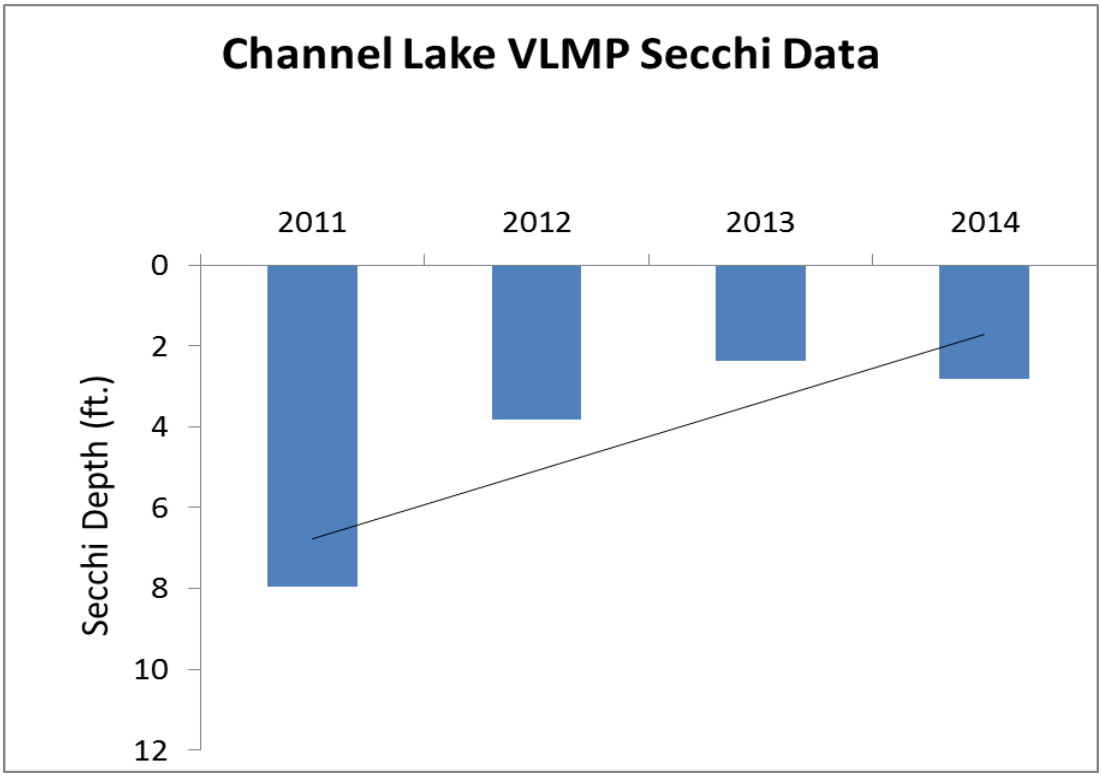


Figure 5: *Lake Catherine and Channel Lake Volunteer Lake Monitoring Program (VLMP) Secchi depth data; showing a decline in secchi depth since 2011.*





Solids

Table 4: *2014 Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Total Volatile Solids (TVS) average concentrations in the epiliminion of the lakes within the Fox Chain.*

Lakes	*TDS (mg/L)	TSS (mg/L)	TVS (mg/L)	TSS Impairment
Bluff Lake	429	11.0	125	No
Channel Lake	369	9.6	119.2	No
Dunns Lake	455	33.2	161.8	Yes
Fox Lake	451	24.4	136.2	Yes
Grass Lake	459	38.7	138.6	Yes
Lake Catherine	374	9.6	112.4	No
Lake Marie	433	13.2	127	No
Lake Matthews	436	25.0	132.2	No
Lake Nippersink	454	31.1	153.4	Yes
Petite Lake	430	14.9	138.2	No
Pistakee Lake	430	14.8	128.6	No
Redhead Lake	396	13.3	126	No
Spring Lake	427	15.1	130.2	No

*TDS is a calculated value.

Another measure of water clarity is turbidity and total suspended solids. Suspended particles dissipate light, which affects the depth at which plants can grow. The total suspended solid (TSS) parameter represents the concentration of all organic and inorganic materials suspended in the lake's water column. Typical inorganic components of TSS are referred to as non-volatile suspended solids (NVSS) and are a calculated value. NVSS originate from weathering and erosion of rocks and soils within the lake's watershed and re-suspension of the lake's sediment. The organic portion of TSS is called volatile suspended solids (TVS) and is mostly composed of algae and other organic matter (i.e. plant material). High TSS values are typically correlated with low water clarity (Secchi disk depth) and high phosphorus concentrations and can be detrimental to many aspects of a lake's ecosystem including the plant and fish communities.

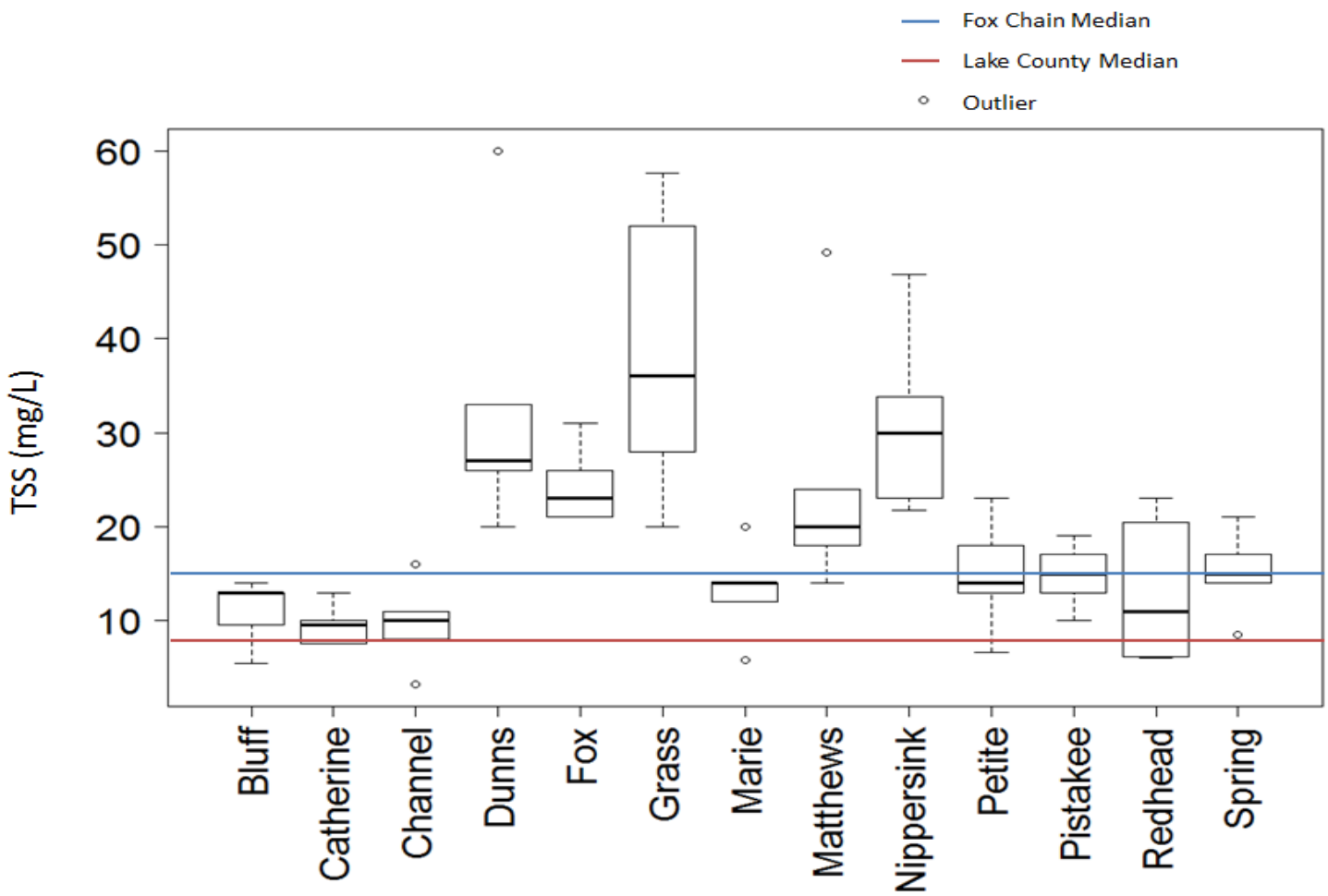
2014 TSS concentrations for the Fox Chain averaged 20 mg/L which is above the Lake County median of 8.2 mg/L. TSS concentrations ranged from 9.6 mg/L (Lake Catherine) to 38.7 mg/L (Grass Lake). Grass Lake is a known sink for most of the sediment entering the Chain of

Lake and contributes to its high TSS concentration.

A lake can have a TSS impairment which is based on if the median surface NVSS is greater or equal to 12 mg/L for the monitoring season. Based on the 2014 sampling data, 4 out 13 lakes within the Fox Chain O'Lakes have TSS impairments, including: Dunn's, Grass, Fox, and Nippersink lakes. Recreational boating is an important activity in the Fox Chain O'Lakes and has a significant impact on the re-suspension of soft sediments within the shallow lakes. A 1994 report from the Army Corps of Engineers studied the impact of boating on sediment resuspension on the Fox Chain O'Lakes and stated that recreation boating enhances turbidity in water less than 6 feet deep and increases shoreline erosion. Boating re-suspends materials through propellers wash and wave generation – and impacts turbidity, aquatic vegetation, and fish spawning areas (USACE, 1994).

The percentage of TSS that are non-volatile suspended solids gives insight into the source of the suspended solids. Lakes that have a higher percentage of NVSS to TSS represent more allochthonous (originating outside of the lake) input into the lakes or re-suspended sediment (Jones and Knowlton, 2005). Grass, Nippersink and Dunn's all have a higher percentage of NVSS to TSS with 71%, 69%, and 60%, respectively. Catherine and Channel have low percentage of NVSS to TSS with 35% and 37%, respectively. Lakes with higher ratio of NVSS to TSS indicate that the suspend solids are more indicative of inorganic material whereas lakes with lower % NVSS may have more algae and organic material.

Figure 6: *The boxplot shows the range of values for TSS concentrations in the epiliminion during the 2014 monitoring season for each lake in the Fox Chain O'Lakes.*



Nutrients: Phosphorus

Table 5: *2014 Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP) average concentrations in the epiliminion in the Fox Chain O'Lakes.*

Lake Name	Average TP (mg/L)	SRP (mg/L)
Bluff Lake	0.112	0.006
Channel Lake	0.068	0.0056
Dunn's Lake	0.107	<0.005
Fox Lake	0.094	0.0058
Grass Lake	0.109	0.0058
Lake Catherine	0.062	<0.005
Lake Marie	0.103	<0.005
Lake Matthews	0.118	<0.005
Lake Nippersink	0.099	0.009
Petite Lake	0.102	0.0062
Pistakee Lake	0.088	<0.005
Redhead Lake	0.061	<0.005
Spring Lake	0.110	0.0066

Organisms take nutrients in from their environment. In a lake, the primary nutrients needed for aquatic plant and algal growth are phosphorus and nitrogen. For most Lake County lakes, phosphorus is the limiting nutrient, which means everything that plants and algae need to grow is available in excess: sunlight, warmth, and nitrogen. Nitrogen, as well as carbon, naturally occur in high concentrations and come from a variety of sources (soil, air, etc.) which are more difficult to control than sources of phosphorus. Lakes that are phosphorus-limited may be easier to manage, since controlling phosphorus is more feasible than controlling nitrogen or carbon. The source of phosphorus to a lake can be external, internal, or both. Phosphorus originates from a variety of external sources, many of which are related to human activities which include: human and animal waste, soil erosion, detergents, sewage treatment plants, septic systems, and runoff from lawn. The unincorporated areas of the Fox Chain O'Lakes use septic or surface discharge systems for sewage disposal. The discharge of untreated septic tank effluent to a lake or watershed adds phosphorus into the system. Home owners should use phosphorus free fertilizer on their lawns. Local municipalities in Lake County are starting to take notice of the benefits of instituting a no P fertilizer ordinance. In January 2008, the Village of Antioch became the first municipality in Illinois to enact a ban on the use of P fertilizers within village limits,

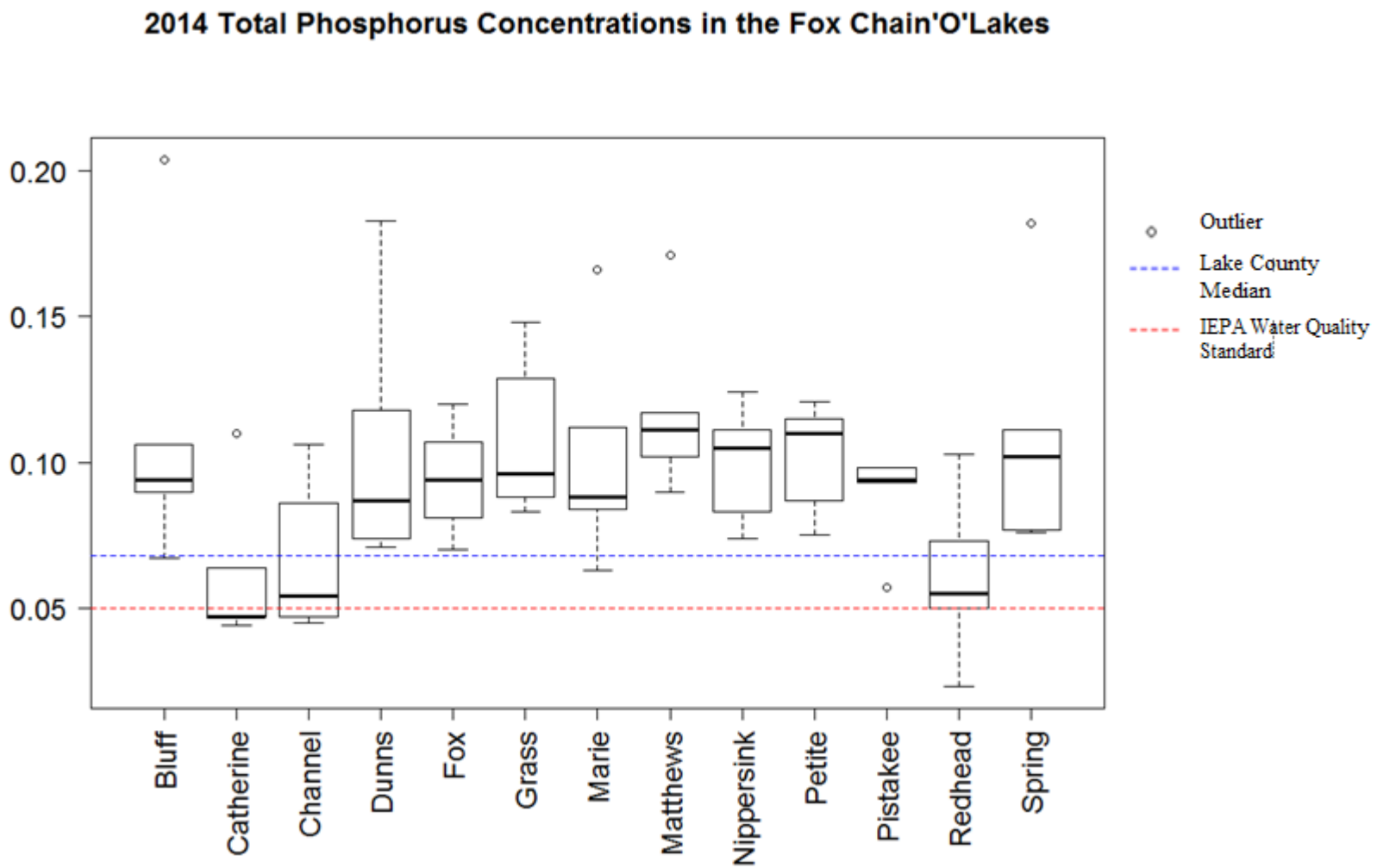
requiring stores that carry fertilizer to post signs about the ban and to provide a no P fertilizer alternative. Additionally, in July of 2010, the state of Illinois passed a law restricting the use of lawn fertilizers containing phosphorus by commercial applicators. Actions like this in Illinois and other states have allowed for fertilizer companies to develop zero phosphorus fertilizer which is now commonly used and sold in many stores.

Phosphorus can also originate from internal sources. Internal sources of phosphorus originate with in the lake and are typically linked to the lake sediment. Carp spawning and feeding activity can release phosphorus by stirring up the bottom sediment and can add phosphorus through their fecal matter. Sediment resuspension and subsequent phosphorus release can also occur through wind/wave action or heavy boat traffic especially in shallow lakes like Fox, Grass and Nippersink lakes. Lakes that experience anoxic conditions also contribute to the release of P from the bottom sediments.

The 2014 average total phosphorus (TP) concentration in the epiliminion for the entire Fox Chain O' Lakes was 0.095 mg/L. Lakes with concentrations exceeding 0.050 mg/L can support high densities of algae and aquatic plants, which can reduce water clarity and dissolved oxygen levels and are considered impaired by the IEPA. All 13 lakes within the Fox Chain O'Lakes exceed the 0.05 mg/L IEPA standard and are considered impaired for TP.

Additionally, sewage treatment plants located within the watershed can influx amounts of the phosphorus in the lakes. While below their yearly maximum allowable loads, the Village of Fox Lake – Tall Oaks STP and the Village of Antioch STP discharged 184 lbs./yr 3,053 lbs./yr of phosphorus in 2014, which may impact nutrient conditions in the lakes.

Figure 7: This boxplots show the range of values for TP concentrations during the 2014 monitoring season for each lake in the Fox Chain O'Lakes. The blue dashed line represents the Lake County median TP concentration (0.068 mg/L) and the red dashed line represents the IEPA Water Quality Standard for TP (0.05 mg/L).



Nutrients: Nitrogen

Table 7: 2014 Nitrogen concentrations in the epilimnion in the Fox Chain O'Lakes

Lake Name	TKN (mg/L)	NH3 (mg/L)	NO2-NO3 (mg/L)
Bluff Lake	1.90	0.25	0.12
Channel Lake	1.46	0.12	<0.05
Dunns Lake	2.33	0.17	0.18
Fox Lake	1.69	0.16	0.18
Grass Lake	1.52	<0.10	0.34
Lake Catherine	1.40	0.11	0.05
Lake Marie	1.80	0.18	0.12
Lake Matthews	1.91	<0.10	<0.05
Lake Nippersink	1.45	<0.10	0.39
Petite Lake	1.83	0.15	0.09
Pistakee Lake	1.65	0.15	0.22
Redhead Lake	1.27	<0.10	<0.05
Spring Lake	1.91	0.24	0.11

Nitrogen is the other nutrient critical for algal growth. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen, and is typically bound up in algal and plant cells. The average 2014 TKN for the Fox Chain O' Lakes was 1.70 mg/L, which was above the county median of 1.20 mg/L (Figure 8). The inorganic form of nitrogen is also important for plant growth and was analyzed in the form of Nitrate-Nitrite (NO2-NO3-N). In 2014, nitrate-nitrite nitrogen for the Chain was 0.150 mg/L; sources of this nitrogen could be numerous, but could have washed in from spring fertilizers or from upstream wastewater treatment facilities or failing septic systems. Fertilizers, particularly in the spring, may contain high concentrations of nitrogen to promote plant grow in both agricultural and residential areas. In May of 2014 an elevated of nitrate/nitrite was detected (0.472 mg/L), just after the spring thaw. While these nitrate/nitrite values were elevated, they do not exceed IL water quality standards. Lakes in the Fox Chain that show this pattern of elevated nitrate/nitrite in the spring/early summer include: Bluff, Fox, Grass, Marie, Nippersink, Petite, Pistakee, and Spring (Figure 9).

The Fox Chain O' Lakes has an average total nitrogen to total phosphorus (TN:TP) ratio of 20:1 which indicates that phosphorus was the nutrient limiting aquatic plant and algae growth in the Fox Chain O' Lakes. This ratio has a direct effect on how much aquatic plant and algae can grow in lakes. Lake Matthews had the highest average TP concentration of 0.1182 mg/L and

a 17:1 (TN:TP)ratio while Redhead Lake had the lowest TP concentration of 0.061 mg/L and a 22:1 (TN:TP) ratio.

Sewage treatment plants can play a role in nutrient fluxes in the lakes as well. The Village of Spring Grove is a sewage treatment plant that discharges into Nippersink Creek and could impact Nippersink Lake, Pistakee Lake, and Redhead Lake. The Village of Spring Grove. This could impact the greater amounts of Nitrate-Nitrite observed in Nippersink and Pistakee in July compared to other lakes in the Fox Chain (Figure 9); although the STP is a few miles upstream of Nippersink Lake. While the STPs were below the maximum allowable loads for the year, the Village of Fox Lake – Tall Oaks, Village of Antioch STP and the Village of Spring Grove total loads of ammonia as N for 2014 were 156 lbs./yr, 728 lbs./yr, and 130 lbs./yr, respectively.

***Figure 8**: 2014 Total TKN concentrations in the epiliminion for the Fox Chain O'Lakes*

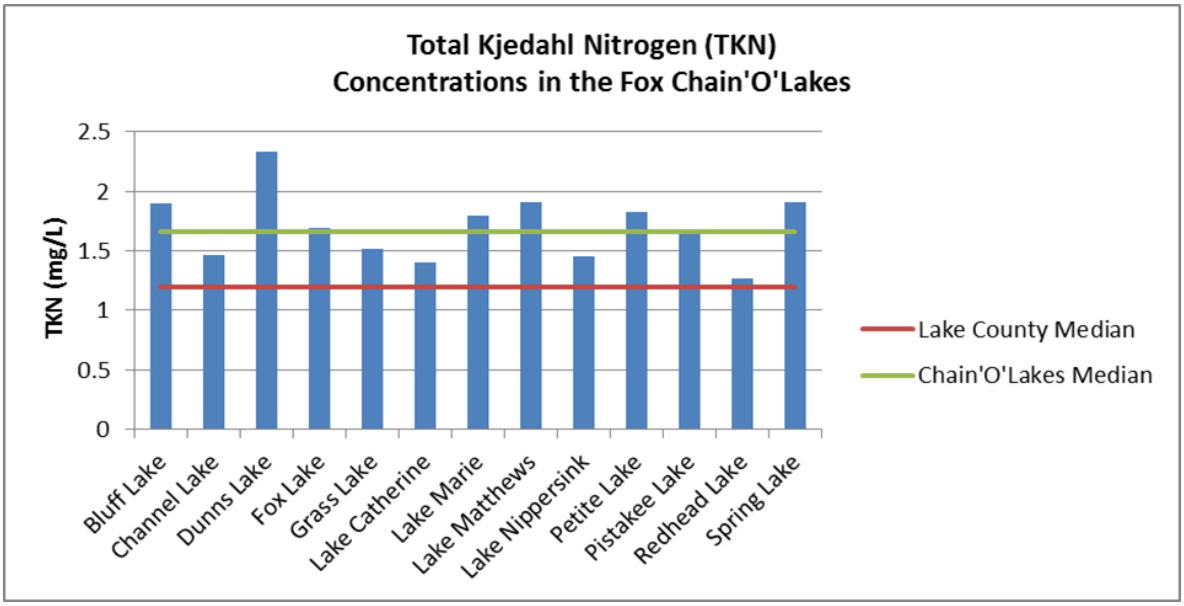
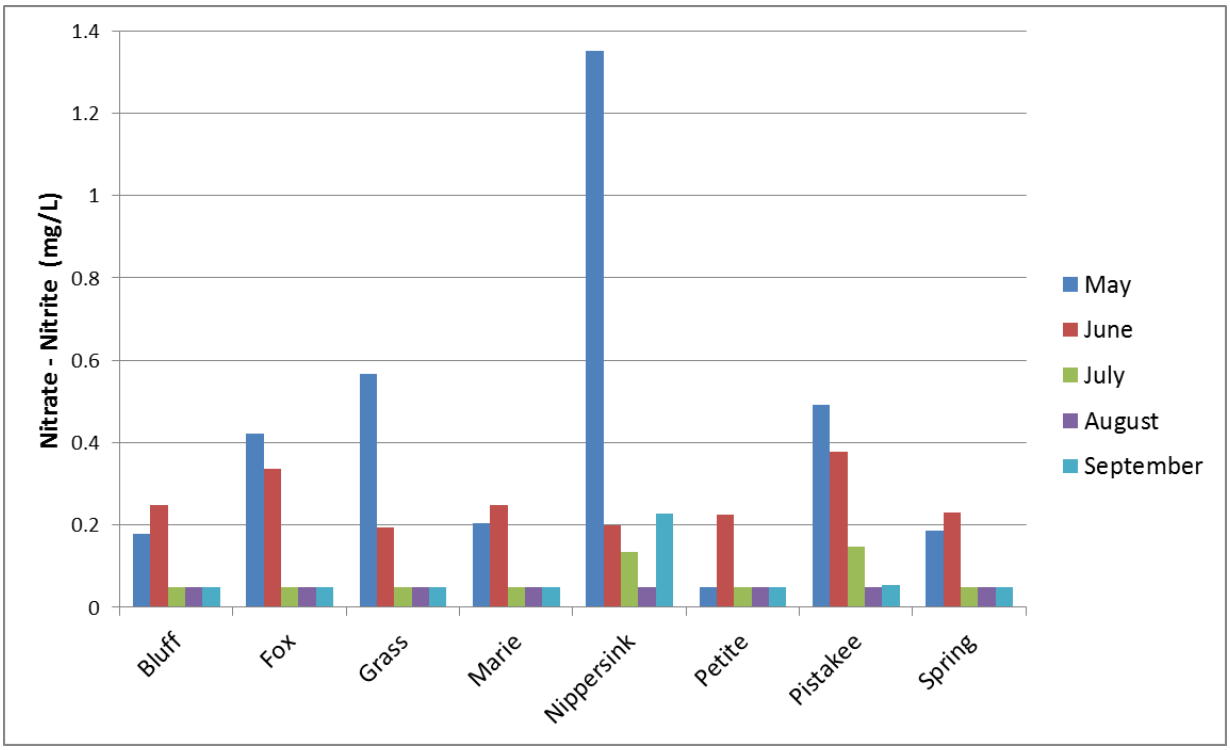


Figure 9: *Nitrate-Nitrite concentrations in the epilimnion for lakes in the Fox Chain who experienced a spring flush of nitrogen. The graph depicts that May and June see increased concentrations of Nitrate-Nitrite compared to July – September, which were typically below detectable limit (0.05 mg/L).*



Conductivity and Chloride

Table 8: 2014 Chloride and Conductivity average concentrations in epiliminion of sampled lakes in the Fox Chain.

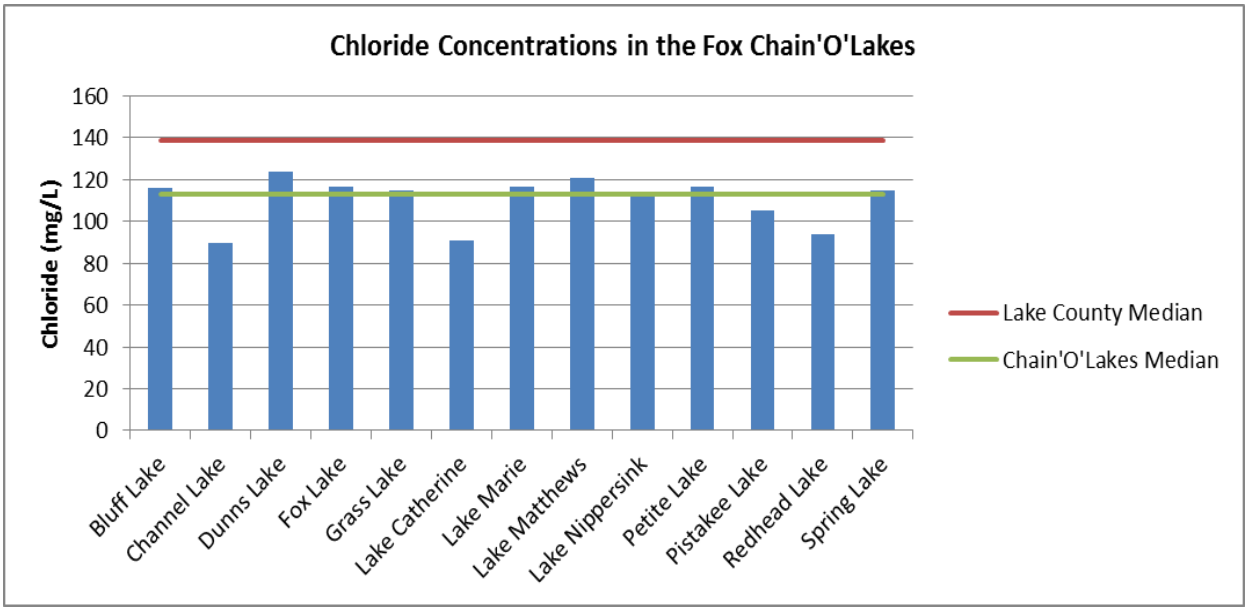
Lakes	Chloride (mg/L)	Conductivity (mS/cm)
Bluff Lake	116	0.7597
Channel Lake	90	0.6397
Dunn's Lake	124	0.8102
Fox Lake	117	0.8020
Grass Lake	115	0.8178
Lake Catherine	91	0.6493
Lake Marie	116	0.7668
Lake Matthews	121	0.7730
Lake Nippersink	113	0.8090
Petite Lake	116	0.7607
Pistakee Lake	104	0.7614
Redhead Lake	94	0.6932
Spring Lake	115	0.7557

Conductivity is a measure of a waters ability to conduct electricity, measured by the water's ionic activity and content. The higher the concentration of (dissolved) ions the higher the conductivity becomes. Conductivity readings, which are influenced by chloride concentrations, have been increasing throughout the past decade in Lake County. Lakes with residential and/or urban land uses in their watershed often have higher conductivity readings and higher Cl- concentrations because of the use of road salts. Storm water run-off from impervious surfaces such as roads and parking lots can deliver high concentrations of Cl- to nearby water bodies. Road salt used in the winter road maintenance consists of the following ions: sodium chloride, calcium chloride, potassium chloride, magnesium chloride, or ferrocyanides which are detected when chlorides are analyzed.

The 2014 average conductivity for Fox Chain O'Lakes 0.7537 mS/cm. This parameter was below the county median of 0.7875 mS/cm, but is a 9.1% increase from the 2002 value of 0.7135 mS/cm. These values are influenced by the winter road maintenance of roads, commercial lots and the surrounding residential areas. The United States Environmental Protection Agency has determined that chloride concentrations higher than 230 mg/L can disrupt aquatic systems and prolonged exposure can harm 10% of aquatic species. The Illinois chloride standard is 500 mg/L. The average chloride concentration in the Chain for 2014 was 110 mg/L. Chlorides tend to accumulate within a watershed as these ions do not break down and are not

utilized by plants or animals. High chloride concentrations may make it difficult for many of our native species to survive. However, many of our invasive species, such as Eurasian Watermilfoil, Cattail and Common Reed, are tolerant to high chloride concentrations.

Figure 10: 2014 average chloride concentrations in the Fox Chain O'Lakes.



Trophic State Index

Table 9: 2014 TSIp rankings for lakes within the Fox Chain O'Lakes

RANK	LAKE NAME	TSIp AVE
65	Redhead	63.20
69	Catherine	63.76
77	Channel	64.91
87	Nippersink	68.00
96	Pistakee	68.71
110	Fox	70.52
113	Petite	70.84
115	Marie	70.93
116	Dunns	71.53
119	Grass	71.77
120	Spring	71.93
125	Bluff	72.00
130	Matthews	72.90

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). A lake's response to additional phosphorus is an accelerated rate of eutrophication. Eutrophication is a natural process where lakes become 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 takes thousands of years. However, human activities that supply lakes with additional phosphorus that drives eutrophication is speeding up this 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, The Fox Chain O' Lakes was eutrophic with a TSIp value of 65.6. Values ranged from eutrophic Redhead Lake with a TSIp value of 63.38 to the hypereutrophic Lake Matthews with a TSIp value of 73.19, ranking 65th and 130th out of 171 lakes studied by the LCHD-ES from 2000-2014 (Appendix B).

Temperature

Water temperature fluctuations will occur in response to changes in air temperatures and can impact other water quality parameters. Monthly temperature profiles were established on each lake by measuring water temperature every foot (for lakes ≤ 15ft deep) or every two feet (for lakes ≥ 15 feet deep) from the surface of the lake to the lake bottom. These profiles are important in understanding the distribution of chemical and biological characteristics because they are affected by increasing water temperatures and thermal stratification. As surface water temperatures increase with increasing air temperatures, typically in the summer months, a large density difference can form between the heated surface water and colder bottom water. Once this difference is large enough, these two water layers will separate and not mix until the density difference is broken. In shallow lakes, stratification and de-stratification can occur several times during the year. Temperature and stratification can have a direct impact on dissolved oxygen (DO) concentrations in the water column.

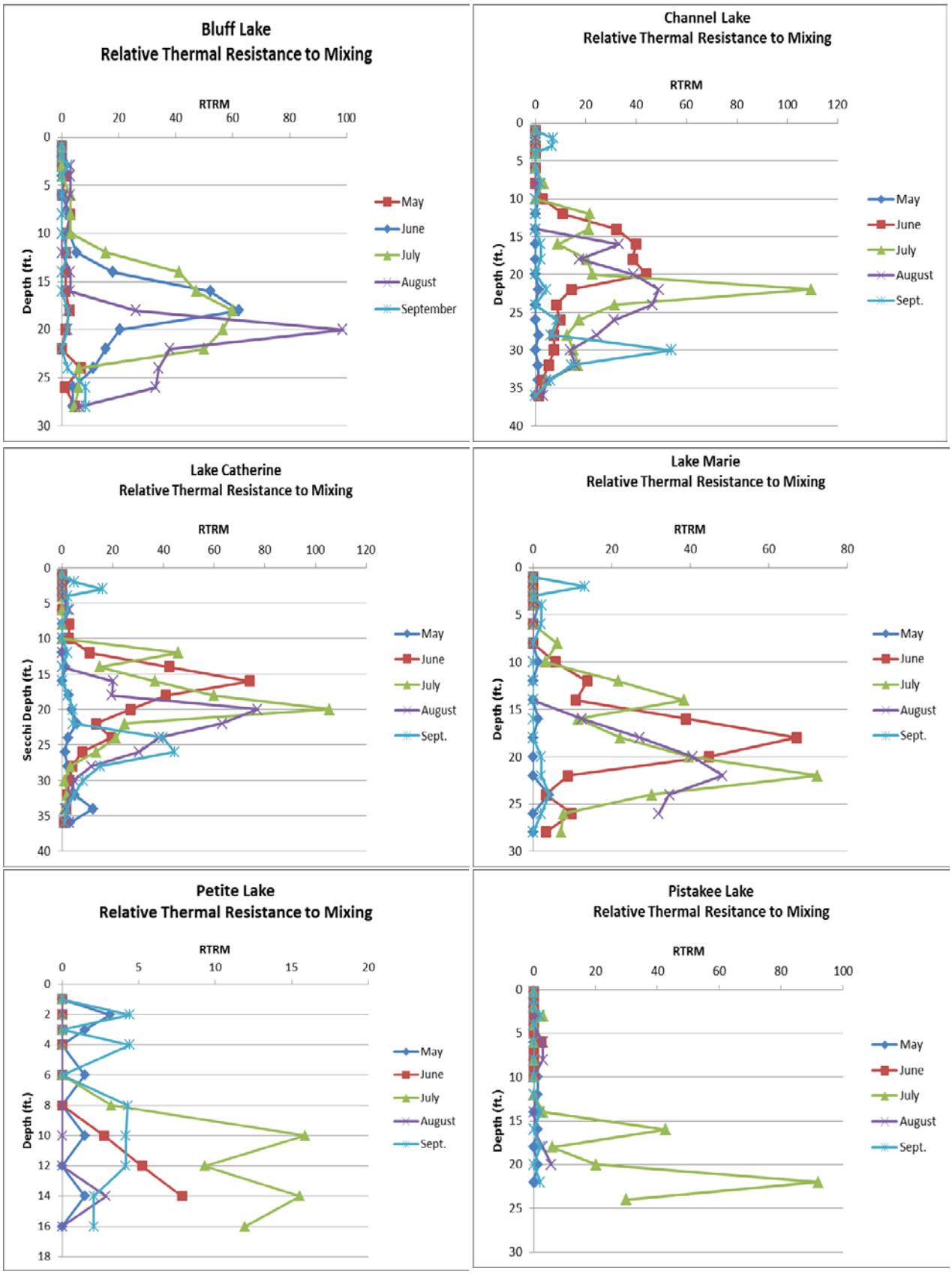
Temperature is used to determine the relative thermal resistance to mixing (RTRM), an index for quantifying thermal stratification in lakes. Calculating the RTRM for each month's depth profiles can identify the thermocline and stability of stratification. The peak RTRM identifies the location and intensity of the thermocline (steepest density gradient). Table 10 lists which lakes within the Fox Chain stratified during the 2014 season based on calculated RTRM. When an RTRM value is greater than 20, it is identified as strong enough to stratify. Lakes in the Fox Chain that stratify during the sampling season are: Bluff, Channel, Catherine, Marie, and Pistakee (Figure 11).

Table 10: 2014 Stratified period on lakes within the Fox Chain O'Lakes.

Lake	Stratified	Does the lake reach anoxic conditions?	Length of Stratified Season
Bluff	Stratified	Yes	June - August
Catherine	Stratified	Yes	June – September*
Channel	Stratified	Yes	June – September*
Dunns	Mixed	No	NA
Fox	Mixed	No	NA
Grass	Mixed	No	NA
Marie	Stratified	Yes	June - August
Matthews	Mixed	No	NA
Nippersink	Mixed	No	NA
Petite	No	Yes	Weakly stratified July
Pistakee	Stratified	Yes	July
Redhead	Mixed	No	NA
Spring	Mixed	No	NA

**LCHD-ES sampling season ended in September. The September sampling date at these lakes did not capture turnover.*

Figure 11: RTRM values by month for Fox Chain O'Lakes



Dissolved Oxygen

Dissolved oxygen (DO) is a major indicator of water quality and is important for aquatic organisms, algae, macrophytes, and for many chemical reactions to occur that are crucial for lake functions. Dissolved oxygen concentrations can have large variations occurring and are affected by diffusion, aeration, photosynthesis, respiration, and decomposition. Temperature, salinity and pressure changes will also cause DO to fluctuate. Dissolved oxygen will vary both seasonally and by depth throughout the water column in lakes. Similar to temperature profiles, dissolved oxygen concentrations were collected on each lake once a month by measuring DO concentrations every foot (for lakes ≤ 15ft deep) or every two feet (for lakes ≥ 15 feet deep) from the surface of the lake to the lake bottom.

If DO concentrations drop below levels that may stress aquatic life (below 5.0 mg/L at 1 foot depth below the lake surface) it becomes a water quality impairment. Low dissolved oxygen primarily is a result of excessive nutrients that stimulate growth of organic matter, such as algae, or the increase of pollutants such as sewage, lawn clippings, and soils that are considered to be "oxygen-demanding". Low dissolved oxygen levels is also often a factor for fish kills. Winter fish kills typically occur when respiration from fish, plants and other organisms is greater than the oxygen production in the lake by photosynthesis. They occur when the water is covered by ice and so cannot receive oxygen by diffusion. High dissolved concentrations can also cause problems in lakes. Supersaturated water can cause gas bubble disease in fish and invertebrates and significant death rates can occur when oxygen remains above 115-120% air saturation for a period of time. Algae blooms can cause supersaturated conditions. If a lake is shallow and easily mixed by wind, the DO concentration is usually consistent throughout the water column. However, shallow lakes are typically dominated by either plants or algae. When many of the plants or algae die at the end of the growing season, their decomposition can significantly reduce DO concentrations. In deeper, thermally stratified lakes, oxygen production is greatest in the upper water layer (epilimnion) where sunlight drives photosynthesis and oxygen consumption is greatest near the bottom of the lake (hypoliminion) where organic matter accumulates and decomposes.

Bluff Lake is the only lake in the Fox Chain that is considered impaired for dissolved oxygen. Bluff Lake's dissolved oxygen concentrations were recorded as 4.73 mg/L at 1 depth below the lake surface on the August sampling date (8/13/2014) which qualifies as a DO impairment. Petite and Marie, lakes near Bluff Lake and sampled on the same day, also had low dissolved oxygen levels. A precipitation event that occurred on 8/11 – 8/12 with approximately 1.94" of rain may have contributed to the decrease in DO on this sampling date. Stormwater from the precipitation events carry oxygen-demanding substances. Sources of oxygen-demanding substances vary from natural (animal waste, decaying vegetation) or human-related sources (oils, greases, grass clippings, pet waste). A heavy precipitation event like the one that occurred in August could send a large pulse of these substances into the lake, reducing dissolved

oxygen. Since the LCHD-ES was monitoring the day after the storm, the decreased DO levels could be a result of this precipitation event.

Dissolved Oxygen profiles can inform us about anoxic conditions (DO ≤ 1mg/L) that may occur in the bottom of lakes. Certain chemical reactions only occur in anoxic conditions; with the primary one of interest in lakes is the release of phosphorus from sediment. This means in anoxic conditions, microbial processes release phosphorus that is typically bounded (and not usable) in sediment particles. When the lake is no longer stratified and the water column mixes, this phosphorus is now available for use and can lead to increased algal blooms. This source of phosphorus is known as "internal loading". Table 10 lists lakes that reach anoxic conditions during the 2014 monitoring season.

Stratification and Nutrients

Stratification has important implications for fisheries, management, phytoplankton populations and water quality. Dimictic lakes often stratify in the summer and have two main mixes, in the spring and fall. In the Fox Chain; Bluff, Catherine, Channel, Marie, Petite, and Pistakee are considered dimictic lakes. Dimictic lakes often experience anoxic conditions during their stratified season. In anoxic conditions, phosphorus and ammonia-nitrogen become more soluble and can be released from the bottom sediments into the hypoliminion. When stratification weakens and the lake begins to mix, these nutrients can mix into the epiliminion and become available for phytoplankton. This can be seen in Bluff, Marie and Pistakee Lake that stratify for a portion of the monitoring season. When the metaliminion layer weakens, the lake can then be mixed more easily and there is an increase in phosphorus concentrations in the epiliminion available for organisms (Figure 13). TP concentrations also spike in the hypoliminion during stratification – and when anoxic conditions are occurring – as shown by Bluff and Marie in Figure 13. LCHD-ES recommends the creation of a bathymetric map for the Fox Chain O'Lakes which can answer questions such as how much (i.e., the volume) of the lake is anoxic (see Recommendations). Internal phosphorus loading both from release of nutrients from sediment as well as being resuspended by boat and carp action can be a significant source of phosphorus to a lake.

Dunn's, Fox, Grass, Nippersink, Matthews, Redhead, and Spring lakes are considered polymictic lakes. These lakes are shallow enough that they do not form a strong enough density gradient to form stratified layers in the summer months. Due to their shallow nature, they can be easily mixed, and re-mixed throughout the ice-free season. Polymictic lakes can also experience anoxic conditions, especially since shallower lakes may have an increased amount of aquatic plants and algae growth due to the abundance of light and nutrients available. When the aquatic plants die and decompose, the microbial decomposition process can use up a significant amount of dissolved oxygen in the water column; which can lead to a concern for fish and other organisms.

Figure 12: Dissolved Oxygen profiles for deeper lakes in the Fox Chain O'Lakes

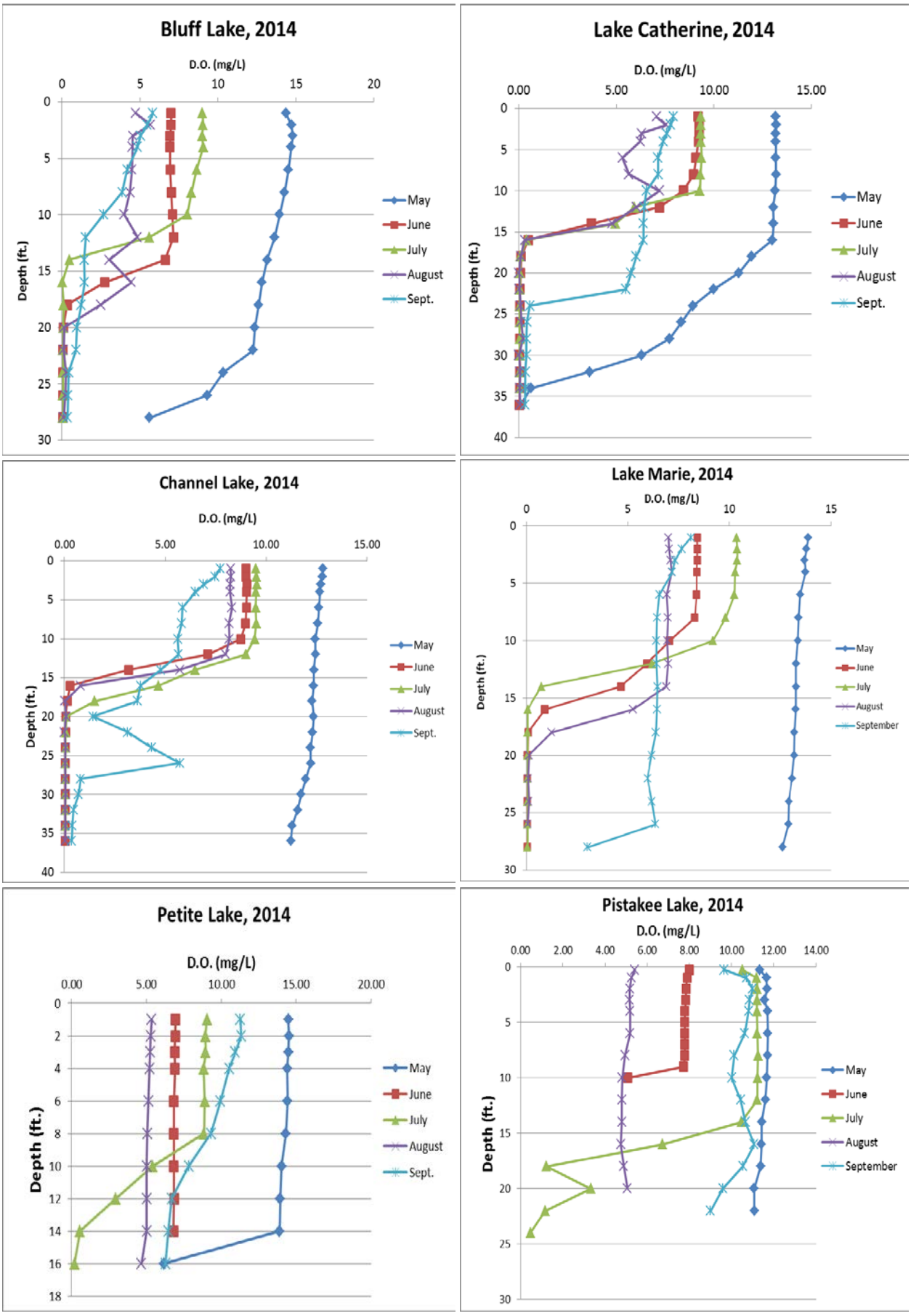
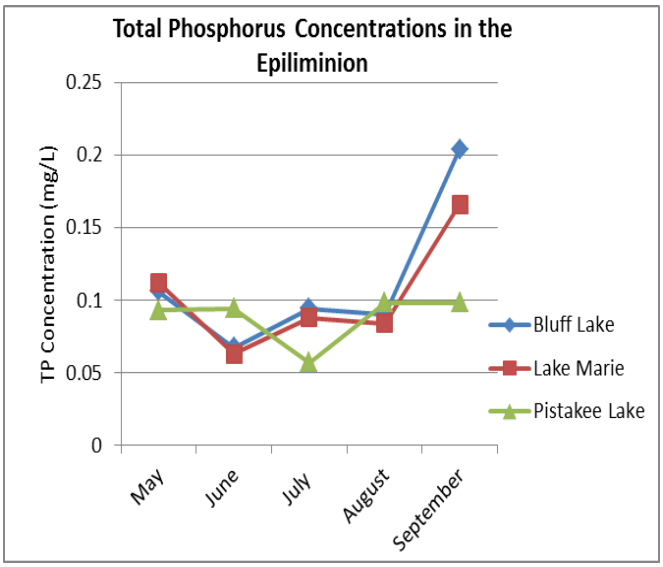
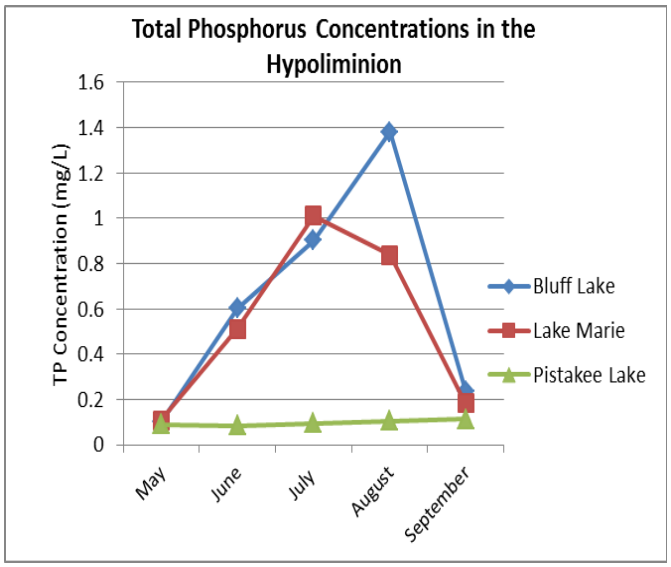


Figure 13: Total Phosphorus of Anoxic Lakes in the Fox Chain O'Lakes





IEPA Indices

The Aquatic Life Use Index (ALI) and the Aesthetic Quality Index (AQI) were used to determine aquatic life use and the extent to which pleasure boating, canoeing, and aesthetic enjoyment (AQI) are attained in the Fox Chain O'Lakes based on IEPA. Both indices are calculated based on the mean Trophic State Index (TSI), the percent surface-areal macrophyte coverage during the peak growing season, and the median concentration of nonvolatile suspended solids. This calculated value describes the degree of support as either nonsupport, partial or full. Lakes with nonsupport or partial designations are then identified for potential causes of impairments.

Table 11 lists the use designations for each of the Chain O'Lakes and Table 12 lists impairments by lake. In the Fox Chain O'Lakes, all of the lakes are impaired for phosphorus, which can cause excessive algae blooms in the lake and support high densities of aquatic plants. None of the lakes are impaired for total nitrogen, pH or total dissolved solids.

Table 11: Lake use designations for the Fox Chain O'Lakes

Lakes	Overall Use	Aquatic Life Use	Aesthetic Quality
Bluff	Partial	Full	Partial
Channel	Partial	Full	Partial
Catherine	Partial	Full	Partial
Dunns	Partial	Full	Nonsupport
Grass	Partial	Full	Partial
Fox	Partial	Full	Partial
Matthews	Partial	Full	Nonsupport
Marie	Partial	full	Partial
Nippersink	Partial	full	Nonsupport
Pistakee	Partial	Full	Partial
Petite	Partial	Full	Partial
Redhead	Partial	Full	Partial
Spring	Partial	Full	Nonsupport

Table 12: Impairments for the Fox Chain O'Lakes

	TP	TN	pH	Low DO	TDS	TSS	Aquatic Plants-Native	Non-Native Aquatic Plants	Non-Native Animals
Bluff	Yes	No	No	Yes	No	No	Yes	Yes	Yes
Channel	Yes	No	No	No	No	No	Yes	Yes	Yes
Catherine	Yes	No	No	No	No	No	Yes	Yes	No
Dunns	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Grass	Yes	No	No	No	No	Yes	No	Yes	Yes
Fox	Yes	No	No	No	No	Yes	No	Yes	Yes
Matthews	Yes	No	No	No	No	No	Yes	Yes	Yes
Marie	Yes	No	No	No	No	No	Yes	Yes	Yes
Nippersink	Yes	No	No	No	No	Yes	No	No	Yes
Pistakee	Yes	No	No	No	No	No	No	Yes	Yes
Petite	Yes	No	No	No	No	No	Yes	Yes	Yes
Redhead	Yes	No	No	No	No	No	Yes	Yes	Yes
Spring	Yes	No	No	No	No	No	No	No	Yes

Aquatic Macrophytes

Aquatic Plants

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 2014, the LCHD-ES conducted surveys on the aquatic vegetation starting on June 20th finishing on September 1st. In order to accomplish this, a 60 meter grid was overlaid upon the footprint of the Fox Chain O'Lakes using ARCGIS10.2. Points falling within footprint were evaluated using the point intercept method. In order to sample the vegetation a rake was tossed into the lake and then retrieved from the lake bottom at each sample point. The bottom depth was recorded and the rake was scored for overall density of plants using the following scale:

Overall Rake Score	
0 = No Vegetation	1 = 1 - 10%
2 = 11 - 40%	3 = 41 - 60%
4 = 60 - 90%	5 = >90%

The vegetation was separated by species and each species was given a score from 1-4 based upon the above scale. A modified Braun-Blaunquet Cover Abundance scale was used to tabulate the data using the midpoint of the rake score percentage values.

Average density, frequency and relative importance were calculated for each species. The relative importance value is the sum of the relative density and relative frequency. The relative importance value (RIV) was ranked and dominant species determined by 50% of the total Relative Importance Value.

In 2014, a total of 2,555 points were sampled in the Fox Chain O' Lakes. Of these points 49.2% of them were vegetated. The total average density of the vegetation was 27.3%; this density is a high estimate, due to some sampling bias that occurred in Fox, Grass and Pistakee lakes. There were 20 aquatic plant species and one macro-algal species (*Chara* spp.) detected during the 2014 vegetation surveys (Table 13). Appendix A, Figure 7 and Figure 8 depict the overall aquatic plant rake density on Fox Chain O'Lakes , separated by the northern and southern lakes.

Table 13. Summary of vegetation sampling results, Fox Chain 'O' Lakes, 2014

Lake Name	Max. Depth (ft.)	# Points Sampled	#Points	Total# Species	Total # Native Species	Floristic Quality Index	Average Density
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
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**

Eurasian Watermilfoil and Curlyleaf Pondweed are non-native invasive plant species that were detected during the aquatic vegetation survey. Eurasian Watermilfoil, although not a dominant plant found in the Fox Chain 'O' Lakes, did occur at 9.9% of all points sampled, and was found to be the 5th most abundant species encountered at our sampling points.

The dominant plants encountered were Coontail, White Water Lily and American Lotus (Table 14) with the average density of 6.3%, 5.5% and 6.4%, respectively,. The frequency or the percentage of sites sampled that contained those species caused these species to be elevated to dominant status as they had frequencies of 20.4%, 19.7% and 14.6%, respectively of the sites sampled. The abundance data was based upon the number of sites sampled, however, there were many areas of the lake beds whose depth could support vegetation but did not get sampled due to their locations falling within navigational lanes for boating, and therefore many of these zones do not support "no wake activity". Due to the shallow nature of many of the lakes in the Fox Chain O' Lakes, the bottoms get churned up during most of the summer season from wave action created by boats or wind, making it hard for plants to survive.

Aquatic plant management strategies have been employed by individuals and associations in Lake Catherine, with the use of pesticides being the most common. In order to apply pesticides Part 895 of the Administrative Code requires a permit be issued by the Illinois Department of Natural Resources. The process is discussed further under Aquatic Plant Management and the Act is presented in Appendix C: Part 894 Fox Chain O'Lakes Aquatic Plant Managment. Pesticide application can impact native aquatic vegetation as well as targeted, aquatic invasive species especially if applications occur later in the Spring (mid-May – early June) and when water temperatures are optimal for growth of native species. In general, invasive species have access to nutrients and light before our native plants due to their having extended growing seasons that begin earlier and/or continue later, providing them a competitive edge.

Additionally, it is estimated that 100,000 yds^3 of sediments enter the Fox Chain 'O' Lakes annually, these sediments can impact aquatic plants by reducing light penetration to the bottom in shallow areas where plants would be expected to normally colonize the lake bottom and sediments also bury plants and their propagules inhibiting the growth and spread of plants.

Internally, a source of suspension of sediment is the dredging activities that take place in areas of the Fox Chain O' Lakes, as the sediments get redistributed into the water column as the dredging bit moves through the sediments. There is also some plant mortality through this process; however, due to the amount of sediment coming into the system from the watershed it is a necessary lake management tool.

Carp activity is another source of reduced water clarity that can impact plant growth as carp feeding habits uproot vegetation and also redistribute sediments in the water. During the 2013 fish survey completed by the IDNR, 138 Common Carp (*Carpinus carpio)* were caught during their electrofishing survey, 63.8% of the carp caught during the survey were found in Grass and Pistakee Lakes.

Sediments, whether coming into the Chain 'O' Lakes externally, internally or, all have nutrients attached to them, especially phosphorus. Lakes with minimal vegetation have difficulties competing against algae for nutrients and lose the competitive edge to that resource. Further impact to the native vegetation occurs and the lake becomes algae dominated making it difficult for plants to access light, making it less likely that the aquatic vegetation will rebound.

Table 14. Abundance ranking for vegetation detected in Fox Chain 'O' Lakes aquatic vegetation survey.

Common Name	Scientific Name	Average Cover	Frequency	Relative Importance
Coontail	*Ceratophyllum demersum*	6.3	20.4	42.7
White Water Lily	*Nymphaea odorota*	5.5	19.7	39.3
American Lotus	*Nelumbo lutea*	6.4	14.6	37.5
Common Duckweed	*Lemna minor*	2.8	13.7	23.3
Eurasian Watermilfoil	*Myriophyllum spicatum*	1.7	9.9	15.7
Sago Pondweed	*Stuckenia pectinata*	1.2	7.2	11.4
Watermeal	*Wolffia spp.*	0.6	3.1	5.3
Common Bladderwort	*Utricularia vulgaris*	0.7	2.4	5.0
Water Stargrass	*Heteranthera dubia*	0.4	2.8	4.2
Giant Duckweed	*Spirodela polyrhizza*	0.3	2.3	3.3
Star Duckweed	*Lemna trisulca*	0.4	1.5	2.8
Flat-stemmed Pondweed	*Potamogeton zosteriformis*	0.2	1.6	2.3
Curlyleaf Pondweed	*Potamogeton crispus*	0.2	1.4	2.0
American Pondweed	*Potamogeton nodosus*	0.1	0.7	1.2
Vallisneria	*Vallisneria Americana*	0.1	0.6	0.9
Chara	*Chara spp.*	0.1	0.6	0.8
White Water Crowfoot	*Ranunculus longirostris*	0.1	0.3	0.7
Slender Naiad	*Najas flexilis*	0.0	0.4	0.5
American Elodea	*Elodea canadensis*	0.1	0.2	0.4
Southern Naiad	*Najas guadalupensis*	0.1	0.2	0.4
Spatterdock	*Nuphar variegate*	0.0	0.1	0.2
	Total Average Cover	**27.3**		

American Lotus

American Lotus, (*Nelumbo lutea*), is a native aquatic plant to Illinois and much of Midwest with populations found from Massachusetts to Minnesota and south to Florida and Texas and also in California. *Nelumbo* is Ceylenian for "sacred bean" and *lutea* is Latin for yellow. In Lake County the flowers of the American Lotus can be seen in Fox Lake, Grass Lake, Nippersink Lake, Petite Lake, Dunn's Lake, Lake Matthews, Pistakee Lake, Sullivan Lake, and East Loon Lake. Back in the late 1800's, Grass Lake was almost entirely covered with this unique plant each summer. A visit by tour boats to the American Lotus beds became popular for

vacationing Chicagoans in the 1890's. Today there are still areas of Chain O' Lakes in which American Lotus blossoms are prevalent. They may cover large areas in varying depths up to 8 feet and may have as many as 8,500 blooms per acre. In late spring the leaves, which can reach 2 feet in diameter, usually stand a foot or two above the surface of the water on thick stems. The flower buds appear in early summer and bloom in July. The showy flowers are seen rising above the tallest leaves with a bright yellow pistil (female organ) surrounded by dozens of stamens (pollen producing male organ). Flowers open in the morning and close at night for two days and then the petals begin to fall off. During this time cross- pollination occurs with the help of insects. Although the petals are gone, the center of the flower continues to grow until it is about 3 inches in diameter. The seed pod can contain up to 20 seeds. The pods are often used in dried floral arrangements. American Lotus reproduces in three ways; through its banana shaped tubers; these can reach 10 inches in length and weigh over a half pound, through rhizomatous growth and by germination of seed.

The seeds, stems, leaves, tubers and rhizomes of the American Lotus are all edible; and the tubers were a major food source consumed by Native Americans who counted on them to get them through the winter months. Even today, one source states that the stamens of the flower can be dried to make an aromatic tea and that entire dried flowers can be used in cooking. Young seeds are noted to be quite tasty and can be eaten like cooked peas; when boiled the plump green seeds have flavor comparable to chick peas with hints of chestnut and corn flavor. Older seeds have been touted as being bitter; however they can be ground to make a flour that is high in protein. The lotus tuber has been compared to a sweet potato and can be eaten raw in salads, put in stir fries or stuffed like a sweet potato.

The American Lotus is important to wildlife and the aquatic food web; like many submerged aquatic plant species, the submerged portions of the plant provide habitat to many micro and macro invertebrates that in turn are food sources for amphibians, fish and ducks. The decaying plant material or "detritus" supports other aquatic invertebrates. The large seeds provide food for duck and other wildlife and beaver and muskrat forage on the tubers and rhizomes.

American Lotus is an aesthetically pleasing plant found along the shores of oxbow lakes and other quiet waters. In the late 1800's tourists would vacation in the Fox Chain O' Lakes hoping to visit the expansive lotus beds inhabiting Grass Lake. Even as late as 1920 the surface of Grass Lake was carpeted by American Lotus. In 1910, the Fox Lake Commercial Association described Grass Lake in a promotional brochure as a "wild stretch of wild rice and lotus…wild rice grows here hundreds of acres…higher than a man's head…so thick that only small channels are discernible…water is not deep…here fish by the millions breed." Aerial photography from 1939 was evaluated by the U.S. Army Corps of Engineers as part of a report on "Recreation and Changing Environment on the Fox Chain O' Lakes and Upper Fox River 1875 – 1996" (Ryder, 1999) and it was estimated that there was approximately 1057 acres of lotus occupying the surface waters of the Fox Chain O' Lakes; Grass Lake was covered by approximately 700 acres, Pistakee Lake 104 acres and Fox Lake 253 acres of lotus beds. Between 1950 and 1960 the lotus

population was nearly extirpated from the Fox Chain 'O' Lakes. Lotus was nearly extirpated from the Fox Chain O' Lakes between 1954 and 1959 as indicated by the 1959 Aerial survey conducted by the Soil Conservation Service (USACOE, 1999). This came at a time when small motorboats were found to dominate the lakes'. Many of those interviewed in the 1996 report by the USACE about the lotus populations recalled that the state and other private interests removed aquatic vegetation in the lakes for several years from the late 50's until the early 60's. It was documented that there was a slight comeback of lotus in Grass lake in the late 1970's; however it was also reported that by 1970 those populations once again disappeared.

The Fox River and Chain O' Lakes Waterway Agency established a "No-Wake Zone" of 150 feet of shorelines in 1993, it was during the period of 1992 and 1996 that lotus are documented to had started to reappear in Grass Lake. The LCHD-ES has measured populations since 2000 and it is estimated that in 2014, 272 acres of lotus occupy the waters of the Fox Chain O' Lakes; and has recorded them on 7 of the lakes. Table 15 quantifies the lotus populations in the Fox Chain O' Lakes from 1939 to present. A map depicting the location and expanse of American Lotus on the Fox Chain 'O' Lakes is shown in Appendix A, Figure 9. There are some populations that do not appear on the map due to the identification of individual plants or very small populations. Matthews Lake had American Lotus detected at one of the vegetation survey sample points however it was not detected during the mapping of Lotus populations in September, 2014.

Table 15. Lotus populations (acres) reported on Fox Chain O' Lakes, 1939 -2014.

Lake Name	2014	2012	2007	2002	2000	1959	1954	1946	1939
Grass Lake	173	46	147	138	79	0	341	736	700
Nippersink Lake	71	50	125	114	95	0	0	0	0
Pistakee Lake	13	11	3	0	0	0	0	129	104
Fox Lake	9	4	105	43	39	0	65	249	253
Lake Marie	5	4	0	0	0	0	0	0	0
Petite Lake	0.5	0.1	0	0	0	0	0	0	0
Dunn's Lake	<0.5	0	0	0	0	0	0	0	0
Total	272	115	290	295	213	0	406	1114	1057

FQI

FQI is a floristic quality index that estimates 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. A floristic quality assessment was conducted on the species detected within

the Fox Chain O' Lakes to allow for comparison among sights as well as to determine its significance as a natural area. The FQI score can contain only native species or it can be calculated to include non-native or adventive species. Adventive species do not carry a conservation co-efficient in the fourth edition however, the

Floristic quality assessments index scores are usually applied to terrestrial systems. Terrestrial systems by their very nature are more diverse in species due to the lack of the stressor (water). Aquatic plants have adaptations to their physiology that allow them to survive under conditions that would normally stress and kill many plant species. Therefore, a very high FQI as can be found in high quality terrestrial systems are not likely. If comparing between true aquatic systems, the FQI can be a useful tool.

FQI scores are based upon Coefficients of Conservatism and are designated by a ranking of 0 – 10. A value of 0 means that it unlikely to have part of the native vegetation of the Chicago region. A score o of 10 would suggest that the species was integrated in natural vegetation in the Chicago region prior to European settlement. The calculation for FQI is presented below (Swink & Wilhelm, 1994)

$$I = C_{mean}\sqrt{N}$$

FQI can also be a useful tool to lake managers or home owner associations (HOA's) determine the extent that management occurring in the lake is affecting the quality of plants found in the lake. The FQI for the Fox Chain 'O' Lakes in 2014 was 29.7 which is very good considering that FQI scores of less than 20 found in terrestrial systems are of no significance from a natural area perspective and areas with FQI values greater than 35 possess sufficient conservatism and richness to be of profound importance from a regional perspective.

The floristic quality assessment does have its limitations; such as it does not account for differences in area; in general, larger areas support a greater number of species than smaller areas. It also does not take into consideration abundances of species, so an area may have a greater number of species contained within it, however, it may be dominated by invasive or less conservative species. It is important for these reasons to whenever possible have abundance data accompanying reported FQI. The LCHD-ES did evaluate both for the Fox Chain O' Lakes vegetation in 2014.

Table 16 below presents all species detected during the 2014 vegetation surveys. The FQI scores for all of the individual lakes that make up the Fox Chain O' Lakes are all less than the FQI score for the entire system (29.7). Notable are FQI scores for Lake Marie whose reported acreage (516) is less than half of that of Pistakee Lake (1700 acres); however the FQI score was the same. Channel Lake and Lake Catherine, are connected yet have slightly different FQI scores Channel the larger of the lakes (337 acres) scored an FQI of 18.7 while Catherine (165 acres) had an FQI score of 21.8. Accounting for the differences were number of species (10 and 12, respectively) and Channel Lake had Curlyleaf Pondweed where it was not found in Lake Catherine. Curlyleaf Pondweed is not given a C value due to reasons described above. This is

also true for Eurasian Watermilfoil, however, that species was detected in both lakes. FQI ranks for Lake County lakes can be found in Appendix B.

Aquatic Plant Management

Herbicide application is a tool utilized by home owner associations, individual residents and lake managers to control aquatic plants in Lake Catherine. Targeted species are usually non-native invasive species; however our records indicate that there have been some treatments over the years, targeting native species.

By Administrative Code, Part 895, the application of herbicides into waters of 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. The targeted species, pesticide and application rate as well as an estimated time when pesticide will be applied is also required. The application can be obtained at the Fox Waterway Agency (http://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 (Appendix C).

It is recommended that a long term Aquatic Plant Management Plan (APMP) be developed for the Fox Chain 'O' Lakes. This would provide parties interested in aquatic plant management with a template to follow and allow decisions on aquatic plant management to be consistent throughout the lakes'. All stakeholders should participate in the development of the plan. Stakeholders would include homeowners, recreational users, homeowner associations and lake management associations, park districts, townships or any other entity managing aquatic plants on the Fox Chain 'O' Lakes as well as the IDNR and the Fox Waterway Agency. All aquatic plant management strategies should be investigated and prioritized by the stakeholders. To accomplish this, the plan should address lake usage, sensitive areas and any areas that herbicides are not allowed to come into contact with plants, such as on property owned by landowners who do not wish to have chemicals used on their property. If pesticides are selected as a method of control, 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 knowledgeable 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. Due to the low

abundance of native species found in the Fox Chain ‘O’ Lakes, management decisions should include plans that would stimulate the growth of native vegetation as well as invasive species control.

Table 16. Plant species detected during 2014 vegetation survey for Fox Chain 'O' Lakes with Floristic Quality Index. (Adventives are non-native species)

	Lake Name												
Common Name	**Bluff**	**Catherine**	**Channel**	**Dunn's**	**Fox**	**Grass**	**Matthews**	**Marie**	**Nippersink**	**Petite**	**Pistakee**	**Redhead**	**Spring**
Acres	86	165	337	68	1881	1623	9	516	718	165	1700	51	43
American Pondweed	0	0	0	0	0	+	0	+	0	0	+	0	0
Common Bladderwort	0	+	+	0	0	+	0	0	0	0	+	+	0
Chara	0	+	+	+	0	0	0	+	0	0	0	0	0
Coontail	+	+	+	+	+	+	0	+	+	+	+	+	+
Curlyleaf Pondweed	+	0	+	0	0	0	0	+	0	+	0	+	0
Common Duckweed	+	+	+	+	+	+	+	+	+	+	+	+	+
American Elodea	0	0	0	0	+	+	0	0	+	0	0	0	0
Eurasian Watermilfoil	+	+	+	+	+	+	+	+	+	+	+	0	+
Flat-stemmed Pondweed	0	+	+	0	+	+	0	+	+	0	+	0	+
Giant Duckweed	0	+	0	0	+	0	0	+	+	+	+	+	0
American Lotus	0	0	0	0	+	+	+	+	+	+	+	0	0
Sago Pondweed	+	+	+	+	+	+	0	+	+	+	+	+	+
Slender Naiad	0	+	0	0	0	0	0	0	+	0	+	0	0
Southern Naiad	0	0	0	+	+	0	0	0	+	0	0	0	0
Spatterdock	0	0	0	0	0	0	0	0	0	0	0	+	0
Star Duckweed	0	0	+	0	+	0	0	+	0	0	0	+	0
Vallisneria	0	+	0	0	0	0	0	+	0	+	0	0	+
White Water Crowfoot	0	0	0	0	0	0	0	0	0	0	+	0	0
Watermeal	0	+	+	+	0	+	0	+	+	0	+	0	0
Water Stargrass	0	+	0	+	0	+	0	+	+	+	+	0	0
White Water Lily	+	+	+	+	+	+	0	+	+	+	+	+	+
FQI Native	**11.0**	**21.8**	**18.7**	**17.0**	**21.2**	**22.2**	**18.3**	**25.2**	**23.2**	**18.7**	**25.2**	**18.7**	**15.2**
FQI W/Adventives	**9.1**	**20.8**	**16.7**	**15.9**	**20.2**	**21.5**	**16.7**	**23.5**	**22.4**	**16.8**	**23.5**	**17.7**	**14.0**
Overall FQI Native	**29.7**												
Overall W Adventives	**28.2**												

NPDES

In addition to a LOP required for herbicide/pesticide application in the Fox Chain O'Lakes, a National Pesticide Elimination System (NPDES) permit is required when pesticides are applied to, over or near the waters of the State. This permit applies to all public waters that have an outflow to the State waters. A Notice of Intent (NOI) must be filled and submitted electronically to the Illinois Environmental Protection Agency (IEPA) at least 14 days prior to any application of pesticides.

- **When is a NPDES permit needed?**
  Prior to any pesticide application made directly to, over or near waters of the state.
- **Who should obtain NPDES permit coverage?**
  The individual pond owner who will apply the herbicide. If the pond owner hires a contract applicator either the contract applicator or the pond owner could apply for NPDES coverage.
- **How do I apply for NPDES permit coverage?**
  File a Notice of Intent (NOI) with the IEPA. The form can be printed from the site listed above. Don't forget the 14 day public notice period and the information regarding the approval and notification process listed above, so plan ahead
- **What does the permit cost?**
  Currently there is no fee however fees may be introduced at a later date.
- **How long is the permit good for?**
  Five years from the date of issuance but not from the date of coverage.
- **Is anything else needed besides the permit?**
  An Adverse Incident Report is needed if there are any adverse impacts related to the application such as spills or accidental overdosing. The incident must be reported to the Illinois Emergency Management Agency immediately and the report must follow within 15 days.
- A Pesticide Discharge Management Plan (PDMP) is required if the annual threshold of 80 acres is past and if you do not meet any of the additional exemptions within the permit. The threshold is determined not only by the size of the pond or lake but by the number of treatments. For example, if a 10 acre pond is treated 9 times with different herbicides within a one-year period, it would be counted as 90 treatment acres and the 80 acre threshold limit would have been passed. This would trigger the need for a PDMP. If treated with the same herbicide 9 times, the additional treatments would not count toward the threshold.

You are allowed to apply only a pesticide that is labeled for aquatic use. The General NPDES permit only applies to pesticide applications that will be made directly to or over waters of the State or at water's edge. Pesticide applications to dry ditches which discharge into waters of the State may also require General NPDES permit coverage.

You must file an updated NOI to modify your NPDES permit coverage to add additional use patterns or treatment areas at least 14 days prior to beginning the pesticide applications. The General NPDES permit coverage is good for 5 years from the issuance date on the permit.

Excerpt : Illinois Department of Natural Resources

Beaches

All licensed inland beaches are tested bi-weekly from May to August by the LCHD-ES. The water samples are tested for *E. coli* bacteria, which are found in the intestines of almost all warm-blooded animals. *E. coli* is used as an indicator organism, meaning that high concentrations of *E. coli* might suggest the presence of harmful pathogens such as, Salmonella, Giardia, etc. While not all strains of E. coli are the same, certain strains can make humans sick if ingested in high enough concentrations. If water samples come back high for E. coli (>235 E. coli/100 ml), LCHD-ES informs the management body for the bathing beach that the beach is closed and a sign is posted indicating the beach closure. There are multiple reasons for high *E. coli* counts. Sewage runoffs from septic fields, storm drains, fecal contamination from waterfowl, dogs and cats, surface run-off from poorly drained areas adjacent to the beach, high fecal concentrations from nearby creeks, and poor water circulation in the swimming area may contribute to the high bacterial counts.

There were thirteen licensed beaches sampled on the Fox Chain O' Lakes in 2014. These lakes were divided into the North and South group of lakes (Appendix A, Figure 10 -11). During the summer of 2014, there were three beaches that exceeded 235 *E. coli*/100 ml. out of the 13 beaches sampled. Highland Beach, located on a channel between Spring and Petite Lake, exceeded the limit 16 times between June 13, 2014 and August 1, 2014. There was very little current flowing between the lakes, along with the constant presence of waterfowl observed at the beach. Stanton Bay (Fox Lake) and Vacation Village (Dunn's Lake) each had one sample that exceeded the maximum allowable limit.

Practicing common sense and good hygiene will go a long way in preventing illness from swimming beaches.

- If you are sick, do NOT swim.
- Do NOT drink the water while swimming.
- Avoid swimming during heavy algae blooms.
- Keep water fowl off the beach.
- Children who are not toilet trained should wear tight-fitting rubber or plastic pants.
- Take a shower before entering the water, and have kids take frequent bathroom breaks.
- Do not feed wildlife.
- Wash your hands after exiting the lake.

Harmful Algal Blooms

Beginning in 2013, the LCHD-ES initiated a program to monitor cyanobacteria (blue-green algae) populations. Algae are important to freshwater ecosystems and most species of algae are not harmful. Algae can grow quickly in water and is often associated with increased concentrations of nutrients such as nitrogen and phosphorus. Blue-green algae, or "cyanobacteria" are a type of algae that can bloom and produce toxins, which are similar to bacteria in structure but utilize photosynthesis to grow. They have no nucleus and lack the photosynthetic pigments found in algae. They usually are too small to be seen individually, but can form visible colonies that can cover large areas of lakes. Certain species of blue-green algae can produce toxins that could pose a health risk to people and animals when they are exposed to them in large enough quantities. At a subset of beaches, an additional water sample was collected to test for the presence of microcystin, a common toxin produced by cyanobacteria (blue-green algae). The sample was sent to an independent laboratory for enzyme linked immunosorbant assay (ELISA).

If a blue-green algal bloom was present at the time of sampling, a small amount of sample was tested for presence of toxin using an Abraxis test strip. The species of cyanobacteria and other dominant algal species were noted, and if the results of the test strip indicated that toxins were present at levels ≥10 ppb, the beach manager was contacted, advised that toxins were present and it was recommended by the LCHD-ES that the beach manager consider closing the beach until the bloom subsided. A bloom is easily detected as the water has an appearance of pea soup and/or like iridescent blue-green paint or toxic substance is on the surface of the water.

Blooms can last for an extended period of time and can deplete the oxygen and block sunlight in the water that other organisms need to live. The water can appear blue-green, bright green, brown, or red and may look like paint floating on the water. Not all blue-green algae produce harmful toxins. The three types of cyanobacteria that are often associated with Harmful Algal Bloom (HAB) are the Anabaena, Aphanizomenon, and Microcystis. The presence of these cyanobacteria does not generally mean that the toxins are present in the water. The presence of toxins can only be verified through a sample analyzed in the lab.

Water samples were analyzed for Harmful Algal Bloom (HAB) in 2013 at swimming beach locations at Bluff, Channel, Dunns, Fox, Grass, Catherine, Marie and Lake Matthews in the Fox Chain. Samples were analyzed for total microcystins. A total of 59 samples were collected at these locations. Out of the 59 samples, 5 samples were below the detection limit and only two samples were above 20 ug/L. Samples over 20 ug/L have potential health risks associated with recreational exposure to elevated concentrations of microcystin and the EPA recommends not to swim in the lake. The two lakes samples with high microcystin levels included Channel Lake and Dunns Lake. The Channel Lake sample was taken on 6/6/2013 and had a concentration of 259.11 ug/L. The Dunn's Lake sample was taken at the Vacation Village beach location on 8/8/2013 with a concentration of 26.63 ug/L.

Algae blooms can frequently appear on backwater and channel locations within the Fox Chain O'Lakes. It is recommended not to swim in recreational water bodies during extreme blooms and to keep pets away from drinking lake water with algal blooms. Most human cases occurred when people swim or ski in affected recreational water bodies during a bloom. If you suspect that you are experiencing symptoms related to exposure to blue-green algae such as stomach cramps, diarrhea, vomiting, headache, fever, muscle weakness, or difficulty breathing contact your doctor or the poison control center. For more information or to report a blue-green algae bloom, contact the Lake County Health Department Environmental Services (847) 377-8030.

Table 17: Harmful Algal Bloom (microcystin) sampling results

Lake	# HAB Samples Collected	# of Non-Detect Samples	Average of detectable samples (ug/L)	Median of samples (ug/L)	Number of samples >20 ug/L	Date and Concentration of >20 ug/L sample
Bluff	5	0	1.13	0.67	0	NA
Channel	8	0	33.74	1.22	1	6/6/2013 at 259.11 ug/L
Dunn's	7	0	10.71	8.63	1	8/8/2013 at 26.63 ug/L
Fox	6	0	2.16	1.14	0	NA
Grass	6	5	0.16	<.15	0	NA
Catherine	5	0	0.78	0.65	0	NA
Marie	4	0	0.65	0.53	0	NA
Matthews	6	0	1.24	0.43	0	NA
Petite	6	0	1.77	1.04	0	NA
Redhead	6	0	0.31	0.27	0	NA

Fisheries

The Fox Chain O' Lakes is managed by the Division of Fisheries - Illinois Department of Natural Resources for over 60 years (1959).

September of 2013 the Illinois Department of Natural Resources (IDNR) conducted a daytime electrofishing survey of the Fox Chain O' Lakes. The survey was undertaken to assess the abundance and diversity of the current fish population. Below is the 2013 summary report from the IDNR for the Fox Chain O' Lakes.

“STATUS OF THE SPORT FISHERY – The Fox Chain 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

LARGEMOUTH BASS – In 2013, bass were collected at a rate of 28 fish/hr compared to 36.4 fish/hr in 2011. Fish measured from 3” - 18.5” long and weighed up to 3.8 lbs.; 45% of the bass collected were over 12” long and sexually mature, 28% exceeded 14 inches (legal size), 18% were over 15” long, 12% over 16”, 8% over 17” and 1% of the bass collected exceeded 18” long. This is a well-balanced population that supports quality panfish development and supports bass angling opportunities.

WALLEYE – The Chain O Lakes is a brood source for the State Hatchery System so it is managed to produce large walleye! In fall 2013, walleye were collected at a rate of 18 fish/hr and ranged from 5” to 27” long. In spring 2013, two 10.5 lb and one 11 lb. females were collected for brood purposes then returned to Lake Marie so they’re still out there! Fall data (n=261)indicated 77% of the walleye sampled exceeded 14” long, 46% were over 18” long and 9% of the sample was over 24” long. These size groups explain the population along harvest regulations.

Muskellunge – Muskie are managed for high catch rates and lower sizes. The average muskie is 36” long but fish up to 51” have been caught by IDNR staff and slightly longer reported by fishermen. It takes at least 12 years for a muskie to reach 48” (legal length) in the Chain and differential growth rates cause a stock piling of male fish below 40”s long so the “average can’t shift” much if half the population “can’t” grow beyond the average. In spring 2013 no spring muskie data was collected because the Chain O Lakes was closed to boat traffic due to flooding from mid-April until mid-May, the time when muskie move and spawn.

BLUEGILL – In 2013, 47% of the bluegill collected (n=1878) were longer than 6” compared to 19% in 2011 and 49% in 2009. These data can vary depending on several factors but since gizzard shad established themselves in 2009, bluegill maximum size has diminished from 8”+ to just over 7.5”. Fish ranged from 0.5” to 7.5”, and topped the scale at 0.35 lbs.; 5% of the bluegill collected were over 7” long and none exceeded 8” long. Since

BLACK and WHITE CRAPPIE – Both black crappie (n=70) and white crappie (n=59) were collected in 2013. Fish measured between 2.8” and 13” long and weighed up to 0.94 lbs.; 39% of black crappie and 62% of white crappie exceeded 9”, and 3% of black crappie and 7% of white crappie exceeded 11” in size. White crappies were poorly sampled during the 2011 survey so their abundance and size was a happy surprise! During the 2013 fishing season crappie 17” were reported by fishermen.

CHANNEL CATFISH – This species is maintained through natural reproduction and are common in river systems. Since the Chain is part of a river system these fish are a significant predator, relatively abundant and caught by a lot of fishermen. Channel catfish ranged in size from 11" to 29" long and weighed up to 10 lbs. In 2013, 79% of the channel catfish collected exceeded 18" in length, 38% were over 22" long and 12% were over 24" long. Flathead catfish are present but not common in the Chain O Lakes above the McHenry Dam but commonly targeted below the McHenry Dam south to Dayton."

This biennial survey is used to assess the health of the fishery. The data collected by IDNR Division of Fisheries provides a historical trend which allows IDNR to plan for the future. Each species of fish requires a different management strategy. The current and historical data forms a guideline for fish stock and water quality management. Although most of the fish on the Chain are self-sustaining, the IDNR regularly stock additional fish to supplement the current population.

Invasive Species

Aquatic invasive species are non-indigenous species that threaten the diversity of abundance of native species, the ecological stability of infested waters, or any recreational or economic activities that are dependent on the water. Eurasian Watermilfoil, Curlyleaf Pondweed, Zebra Mussels and a carp are four invasive species that are discussed in further detail in the following section.

Eurasian Watermilfoil

Eurasian Watermilfoil (EWM) is an aquatic invasive species discovered in North America in the 1940's and has invaded nearly every US state and at least three Canadian Provinces. 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. Eurasian Milfoil spreads when plant pieces break off (fragment) and float on water currents before coming to rest upon bottom substrate. It can cross land to new waters by clinging to sailboats, personal watercraft, powerboats, motors, trailers, and fishing gear.

EWM was detected in 12 of the 13 Fox Chain O'Lakes sampled during the 2014 aquatic vegetation surveys (Table 18). Redhead Lake was the only lake that did not have EWM detected. While EWM was found at most lakes in the Fox Chain O' Lakes the overall abundance of EWM varied. It was a member of the dominant plants found in Bluff, Matthews, Marie, Petite and Pistakee lakes. The density of the EWM was relatively minor component of the vegetation density recorded in lakes. Bluff Lake had the highest representation of plant density with 68.8% of the density being represented by EWM. EWM represented 33.5% and 28.5% of the total plant

density in Matthews and Pistakee, respectively. The frequency of EWM in the lakes elevated EWM into dominant status (Table 18).

Table 18. Abundance of Eurasian Watermilfoil on Fox Chain 'O' Lakes, 2014

Lake Name	Average Density	Frequency	Relative Importance
Bluff*	9.25	10.00	76.95
Channel	1.09	5.29	7.99
Dunn's	0.72	7.14	9.53
Fox	1.25	4.52	13.11
Grass	0.07	0.43	0.51
Catherine	1.17	9.20	17.87
Matthews*	9.08	73.68	81.80
Marie*	4.37	19.28	23.16
Nippersink	0.01	0.26	0.48
Petite*	1.88	12.63	49.97
Pistakee*	2.42	22.44	20.49
Redhead	NP	NP	NP
Spring	4.41	24.39	28.82

Curlyleaf Pondweed

Curlyleaf Pondweed (CLP) is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidentally introduced to the United States waters in the mid-1880's by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with a distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long.

This aquatic plant has an unusual life history. Unlike native pondweeds it begins growing in the early spring. CLP has even been documented growing under the ice in lakes. The plant then reaches maturity in midsummer, typically June in Lake County when our natives are starting to emerge.

CLP becomes invasive in some areas because its adaptations for low light tolerance and low water temperatures tolerance which allow the plant to get a head start and outcompete native plants in the spring. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Large populations of CLP

also can cause changes in nutrient availability. In midsummer, CLP plants usually die back which is typically followed by an increase in phosphorus availability that may fuel nuisance algal blooms. CLP can also form dense mats that interfere with boating and other recreational uses. These dense mats can decrease recreational capacity and reduce aesthetic appeal for lakes.

Curlyleaf Pondweed was detected in 6 of the 13 Fox Chain O'Lakes sampled during the 2014 vegetation Surveys (Table 19). The low abundance of this plant is likely related to the life cycle of the plant. It is in highest abundance in late spring and the vegetation surveys for the Fox Chain O'Lakes were conducted in mid to late summer (July-August). Lakes where CLP was detected during 2014 are: Bluff, Channel, Marie, Petite, Pistakee, and Redhead. While CLP was found in these lakes, it was found in low abundance lakes, it was found in low abundance, with Bluff having most CLP found at sites (8.3%) and Pistakee with the lowest (0.1%). CLP is not a dominant species.

Table 19: Count of Curlyleaf Pondweed Density by Lake

	Bluff	Channel	Marie	Petite	Pistakee	Redhead
Present	8	7	3	2	1	1
Common	1	9	1	1	0	0
Abundant	0	2	0	0	0	0
Dominant	0	0	0	0	0	0
Percentage of sites with CLP	8.3%	4.4%	0.6%	1.3%	0.1%	1.8%

Zebra Mussels

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, 32 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.

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.

Zebra mussels have also caused economic problems for large power plants, public water supplies, and industrial facilities, where they clog water intake pipes. Boats stored on the water offer suitable areas for zebra mussels to start a colony. Once established it can affect cooling and exhaust systems on boats and create extra drag causing lower fuel economy. Studies on the transport of the zebra mussel have shown that they can be found in any area of a boat that holds water, including the engine cooling system, bilge water, and bait buckets used in fishing. Researchers found that many of the mussel larvae were being transported via aquatic plants that were taken from one lake to another on boats and trailers. 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.

A biocide called Zequanox has shown to be effective against zebra mussels and it is not toxic to humans, native bivalves, and fish. In-lake tests show that it reached 97.1% mortality on zebra mussels within 14 days of treatment . Zequanox is a non-chemical solution made from dead cells of a naturally occurring microbe (*Psuedomonas flourescens*). It is still in the experimental phase and not yet commercially available. Currently the winter drawdown of the water level exposes the zebra mussels located along the shoreline.

Below are some tips from the Great Lakes Sea Grant Network that can help prevent the spread of zebra mussels:

Always inspect your boat and boat trailer carefully before transporting. Studies have shown that transport via aquatic plant fragments is one of the major contributors to the spread of zebra mussels.

- Drain all bilge waters, live wells, bait buckets and engine compartments before entering another lake. Make sure water is not trapped in your trailer. Never transport water from one lake to another.
- Flush clean water (tap) through the cooling system of your motor to rinse out any larvae.
- Full grown zebra mussels can be easily seen but cling stubbornly to surfaces. Boats that have been in the water for long periods of time should be carefully inspected. Carefully scrape the hull (or trailer), or use a high pressure spray (250 psi) to dislodge them. Or leave your boat out of the water for at least 5 days, preferably up to two weeks. The mussels will die and drop off.

- In their earlier stages, attached zebra mussels may not be easily seen. Pass your hand across the boat's bottom - if it feels grainy, it's probably covered with mussels. Don't take a chance; clean them off by scraping or blasting.
- Dispose of the mussels in a trash barrel or other garbage container. Don't leave them on the shore where they could be swept back into the lake or foul the area.

Carp

Carp (*Cyprinus carpio*) are considered to be one of the most damaging invasive fish species. Originally introduced to the Midwest waters in the 1800's as a food fish, carp can now be found in 48 States. In the U.S., the common carp is more abundant in manmade impoundments, lakes, and turbid sluggish streams and less abundant in clear waters or streams with a high gradient (Pflieger 1975; Trautman 1981; Ross 2001; Boschung and Mayden 2004). They are also highly tolerant of poor water quality. Participation in the Clean Waters Clean Boats program will help prevent other invasive species from entering the lake. Never release plants, fish or animals into a body of water unless they came out of that body of water.

The common carp has a dark copper-gold back with sides that are lighter, a yellowish belly and olive fins. They have 2 pairs of short barbells on their upper lip and their dorsal and anal fins have a leading spine that is serrated. They spawn from early spring to late summer in water ranging from 15 – 28 C and prefer freshly flooded vegetation as spawning substrate. They prefer to spawn in shallow weedy areas in groups consisting of one female and several males. A single female can produce up to 100,000-500,000 which hatch in 5-8 days. The spawning ritual involves a lot of thrashing in shallow water contributing to turbidity problems. Even though carp are prolific spawners, most of the eggs succumb to predation, fungus and bacteria. The carp population on the Fox Chain O' Lakes is made up of 2-3 year classes. The average size of the carp in 2013 for all the lakes was 23.4 inches and weighing 6.25 lbs. The Chain has a healthy population of predator fish such as bass, walleye, catfish and musky that feed on the juvenile carp.

Carp are omnivorous and feed over soft bottom substrate where they suck up silt and filter out crustaceans, insect larvae and other desirable food items. Carp are very active when feeding and can be observed around shallow areas where they uproot plants which increase turbidity and nutrient concentrations. The resuspension of sediments causes an increase in nutrients causes algal blooms and reduction in light penetration that impacts aquatic plants.

Shad

Gizzard shad are native to central and eastern United States mainly in warm low gradient rivers and streams as well as reservoirs, lakes and ponds. Shad are filter feeders; they prefer warm nutrient rich waters. Their range is temperature limited. Die offs usually occur when the water temperature drops below 37 F. Shad can extend their range during a string of warm years; the Illinois DNR collected its first sample of gizzard shad in the Fox Chain O' Lakes in 2007.

These shad migrated up the Fox River over fish ladders and dams in order to make it to the Fox Chain.

The gizzard shad is a deep bodied fish that is laterally compressed (nearly flat when lying on their side). The dorsal fin has 10 to 12 rays and the last one extends back towards a deeply forked tail. The gizzard shad has silvery blue-green to gray coloration on its back and the sides are silvery with no lateral line. The mouth is small, with the lower jaw slightly shorter than the upper jaw. The mouth does not extend back past the gizzard shad's large eyes. Like most shad, juveniles and young adults have a dark spot behind the gill plate. This spot is faint or disappears completely in larger, older fish. The belly tapers to a point where the scales fold over forming a saw like appearance.

While most shad live for 3-5 years, some have been documented to live past 10 years. They reach maturity in 2-3 years and females can produce 40,000 to 450,000 eggs. Spawning takes place during the middle of spring to early summer and usually occurs in the evening. The preferred spawning temperature is between 60 F and 70 F. Male and female shad congregate along the shallow sandy or gravel areas where eggs are released and fertilized. Once the eggs hatch they are on their own since there is no parental care from the parents. The success of the shad fry correlates with the abundance of zooplankton along with stable water level and warmer temperatures. Drastic changes in water level and temperature can decrease the survival rate of the fry. Once they reach the juvenile stage, they grow rapidly by feeding primarily on detritus, zooplankton and phytoplankton (Yako et al. 1996; Schause and Vanni 2000).

Gizzard shad can have a major influence on nutrient cycling and fish communities in lakes, particularly in hypereutrophic systems, where it can be the dominant fish species. Gizzard shad can release large quantities of nutrients from sediments into the water column, and the feeding and excretion activities of this species can greatly increase phytoplankton biomass and decrease water clarity (Schaus 2007). Shad predation on zooplankton and nutrients released by fish in the water column can increase phytoplankton (Schaus and Vanni 2000). Increase in phytoplankton (algae blooms) causes a decrease in water clarity therefore limiting the amount of light penetration available for aquatic plants.

Gizzard shad provide an abundant food source for bass and walleye, but they may compete with bluegill, crappies and other young of the year game-fish for food. Shad have rapid growth rates, often growing to 5.5 inches in length during their first year. This provides a smaller window of opportunity for bass and walleyes which are gape limited and can only feed effectively on shad up to 6". The lakes and rivers in southern states have an overabundance of adult shad measuring 8" or larger due to lack of predators. Fortunately, the Chain has a healthy population of muskies, which are capable of feeding on adult shad. Muskies have benefited from this new food source which is not only abundant but it's easier for them to catch than bluegills and perch. The less energy a fish spend chasing its prey the more energy it saves on growing.

Muskie appears to have gained between 1 and 2 pounds per fish since gizzard shad showed up. Males are about 1 pound heavier and females are about 2 pounds heavier for older

mature fish. A 45" female musky in 2006 weighed about 27.7 pounds and a 45" female in 2012 weighed about 29.9 pounds. –Frank Jakubicek, IDNR

Gizzard shad can alter the size and density structure of a fishery. They may stunt the bluegill population through common food competition or by reducing the predation pressure which allows for higher recruitment creating a stunted population. Bass, walleye and musky prefer soft rayed fish like the shad over the spiny bluegill. At this point it is hard to predict what the overall outcome of the gizzard shad will be on the fishery. At least for now, it gives fishermen hope that the shad will help produce record size game fish in the Fox Chain O' Lakes in the near future.

Shoreline

Erosion is a natural process primarily caused by water which results in the loss of material from the shoreline. Disturbed shorelines caused by human activity such as clearing of vegetation and beach rocks, and increasing runoff will accelerate erosion. The main causes of erosion are rain, melting snow, wind and wave action. Rain can loosen soil and wash it down gradient towards the lake. Creating a native plant buffer helps prevent soil erosion as well as filter out pollutants and unwanted nutrients from entering the lake. Native plants can be planted along the shoreline since plant roots hold the soil particles in place so they are not easily washed away during a rain event, melting snow or wave action. Loose rocks and gravel placed on top of a filter fabric prevents soil from washing away before newly planted seed and vegetation has a chance to grow. Eroded materials cause turbidity, sedimentation, nutrients, and pollutants to enter a lake. Shore line buffer zone planted with native vegetation not only reduces runoff by increasing water infiltration into the ground, it also offers food and habitat for wildlife. Less runoff means fewer nutrients, sediments and other pollutants entering the lakes and streams. Excess nutrients are the primary cause of algal blooms and increased aquatic plant growth. Once in the lake, sediments, nutrients and pollutants are harder and more expensive to remove.

A significant portion of the shoreline in the Fox Chain O' Lakes is vertical seawall and may contribute to poor plant coverage near shore. Vertical seawalls reflect wave energy, which can cause scouring of the lakebed, increased turbidity and habitat loss for lake organisms. This can make it difficult for aquatic plants to grow, near the seawall edge. Stone re-facing is adding layers of stone in front of an existing seawall to create a more natural shoreline. The stones help absorb wave energy that would otherwise reflect back and scour the bottom of the lake. This provides excellent habitat for fish, turtles and other aquatic animals. A permit may be required for any shoreline restoration in public waters, including the Fox Chain O'Lakes. It is advised to check with the Illinois Department of Natural Resources on needed permits before implementing any shoreline projects.

Recommendations

The Fox Chain O' Lakes' management is administered by the Illinois Department of Natural resource and the Fox Waterway Agency. To improve the overall quality of the Fox Chain O' Lakes; the LCHD-ES has the following recommendations:

- Develop an aquatic plant management plan that restores density and diversity.
- Create a bathymetric map for individual lakes.
- Participate in the Volunteer Lake Monitoring Program.
- Address areas of severe shoreline erosion.
- Stone re-facing of vertical seawalls.
- Encourage homeowners to incorporate native plants in their landscaping through rain gardens or shoreline filter strips.
- Enforcement of no-wake zones.
- Participate in the Clean Waters Clean Boats Program and educate lake users on aquatic invasive species.
- Install a permanent staff gauge to monitor lake level fluctuations.
- Inspect septic systems regularly.
- Use phosphorus free lawn fertilizer.
- For snow and ice management, use salt alternatives and proper application procedures for homeowners.

Develop an Aquatic Plant Management Plan

The LCHD-ES encourages those charged with Aquatic Plant Management to develop a long term aquatic plant management plan (APMP) to restore native plant density and diversity and minimize the impact from exotic species. In order to develop this you will need to gather all stakeholders using the Fox Chain 'O' Lakes to present best management practices for aquatic plant management, locate sensitive areas, such as those set aside for habitat or swimming areas; realistic goals should be set and the objectives to reach those goals defined. Those charged with aquatic plant management should be familiar with herbicides, permitting and bottom ownership. The resulting plan can be used as a template by anyone interested in managing plants on the Fox Chain 'O' Lakes. Allowing them to develop clear and concise requests for quotes for any work they might want to subcontract. Part of the plan should also address monitoring, new invaders and how invasive plants like Hydrilla would be dealt with upon its detection. The plan should be reviewed and updated every five years, however, monitoring to make sure that goals are being realized should be conducted more frequently to allow for tweaking of objectives if necessary.

The APMP needs to identify all lake stakeholders, lake uses, and past lake issue and should incorporate the following:

1. Goal: Define the outcome that is most agreeable and achievable based on lake morphology and lake users

2. Problem Assessment: collect information about a problem and alternatives evaluating general feasibility
3. Recommendations: prioritize management options, setting objectives and drafting the plan
4. Education and Outreach: initiated at the beginning of the APMP and should continue throughout the APMP
5. APMP Management: management of assets, detailed records of expenses and time
6. Implementation: scheduling activities for taking action to achieve goals
7. Monitoring: biological communities and water quality parameters on a regular basis (consider joining the Volunteer Lake Monitoring Program)
8. Evaluation: Assessment of management techniques and stakeholder satisfaction

Due to the low abundance of native species found in the Fox Chain 'O' Lakes, management decisions should include plans that would stimulate the growth of native vegetation as well as invasive species control.

Create a Bathymetric Map

Bathymetric maps, also known as depth contour maps, display the shape and depth of a lake. They are valuable tools for lake managers because they provide information about the surface area and volume of the lake at certain depths. This information is essential for effective lake management when considering whole-lake herbicide treatments, harvesting activities and alum treatments, and answering questions such as how much of the lake loses dissolved oxygen in the summer and how much of the lake bottom can be inhabited by plants. Bathymetric maps can help lake managers determine appropriate management options for their lake. Other common uses for the map include sedimentation control, fish stocking, and habitat management.

The LCHD-ES recommends the creation of an updated bathymetric map for lakes within the Fox Chain that do not already have recent one, which is all of the lakes except Redhead Lake.

Participate in the Volunteer Lake Monitoring Program

The Volunteer Lake Monitoring Program (VLMP) was established in 1981 by the Illinois Environmental Protection Agency (Illinois EPA). The goal of the program is to gather fundamental information on water quality on Illinois inland lakes and to provide an educational opportunity for citizens.

The VLMP relies on volunteers to collect a series of water quality information on their lake. The primary measurement is a Secchi depth reading. Other observations that volunteers record include water color, suspended algae and sediment, aquatic plants, and odor. Volunteers who have been a part of the VLMP for at least two years are qualified to participate in Tier 2 of the program. In addition to recording Secchi depth and the other observations listed above, Tier 2 volunteers collect water quality samples once a month throughout the monitoring season. These

samples are shipped to IEPA laboratory and a variety of water quality parameters are measured including phosphorus, nitrate-nitrite nitrogen, total and volatile suspended solids.

All lakes within the Fox Chain are in need of VLMP volunteers. For more information about the VLMP or to join the program to monitor a lake, contact the VLMP Regional Coordinator:

Alana Bartolai

Lake County Health Department

500 W. Winchester Rd., Suite 102

Libertyville, IL 60048

847-377-8009

Abartolai2@lakecountyil.gov

Address Areas of Extreme Erosion

- ***Stone re-facing of vertical sea walls***

  Vertical seawalls reflect wave energy, which can cause scouring of the lakebed, increased turbidity and habitat loss for lake organisms. This can make it difficult for aquatic plants to grow, near the seawall edge. A significant portion of the shoreline in the Fox Chain O'Lakes is vertical seawall and may contribute to poor plant coverage near shore

  Stone re-facing is adding layers of stone in front of an existing seawall to create a more natural shoreline. The stones help absorb wave energy and provide habitat. This minimizes the negative effects of an inflexible vertical seawall. Estimated costs for re-facing vertical seawalls are approximately $50 per linear foot (Tippecanoe Watershed Foundation). Please check with the Illinois Department of Natural Resources on necessary permits required for shoreline alterations in public waters.

- ***Native Plantings: Shore land Buffer Strips and Rain Gardens***

  Native plants have deeper root systems than turf grass and are able to reduce erosion, filter pollutants, reduce runoff, and provide wildlife habitat. There are a few ways to incorporate native plantings into a landscape that can benefit water quality including buffer strips around the lake shoreline and rain gardens on homeowner properties.

  Shore land buffers filter runoff, stabilize sediment, and reduce overall runoff into the lake. Sediment and nutrients can be removed by filtration by settling the plant vegetation in the buffer strip. Soluble pollutants are also taken up through plant roots and can be consumed by microorganisms in the soil. The deep root systems of native plantings increase infiltration, allowing less runoff to reach the lakes. A concern about buffer strips is that homeowners may be unable to approach the lake on their property. Lake access can be allowed by a smaller mowed path to the shoreline, allowing access and not interrupt the integrity of the buffer strip. The mowed path should be kept at not less than 6 inches tall and not more than 6 feet wide.

  A buffer strip of at least 20 feet is recommended. Wider strips (50 or even 100 feet) are recommended on steeper slopes or areas with severe erosion problems. If there are shorelines that are already severely or moderately eroding or with slopes greater than 3:1, additional erosion control techniques may have to be included such as biologs, A-Jacks, or riprap. Once established buffer strips require very little maintenance and do not need

to be continuously mowed, watered, or fertilized. Occasional removal of weedy species may be required to prevent weedy species from taking over the buffer strip. An additional positive of native plants can also withstand fluctuating water levels more effectively than turf grass, and can also help reduce velocity of water during flood events.

Rain gardens have a similar function as shore land buffers. Rain gardens are created to allow runoff to pass through an area of native vegetation that increases infiltration and filters pollutants. By increasing infiltration, runoff from the homeowner's property is reduced.

Both rain gardens and shore land buffer can be aesthetically pleasing and can provide critical habitat to wildlife such as pollinators, birds, and amphibians.

Enforcement of No Wake Zones

No wake zones are designated areas where boaters are required to reduce speed to minimize the wake produced from their boat. Boats that reduce speed in shallow areas will help keep re-suspended sediment from reducing water clarity and water quality. In waters less than six feet deep, the bottom sediment is easily re-suspended due to wave and boat action, and does not settle back to the bottom for 2 to 4 days. Enforcing no wake zones, and even restricting boating from certain areas can reduce the amount of re-suspended sediment increasing water clarity. It can also greatly improve aquatic macrophyte coverage in the lakes. The constant wave action from boats, wind, and carp action can cause the water to be too turbid and minimize the amount of light reaching the water column, prohibiting plants from growing. Enforcing no wake zones, especially in areas where native plants are thriving, can increase overall plant coverage.

There is currently an ordinance by the Fox Waterway Agency that sates "it is unlawful for any person to operate any boat in excess of 5 miles per hour or at a sufficient speed as to create a wake" in areas defined by the Fox Waterway Agency. These areas include:

- 150 feet from shore throughout the Chain O'Lakes
- All side and secondary channels throughout the Chain O'Lakes and Fox River

For a full list of designated no-wake zones in the Fox Chain O'Lakes see the attached document in the Appendix C (Chapter 6: Restricted Areas).

The 1994 US Army Corps of Engineers study that examined the impact of recreational boating on the Fox Chain O'Lakes and concluded:

- "Recreational boating enhances turbidity in water less than 6 feet deep, increases shoreline erosion, and has more season and cumulative impacts on these lakes than other types of localized boat-related activities such as spills.
- Boat-generated turbidity adversely affects aquatic communities, dissemination of routed aquatic vegetation, elimination of firm substrate by deposition of soft sediments, and consequently affects the spawning of fishes.
- Turbidity generated by 30 boats per hour is comparable to the turbidity generated by a

sustained wind of 20 mile per hour (mph)

- A normal 20-foot-long boat created wake waves equivalent to the waves generated by a 57 mph wind across the same area and in the same direction
- The intensity of summer boating activity has a similar environmental impact to that of a storm-like condition 12 hours per day on the weekend and 5 hours per day on weekdays.
- A statistically significant positive correlation existed between boating activities and turbidity on daily and weekly basis."

Aquatic Invasive Species

The Fox Chain O'Lakes is a one of the busiest inland recreational waterways per acre in the United States with weekend usage around 60,000 people, and up to 100,000 on holidays (2009, Antioch Chamber of Commerce). Since lake usage includes people from all over the State of Illinois and outside of Illinois, it is important to make the recreational users of the Fox Chain O'Lakes aware of the presence of aquatic invasive species and steps they can take to minimize the spread of species into and out of the lake. The Fox Chain O'Lakes have zebra mussels, milfoil, and curlyleaf pondweed all of which are easily spread by "aquatic hitchkiking". Steps the Fox Chain O'Lakes can take to reduce to the spread of invasive are:

- ***Install educational signs at boat launches on aquatic invasive species***
  Aquatic invasive boat ramp signs can encourage lake users to help stop the spread of invasive species. Boat ramp signs should indicate that the Fox Chain'O'Lakes are currently infested with AIS, and provide steps that recreational users can take that will prevent the spread of AIS species into and out of the lakes. The Illinois- Indiana Sea Grants initiative of "Be a Hero-Transport Zero" and the "Clean Waters Clean Boats program" is a way to educate recreational water users about aquatic invasive species. The "Be A Hero-Transport Zero" recommends following these simple steps to help reduce the spread of invasive:
    - Remove plants, animals, and mud from all equipment
    - Drain water from live wells and bait buckets
    - Dry items

  For additional information, visit the Illinois-Indiana Sea Grant website at http://www.iisgcp.org/ais.

- ***Encourage boat washing, or install boat washing stations at launches***
  Boat washing/cleaning stations use high-pressure water spray to remove aquatic invasive species from the exterior of boats, trailers, and equipment. It is only one step in the process for AIS prevention. There a multiple options for ways to wash a boat including:
    - Permanent station located at boat launch accesses
    - Portable Station

Allows watercraft on top where the boat is then washed and the it collects and contain all wastewater. The advantage is that is sets up in minutes making washing possible at most locations.

- Sprayer system

  The sprayer system is more flexible and convenient, and is a coin operated pressure washer. Costs approximately $3,200 (230 volt system)
- Commercial car washes
- Home washing

To be most effective, a wash station should have a person operating it to help the boater clean their boat. Considerations include the expense of initial set up and expense of staffing the stations. Boater willingness and attitude may also play a role. It is important to consider the boat traffic on lake and the time it takes to wash boats so there is a not a backup in boat washing – which could make unsafe conditions at boat launches.

Install Staff Gage

Wide fluctuations in lake level can create problems for lakeside residences, marinas, businesses, and impact near shore habitat for lake organisms. Changes in water level are typically associated with shifts in weather patterns, such as extended periods of unusually high or low precipitation. It may also be associated with human activities such as withdrawals for water use and dams that control water levels. A staff gage can be placed in a stream or lake to read water depth and lake water level. Staff gages can monitor changes in lake levels over time. The simplest way to install a staff gage is to attach it to a permanent structure, such as a bridge piling, although sometimes you may need to create your own structure to mount the gage on to, such as a metal pipe. Choosing a good location is important for the gage. The gage should be able to be in water during low-water level years and not overtopped during high water years. It should also not pose a risk to boaters and recreational users of the lake.

Septic Systems

A large majority of the residential and commercial properties around the Fox Chain O'Lakes are on a septic system. It is recommended that septic systems are inspected regularly in order to prevent sewage discharge into the lake. Septic tanks should be pumped as often as necessary (2-4 years) in order to remove the solids from the tank. Inspect absorption field for wet spots or ponding of water and sewage odors. Grass may grow denser and greener in these areas especially during the dry summer months. The Illinois Environmental Protection Agency and the Lake County Health Department recommends the following:

- Limit the water entering your septic tank and give your system time to rest after heavy use. Use water saving fixtures; repair leaky toilet and dripping faucets.
- Do not connect sump pump discharges to your septic system.

- Pump tanks when the sludge level fills ¾ of the septic tank.
- Avoid using a garbage disposal in order to limit the amount of solids entering the septic tank.
- Discard grease in the garbage instead of the drain. Also, use of liquid softeners can contribute to excessive scum in the septic system.
- Install a lint trap on your washing machine. Lint will clog the drain pipes in the absorption field.
- Keep water softener discharges out of your septic system. Sodium in the water softener reacts with the soil and reduces the absorption field's efficiency.
- Do not drive or park vehicles on top of the septic field. This can compact the soil and break pipes.
- Route surface drainage away from your septic field. Snow melt, rain or other runoff can temporarily inundate your field.

Phosphorus Free Lawn Fertilizer

Lakes in the Fox Chain O'Lakes exceed the water quality standard for phosphorus. Excess phosphorus from lawn fertilizers causes algal blooms in our waters. Use only phosphorus-free lawn fertilizer or request phosphorus-free fertilizer from your landscaper or lawn service. Soils in our area already contain sufficient phosphorus for a healthy lawn. On the standard bag of fertilizer, one can find three numbers (20-20-4). The middle of the three numbers represents the amount of phosphorus in the mix. Fertilizers should only be purchased if this middle number is zero, unless soil tests have determined your lawn needs additional phosphorus. In most cases, new lawns are typically the only lawns in that would benefit from a limited amount of phosphorus.

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Appendix A:
Maps

Figure 1: Public boat launches in the Fox Chain O'Lakes

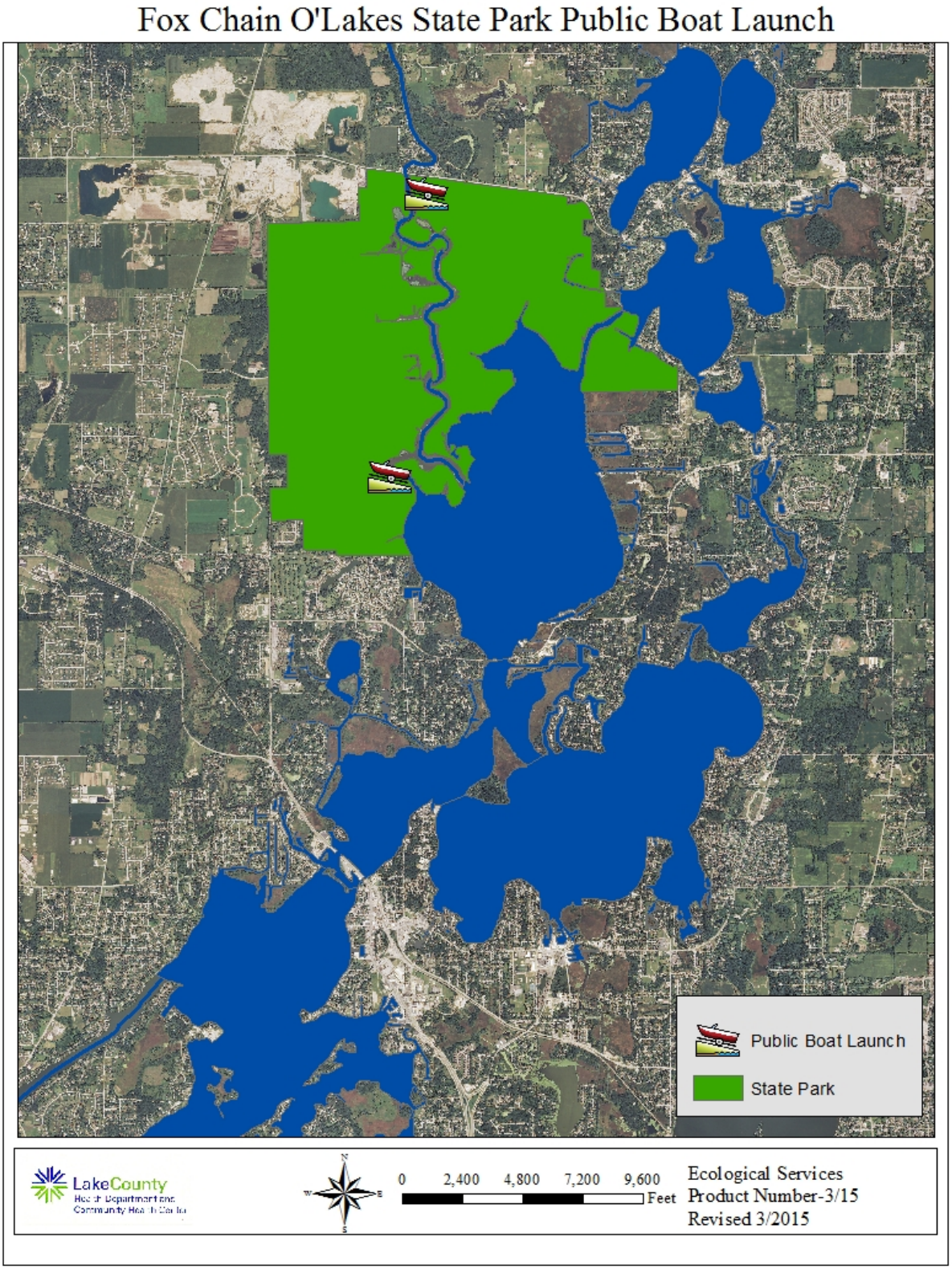


Figure 2: Fox River Watershed that drains into the Fox Chain O'Lakes with significant tributaries. Watershed boundary aggregated from data from the Southeastern Wisconsin Regional Planning Commission and the Illinois Rivers Decision Support System.

Fox Chain and Upper Fox River Watershed

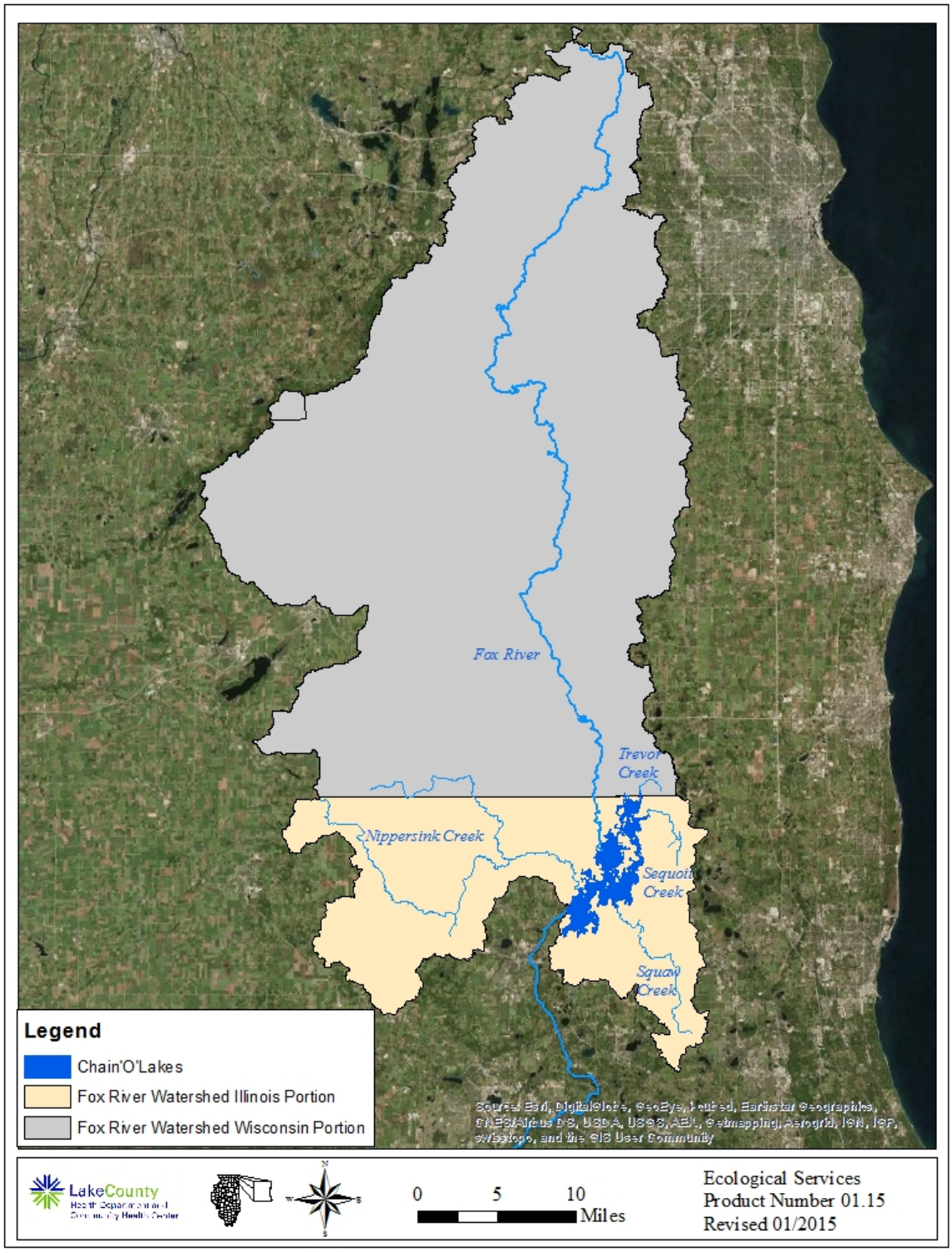


Figure 3: USGS Gage stations where continuous flow and water levels are recorded used for lake level data in the Fox Chain O'Lakes.

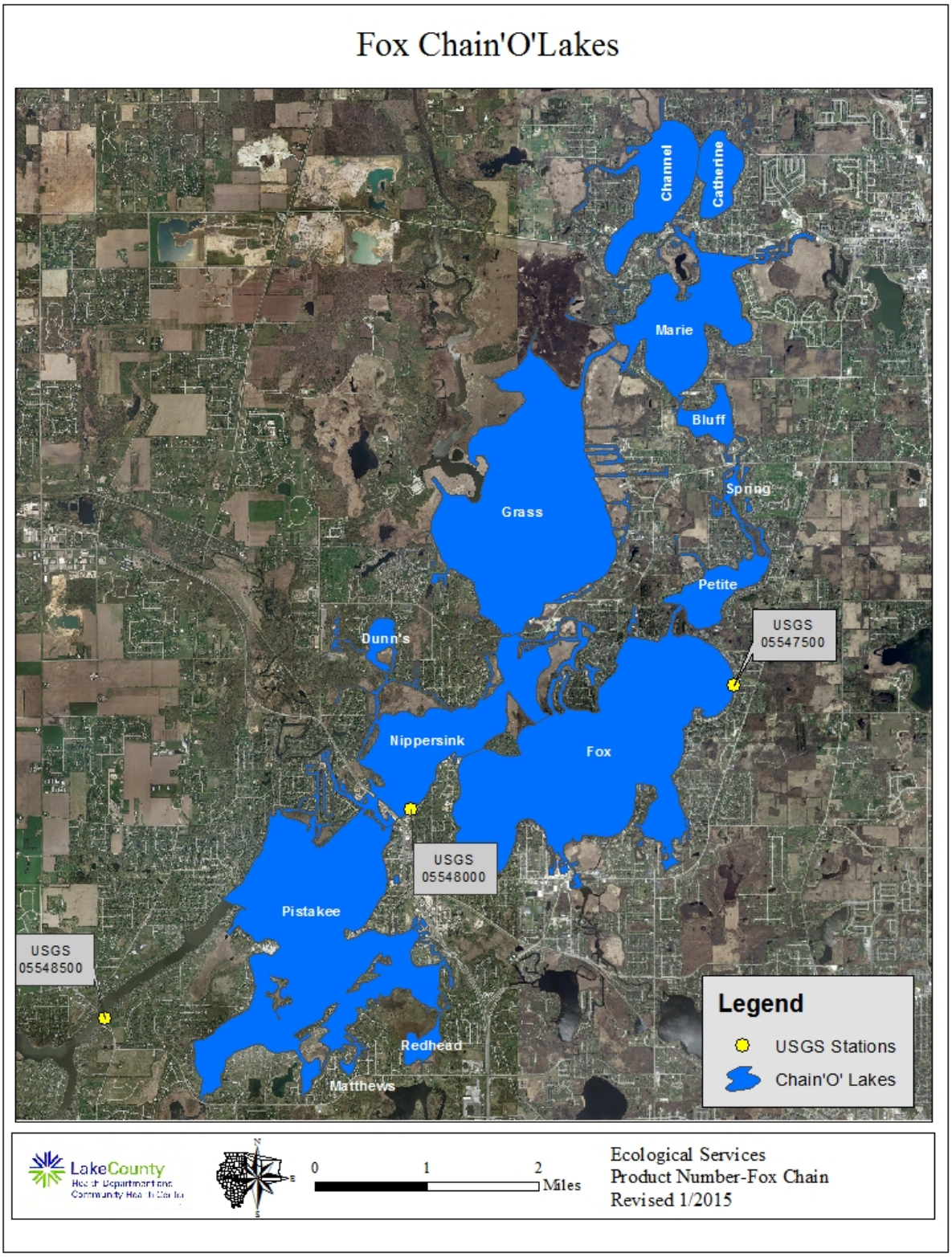


Figure 4: Dredging locations in the Fox Chain O'Lakes by the Fox Waterway Agency in 2014. The Fox River Waterway Agency removes approximately 128,000 cu.yds. annually from the Fox Chain.

Figure 5: Sampling points in the Fox Chain O'Lakes - North

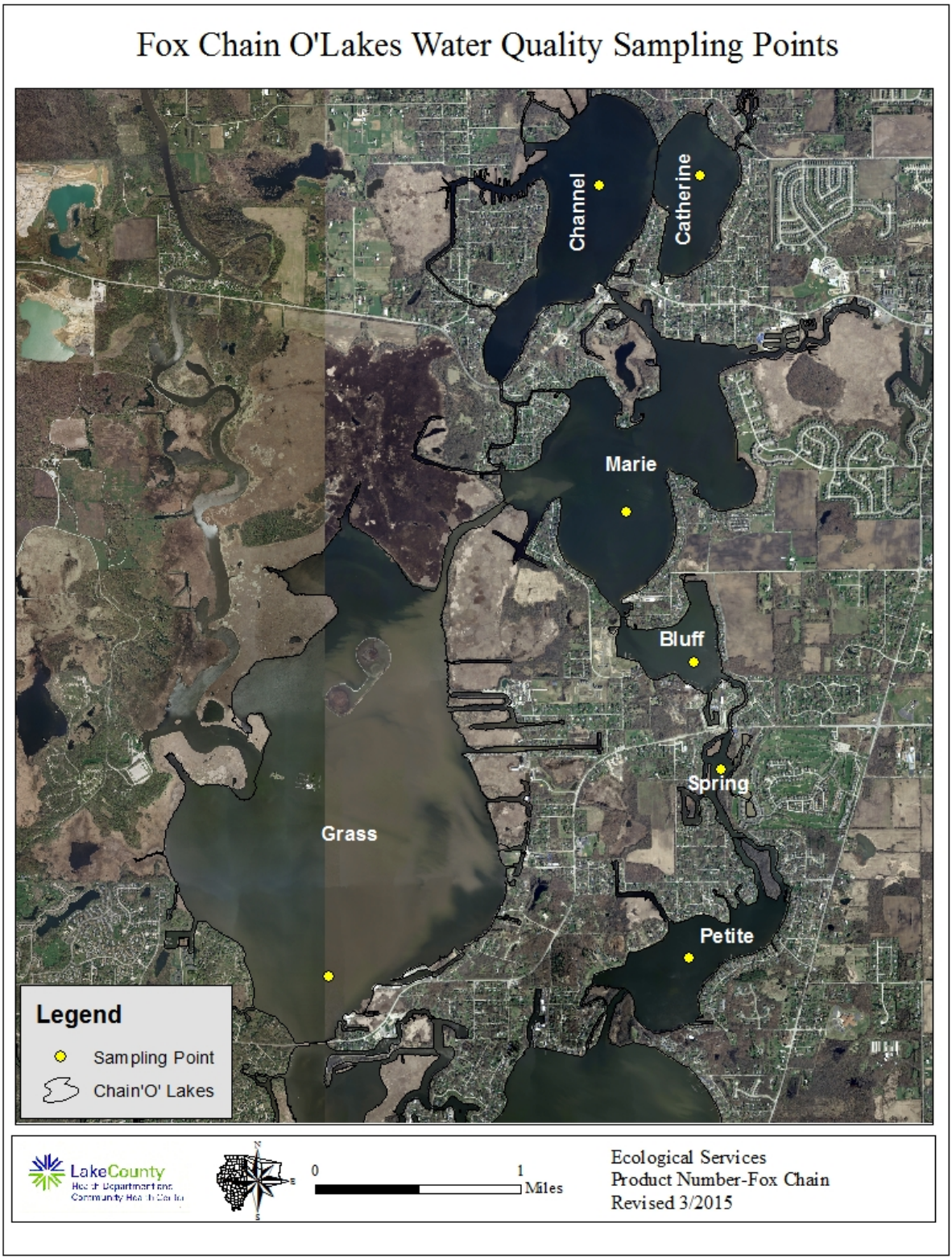


Figure 6: Sampling points in the Fox Chain O'Lakes - South

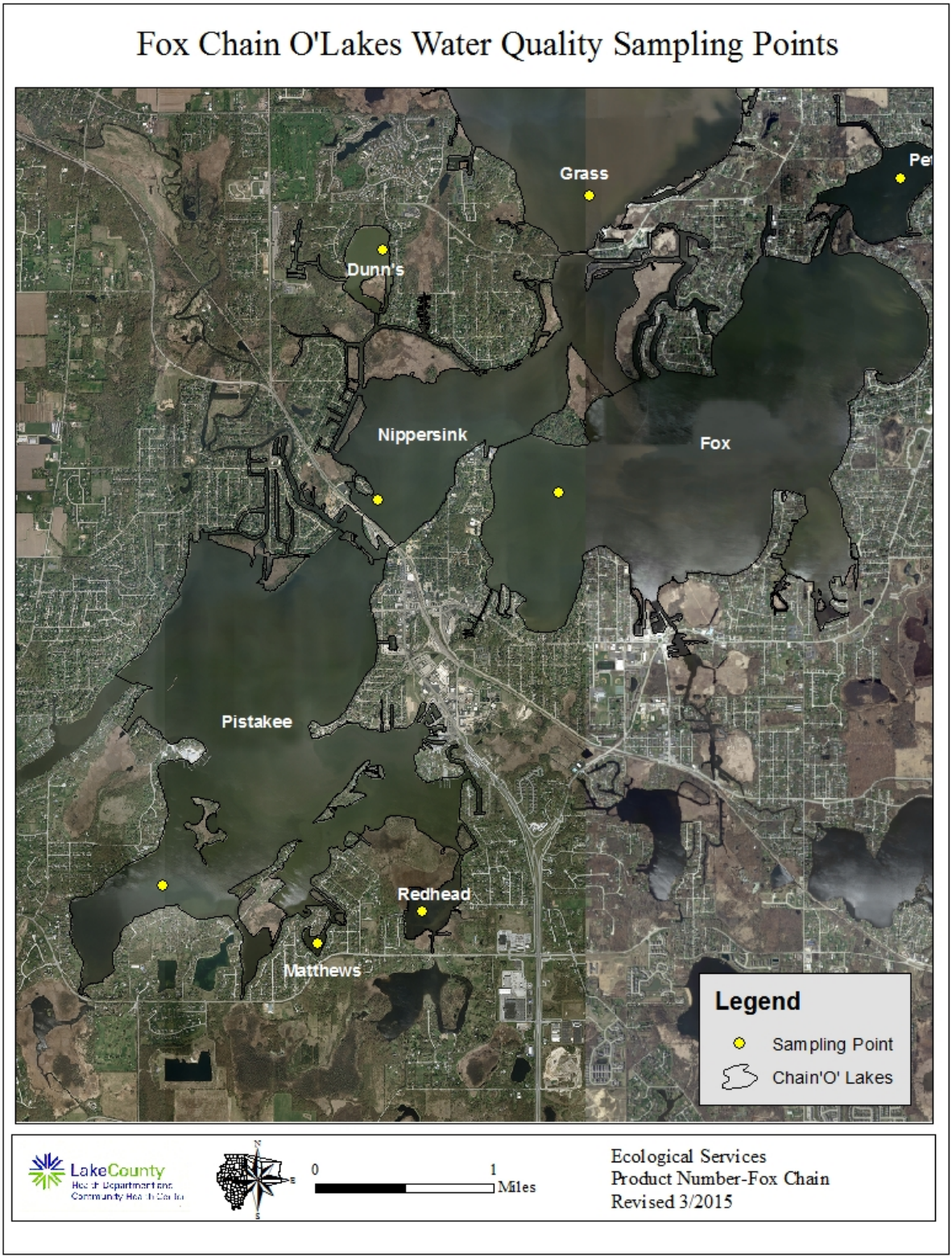


Figure 7: 2014 Aquatic Plant Rake Density on Fox Chain O'Lakes – North

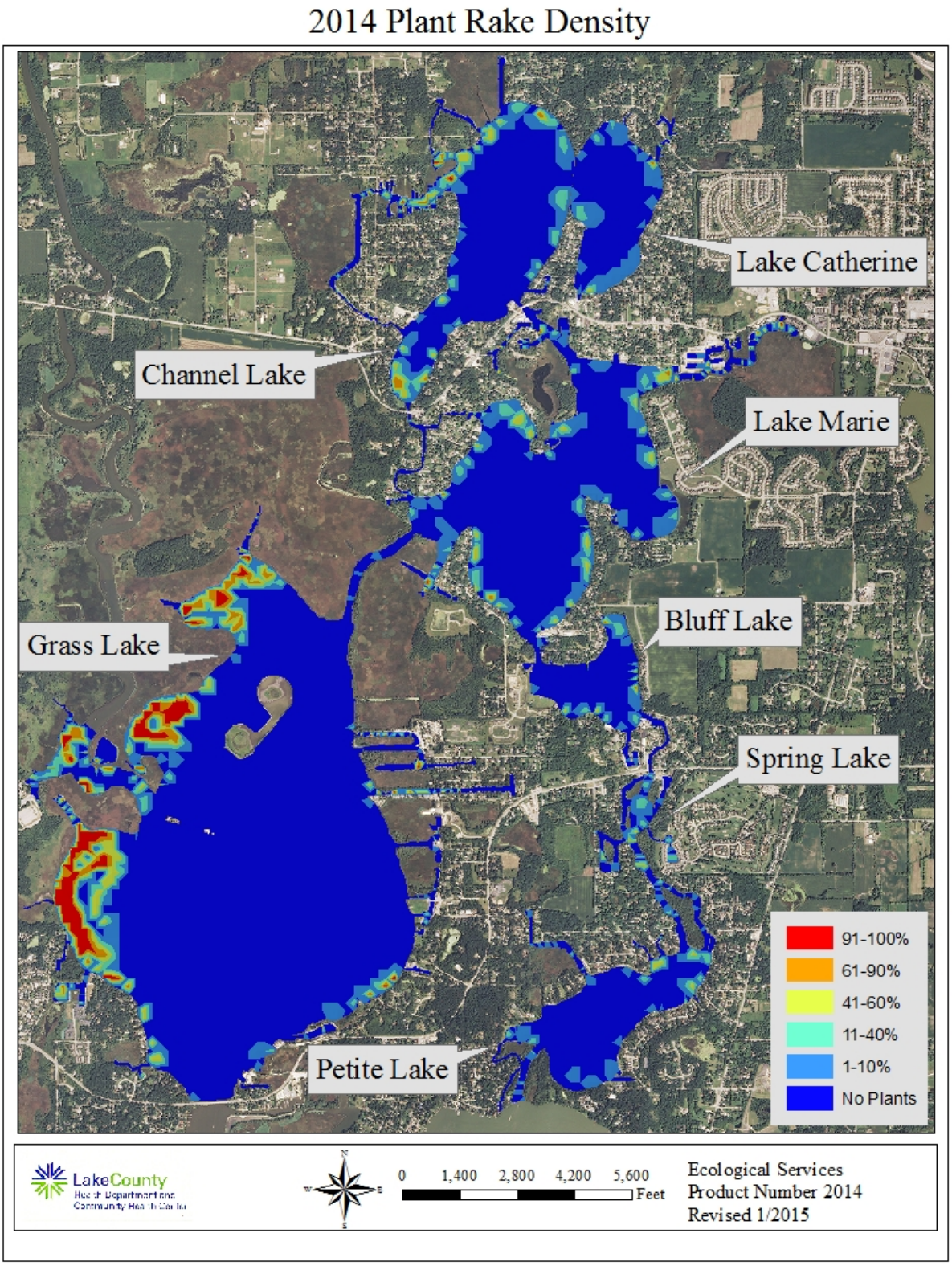


Figure 8: 2014 Aquatic Plant Rake Densities on Fox Chain O'Lakes – South

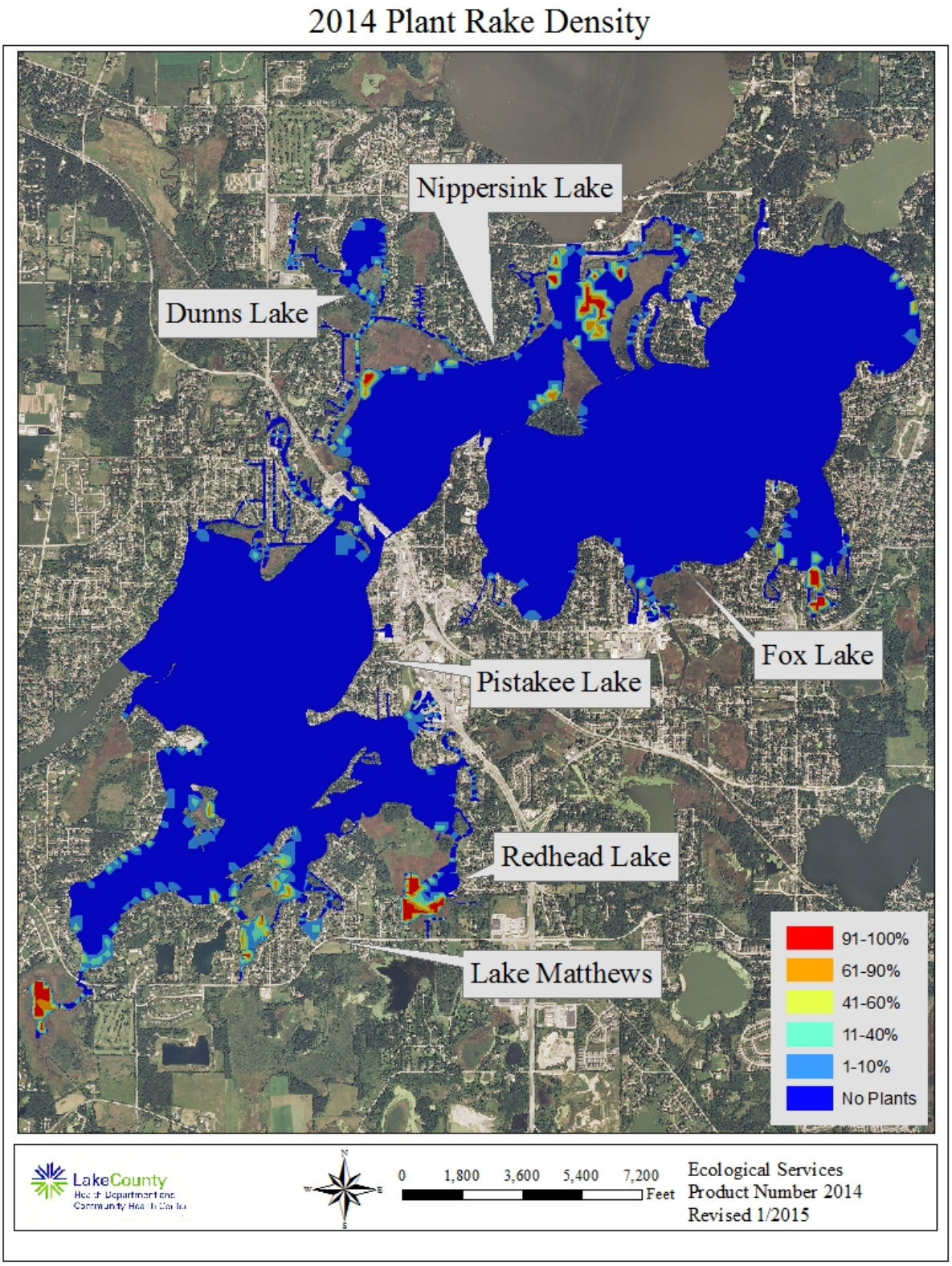


Figure 9: American Lotus populations on the Fox Chain 'O' Lakes, 2014.

Figure 10: North Fox Chain O'Lakes 2014 Lake County Health Department Licensed Beaches

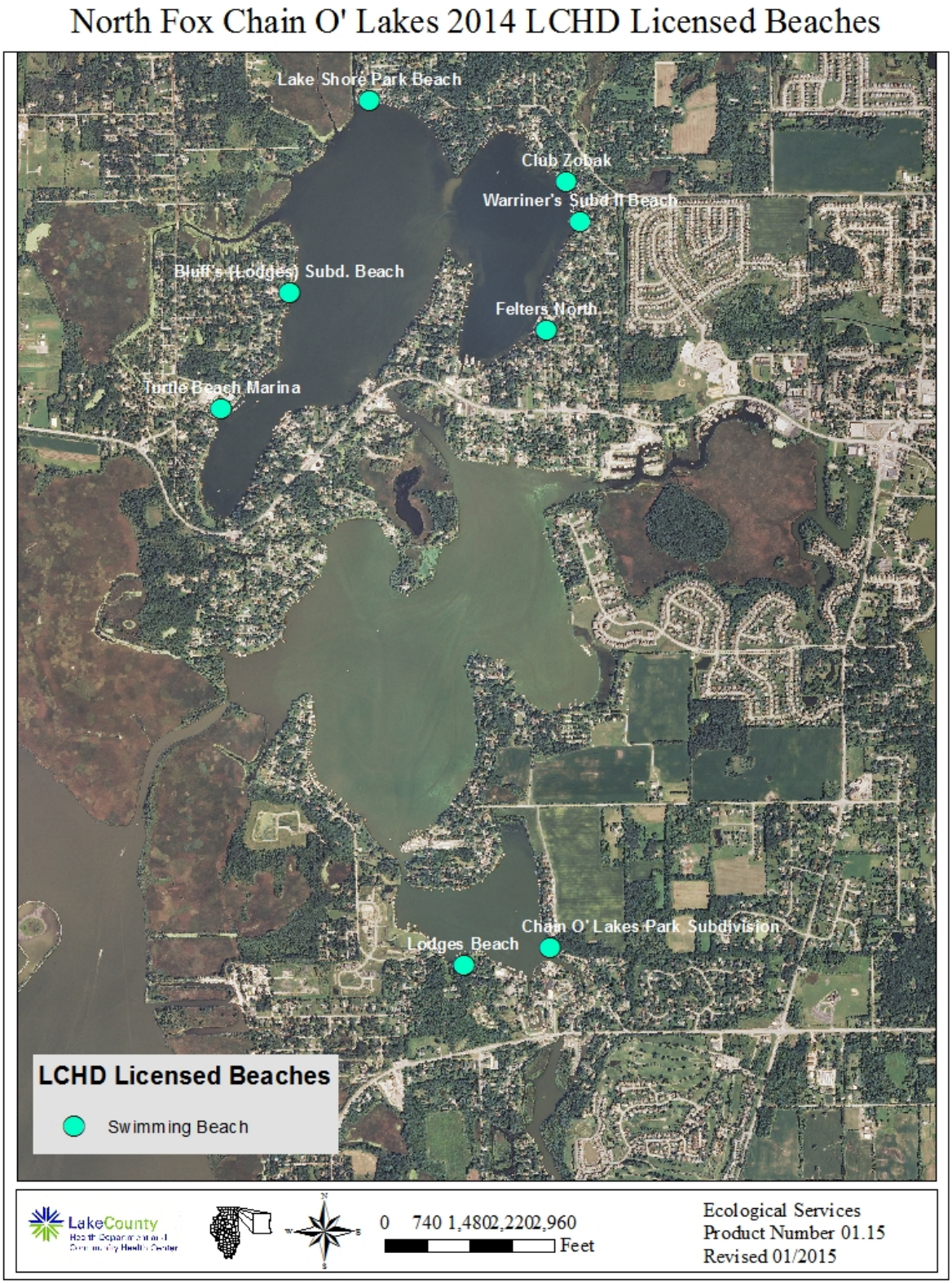
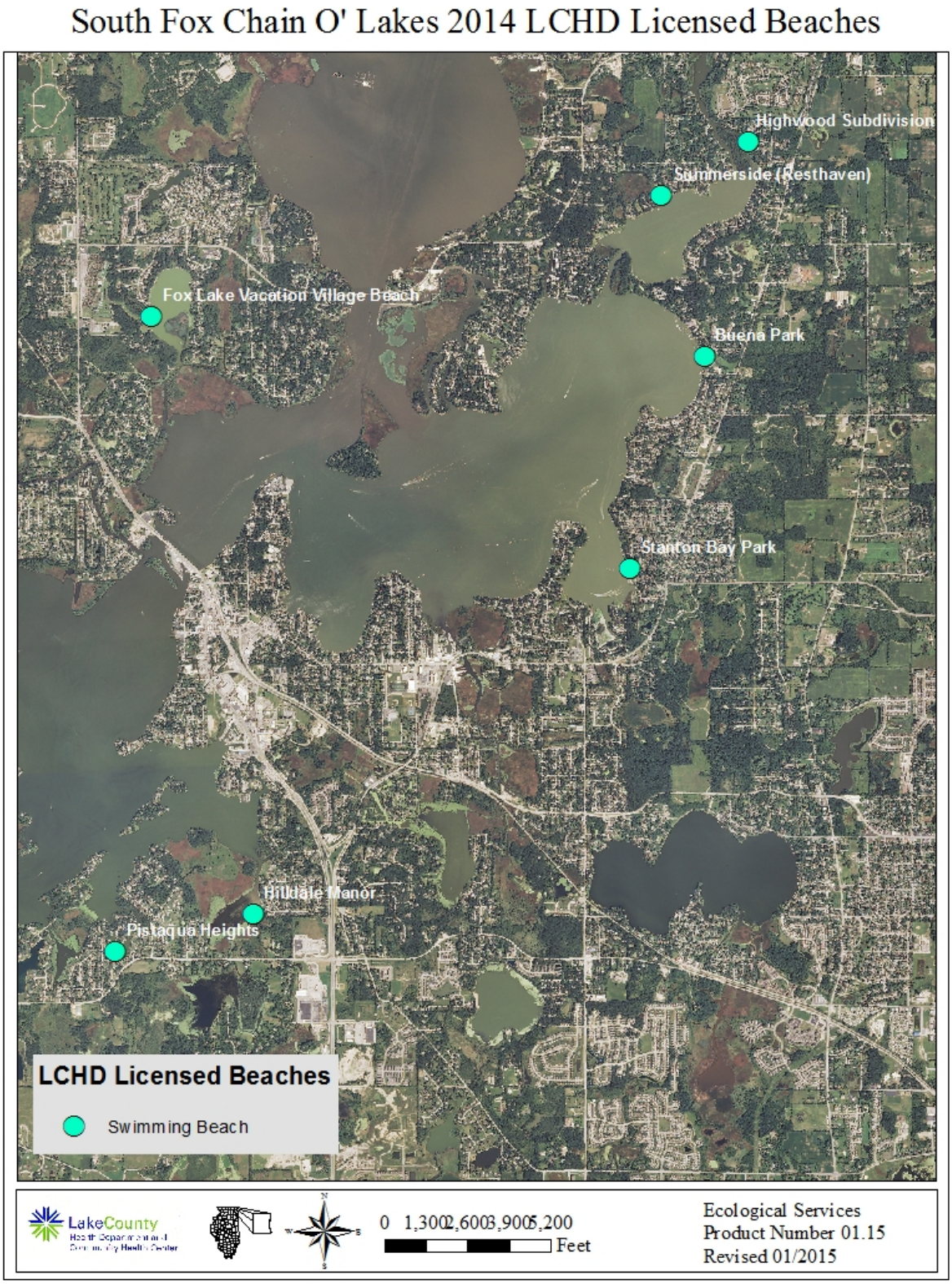


Figure 11: South Fox Chain O'Lakes 2014 Lake County Health Department Licensed Beaches



Appendix B:

Tables

2014 Chain O'Lakes Water Quality Data - Epiliminion Average Concentrations

Lakes	ALK	TKN	NH3	NO3	TP	SRP	TDS*	Cl-	TSS	TS	TVS	COND	pH	SECCHI	DO
Bluff Lake	200	1.90	0.25	0.12	0.112	0.006	429	116	11.0	491.4	125	0.7597	8.25	2.5	8.11
Channel Lake	180	1.46	0.12	<.05	0.068	0.0056	369	90	9.6	413	119.2	0.6397	8.43	2.8	9.27
Dunns Lake	200	2.33	0.17	0.18	0.107	<.005	455	124	33.2	551.8	161.8	0.8102	8.33	1.2	11.73
Fox Lake	218	1.69	0.16	0.18	0.094	0.0058	451	117	24.4	530	136.2	0.8020	8.22	1.2	9.22
Grass Lake	241	1.52	<0.10	0.34	0.109	0.0058	459	115	38.7	557.6	138.6	0.8178	8.31	0.9	10.98
Lake Catherine	183	1.40	0.11	0.05	0.062	<.005	374	91	9.6	413.6	112.4	0.6493	8.43	2.9	9.13
Lake Marie	201	1.80	0.18	0.12	0.103	<.005	433	116	13.2	494.2	127	0.7668	8.41	1.9	9.39
Lake Matthews	202	1.91	<0.10	<.05	0.118	<.005	436	121	25.0	510.2	132.2	0.7730	8.25	1.5	10.23
Lake Nippersink	237	1.45	<0.10	0.39	0.099	0.009	454	113	31.1	559.6	153.4	0.8090	8.16	0.9	9.96
Petite Lake	198	1.83	0.15	0.09	0.102	0.0062	430	116	14.9	501.8	138.2	0.7607	8.31	2.0	9.23
Pistakee Lake	218	1.65	0.15	0.22	0.088	<.005	430	104	14.8	494	128.6	0.7614	8.20	2.1	9.32
Redhead Lake	211	1.27	<0.10	<.05	0.061	<.005	396	94	13.3	457.2	126	0.6932	8.04	2.2	8.08
Spring Lake	200	1.91	0.24	0.11	0.110	0.0066	427	115	15.1	494.2	130.2	0.7557	8.28	1.8	8.81
Overall Chain Average	*207*	*1.70* [k]	*0.15* [k]	*0.15* [k]	*0.09*	*.01* [k]	*426*	*110*	*19.5*	*497.58*	*133.0*	*0.7537*	*8.28*	*1.83*	*9.50*

Glossary
ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH3 = Ammonia nitrogen, mg/L
NO3 = Nitrate nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
*TDS = Total dissolved solids, mg/L
TSS = Total suspended solids, mg/L
TS = Total solids, mg/L
TVS = Total volatile solids, mg/L
SECCHI = Secchi Disk Depth, Ft.
COND = Conductivity, milliSiemens/cm

*TDS is a calculated value

k = Denotes that the actual value is known to be less than the value presented

For average calculations, non-detects were valued at the non-detect level.

2014 Chain'O'Lakes Water Quality Data - Hypoliminion Average Concentrations

Lakes	ALK	TKN	NH3	NO3	TP	SRP	TDS*	Cl-	TSS	TS	TVS	COND	pH	DO
Bluff	238	5.87	3.1	0.11	0.64	0.54	469	125	7.8	508.2	114.6	0.8381	7.4	2.1
Catherine	231	5.602	4.4	<0.05	0.60	0.53	417	97.3	5.5	445.8	118	0.7351	7.2	0.5
Channel	235	6.392	5.4	<0.05	0.73	0.67	419	95.4	7.7	445.4	114.4	0.7384	7.3	2.4
Fox	216	1.706	0.2	0.18	0.10	<0.005	453	118	21.8	534	144.6	0.8062	8.2	8.9
Marie	229	4.5	3.2	0.08	0.53	0.46	454	117	9.2	503.4	128.8	0.8090	7.7	3.9
Petite	199	1.852	0.2	0.09	0.10	0.01	431	116	12.8	487.4	123	0.7635	8.1	6.8
Pistakee	223	1.794	0.3	0.21	0.10	0.01	434	104	13.7	507.8	137.2	0.7694	8.0	7.2
Overall Chain Average	*224*	*4.0*	*2.39*	*0.11*	*0.40*	*0.32*	*440*	*110.3*	*11.2*	*490.3*	*125.8*	*0.7800*	*7.7*	*4.5*

Glossary

ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH3 = Ammonia nitrogen, mg/L
NO3 = Nitrate nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
TDS = Total dissolved solids, mg/L
TSS = Total suspended solids, mg/L
TS = Total solids, mg/L
TVS = Total volatile solids, mg/L
SECCHI = Secchi Disk Depth, Ft.
COND = Conductivity, milliSiemens/cm

*TDS is a calculated value

k = Denotes that the actual value is known to be less than the value presented

For average calculations, non-detects were valued at the non-detect level.

2014 Water Quality Data Fox Chain'O'Lakes

	ALK	TKN	NH3	NO3	TP	SRP	Cl-	TDS*	TSS	TS	TVS	COND	pH	Secchi	DO
Bluff Lake															
07-May-14	190	1.96	<0.1	0.178	0.106	<0.005	130	434.3	14	519	138	0.7693	8.97	1.3	14.8
11-Jun-14	196	1.52	0.245	0.249	0.067	<0.005	114	434.2	5.5	499	119	0.7692	8.17	4.92	6.93
09-Jul-14	199	1.59	<0.1	<0.05	0.094	<0.005	108	413.5	13	488	139	0.7279	8.52	3.5	8.99
13-Aug-14	205	1.76	<0.1	<0.05	0.09	<0.005	112	424.6	9.6	490	138	0.75	8.01	1.83	4.53
17-Sep-14	210	2.68	0.687	<0.05	0.204	0.01	116	440.7	13	461	91	0.782	7.56	1	5.3
Channel Lake															
06-May-14	187	1.73	<0.1	<0.05	0.106	<0.005	92.5	370.3	16	441	125	0.642	8.79	1.5	12.7
10-Jun-14	187	1.15	<0.1	<0.05	0.045	<0.005	94.8	378.3	3.2	422	126	0.6579	8.48	6.9	9.04
08-Jul-14	173	1.2	<0.1	<0.05	0.054	<0.005	81	373.7	8	398	110	0.6488	8.41	2.8	9.5
12-Aug-14	181	1.46	<0.1	<0.05	0.047	0.008	90.2	362.2	11	419	133	0.6259	8.57	1.4	8.22
16-Sep-14	174	1.78	0.199	<0.05	0.086	<0.005	90.4	361.2	10	385	102	0.624	7.9	1.25	6.9
Dunns Lake															
07-May-14	190	2.35	<0.1	0.423	0.118	<0.005	117	442.2	27	519	140	0.785	8.48	1.5	12.2
11-Jun-14	218	2.39	0.466	0.335	0.074	<0.005	121	472.4	20	552	148	0.845	8.15	1.79	9.39
09-Jul-14	197	2.01	<0.1	<0.05	0.087	<0.005	117	450.7	33	554	172	0.802	8.3	1.1	13.4
13-Aug-14	212	3.07	<0.1	<0.05	0.183	<0.005	133	472.9	60	589	181	0.846	8.01	0.7	7.91
17-Sep-14	182	1.85	<0.1	<0.05	0.071	<0.005	132	436.2	26	545	168	0.773	8.71	1	15.7
Fox Lake															
06-May-14	208	1.71	<0.1	0.567	0.094	<0.005	126	477.4	26	593	181	0.855	8.08	1	12
10-Jun-14	224	1.65	0.361	0.193	0.07	0.007	115	458.3	31	533	131	0.817	8.06	0.7	6.96
08-Jul-14	216	1.38	<0.1	<0.05	0.081	0.007	110	432.6	21	500	119	0.766	8.36	1.4	9.2
12-Aug-14	225	1.87	0.104	<0.05	0.107	<0.005	112	438.7	21	512	132	0.778	8.13	1.42	6.3
16-Sep-14	217	1.84	0.114	<0.05	0.12	<0.005	120	446.7	23	512	118	0.794	8.49	1.3	11.7

Glossary

ALK = Alkalinity, mg/L $CaCO_3$

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NO3 = Nitrate nitrogen, mg/L

TP = Total phosphorus, mg/L

SRP = Soluble reactive phosphorus, mg/L

TDS = Total dissolved solids, mg/L

TSS = Total suspended solids, mg/L

TS = Total solids, mg/L

TVS = Total volatile solids, mg/L

SECCHI = Secchi Disk Depth, Ft.

COND = Conductivity, milliSiemens/cm

k = Denotes that the actual value is known to be less than the value presented

For average calculations, non-detects were valued at the non-detect level.

*TDS is a calculated value

2014 Water Quality Data Fox Chain'O'Lakes

	ALK	TKN	NH3	NO3	TP	SRP	Cl-	TDS*	TSS	TS	TVS	COND	pH	Secchi	DO
Grass Lake															
06-May-14	220	1.6	<0.1	0.581	0.088	<0.005	113	441.7	36	559	153	0.784	7.92	0.78	11.3
10-Jun-14	248	1.75	<0.1	0.117	0.129	<0.005	114	456.8	57.6	582	145	0.814	8.33	0.68	10.1
08-Jul-14	263	1.37	<0.1	0.421	0.096	0.009	99.5	457.3	28	544	131	0.815	8.22	1.1	11.6
12-Aug-14	221	1.66	<0.1	<0.05	0.148	<0.005	133	464.3	52	567	148	0.829	8.57	0.75	8.5
16-Sep-14	251	1.22	<0.1	0.509	0.083	<0.005	113	473.4	20	536	116	0.847	8.52	1	13.4
Lake Catherine															
07-May-14	186	1.7	<0.1	<0.05	0.11	<0.005	94	375.4	13	426	104	0.6522	8.89	1.61	13.2
10-Jun-14	188	1.22	<0.1	<0.05	0.047	<0.005	93	384.2	7.6	429	124	0.6696	8.49	7.5	9.25
08-Jul-14	188	1.22	<0.1	<0.05	0.047	<0.005	87	387	7.6	417	122	0.6752	8.41	2.6	9.34
13-Aug-14	182	1.29	<0.1	<0.05	0.044	<0.005	90.2	364.6	9.6	396	106	0.6307	8.33	1.58	6.29
16-Sep-14	171	1.57	0.137	<0.05	0.064	<0.005	90.8	358.7	10	400	106	0.619	8.03	1.23	7.59
Lake Marie															
06-May-14	190	2.02	<0.1	0.203	0.112	<0.005	128	436.7	20	535	146	0.7741	8.93	1.5	13.7
10-Jun-14	208	1.36	0.155	0.249	0.063	<0.005	118	443.5	5.8	498	106	0.7876	8.36	3.1	8.42
08-Jul-14	203	1.6	<0.1	<0.05	0.088	<0.005	107	434.4	14	471	110	0.7695	8.61	1.9	10.4
12-Aug-14	203	1.75	<0.1	<0.05	0.084	<0.005	112	420.1	12	484	144	0.741	8.37	1.9	7.09
16-Sep-14	203	2.27	0.446	<0.05	0.166	<0.005	117	430.6	14	483	129	0.762	7.79	0.95	7.33
Lake Matthews															
07-May-14	186	1.66	<0.1	<0.05	0.102	<0.005	124	433.1	20	514	128	0.767	8.44	1.5	11.8
11-Jun-14	190	2.84	0.107	<0.05	0.171	<0.005	119	432.1	49.2	521	149	0.765	8.08	1.4	9.28
09-Jul-14	219	1.73	<0.1	<0.05	0.117	<0.005	119	449.7	24	511	129	0.8	8.24	1.6	9.2
13-Aug-14	207	1.67	<0.1	<0.05	0.111	<0.005	122	444.2	14	515	141	0.789	8.03	1.8	8.58
17-Sep-14	210	1.63	<0.1	<0.05	0.09	<0.005	120	421.6	18	490	114	0.744	8.48	1.1	12.3
Lake Nippersink															
06-May-14	247	1.38	<0.1	1.35	0.074	<0.005	115	469.3	33.8	621	170	0.839	7.71	0.91	12
10-Jun-14	247	1.58	<0.1	0.2	0.124	0.006	110	456.3	21.8	587	169	0.813	8.12	0.7	7.27
08-Jul-14	246	1.54	<0.1	0.134	0.111	0.024	103	439.7	46.8	549	162	0.78	8.3	0.83	10
12-Aug-14	211	1.42	<0.1	0.05	0.105	<0.005	125	450.7	30	510	140	0.802	8.26	1.25	7.3
16-Sep-14	236	1.33	<0.1	0.227	0.083	<0.005	114	455.3	23	531	126	0.811	8.4	0.9	13.2

Glossary

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TP = Total phosphorus, mg/L

SRP = Soluble reactive phosphorus, mg/L

TDS = Total dissolved solids, mg/L

TSS = Total suspended solids, mg/L

TS = Total solids, mg/L

TVS = Total volatile solids, mg/L

SECCHI = Secchi Disk Depth, Ft.

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For average calculations, non-detects were valued at the non-detect level.

*TDS is a calculated value

2014 Water Quality Data Fox Chain'O'Lakes

	ALK	TKN	NH3	NO3	TP	SRP	Cl-	TDS*	TSS	TS	TVS	COND	pH	Secchi	DO
Petite Lake															
07-May-14	178	2.1	<0.1	<0.05	0.121	<0.005	130	431.8	23	523	136	0.7644	8.97	1	14.5
11-Jun-14	200	1.61	0.312	0.226	0.075	0.011	113	437.7	6.6	517	139	0.7761	8.14	3.5	6.9
09-Jul-14	199	1.53	<0.1	<0.05	0.087	<0.005	114	418	13	478	135	0.7368	8.49	2.67	8.96
13-Aug-14	209	1.87	0.118	<0.05	0.11	<0.005	110	431.1	14	514	164	0.763	7.9	1.75	5.25
17-Sep-14	206	2.02	<0.1	<0.05	0.115	<0.005	115	431.1	18	477	117	0.763	8.07	1.1	10.5
Pistakee Lake															
07-May-14	204	1.84	<0.1	0.491	0.093	<0.005	113	437.7	17	506	123	0.776	8.42	2	11.6
11-Jun-14	231	1.78	0.233	0.378	0.094	<0.005	100	439.7	19	521	148	0.78	8.04	2.4	7.83
09-Jul-14	215	1.24	<0.1	0.148	0.057	<0.005	98.5	419.6	15	484	123	0.74	8.33	2.2	11.2
13-Aug-14	222	1.8	0.164	0.05	0.098	<0.005	102	432.6	13	495	140	0.766	7.85	2.2	5.16
17-Sep-14	219	1.57	0.145	0.055	0.098	<0.005	107	422.1	10	464	109	0.745	8.36	1.94	10.9
Redhead Lake															
07-May-14	213	1.3	<0.1	<0.05	0.073	<0.005	102	416	11	478	120	0.733	8.3	2	9.89
11-Jun-14	226	1.81	<0.1	<0.05	0.103	<0.005	104	428.1	23	523	139	0.757	8.17	1.5	7.58
09-Jul-14	208	1.18	<0.1	<0.05	0.055	<0.005	83.5	379.3	20.4	431	115	0.66	7.8	2.2	5.55
13-Aug-14	207	1.14	<0.1	<0.05	0.05	<0.005	101	406	6	462	154	0.713	7.87	2.5	6.46
17-Sep-14	201	0.906	<0.1	<0.05	0.023	<0.005	79.6	350.7	6.1	392	102	0.603	8.07	2.6	10.9
Spring Lake															
07-May-14	189	2.08	<0.1	0.187	0.111	<0.005	128	435.8	21	518	123	0.7722	8.98	1.1	15.5
11-Jun-14	195	1.59	0.319	0.231	0.076	0.012	110	423.5	8.5	502	144	0.7479	8.05	3.08	6.95
09-Jul-14	202	1.48	<0.1	<0.05	0.077	<0.005	109	415.8	14	478	129	0.7325	8.49	2.12	8.46
13-Aug-14	205	1.83	<0.1	<0.05	0.102	<0.005	110	421.5	17	500	137	0.7438	8.2	1.42	6.29
17-Sep-14	210	2.55	0.605	<0.05	0.182	0.006	116	440.7	15	473	118	0.782	7.68	1.2	6.89

Glossary

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*TDS is a calculated value

Lake County average Floristic Quality Index (FQI) ranking 2000-2014.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	37.4	38.9
2	East Loon Lake	34.7	36.1
3	Cranberry Lake	29.7	29.7
4	Deep Lake	29.7	31.2
5	Little Silver Lake	29.6	31.6
6	Round Lake Marsh North	29.1	29.9
7	West Loon Lake	27.1	29.5
8	Sullivan Lake	26.9	28.5
9	Bangs Lake	26.2	27.8
10	Third Lake	25.1	22.5
11	Fourth Lake	24.7	27.1
12	Indpendence Grove	24.6	27.5
13	Sterling Lake	24.5	26.9
14	Sun Lake	24.3	26.1
15	Lake Zurich	24.3	27.1
16	Redwing Slough	24.0	25.8
17	Schreiber Lake	23.9	24.8
18	Lakewood Marsh	23.8	24.7
19	Deer Lake	23.5	24.4
20	Round Lake	23.5	25.9
21	Pistakee Lake	23.5	25.2
22	Lake Marie	23.5	25.2
23	Honey Lake	23.3	25.1
24	Lake of the Hollow	23.0	24.8
25	Cross Lake	22.4	24.2
26	Nippersink Lake (Fox Chain)	22.4	23.2
27	Countryside Glen Lake	21.9	22.8
28	Grass Lake	21.5	22.2
29	Davis Lake	21.4	21.4
30	Butler Lake	21.4	23.1
31	Lake Barrington	21.2	21.2
32	Duck Lake	21.1	22.9
33	Timber Lake (North)	20.9	23.4
34	Lake Catherine	20.8	21.8
35	ADID 203	20.5	20.5
36	Broberg Marsh	20.5	21.4
37	McGreal Lake	20.2	22.1
38	Fox Lake	20.2	21.2
39	Lake Kathryn	19.6	20.7
40	Fish Lake	19.3	21.2
41	Druce Lake	19.1	21.8
42	Turner Lake	18.6	21.2
43	Wooster Lake	18.5	20.2
44	Salem Lake	18.5	20.2
45	Lake Helen	18.0	18.0
46	Old Oak Lake	18.0	19.1
47	Potomac Lake	17.8	17.8
48	Redhead Lake	17.7	18.7
49	Long Lake	17.7	15.8
50	Hendrick Lake	17.7	17.7
51	Rollins Savannah 2	17.7	17.7
52	Grandwood Park Lake	17.2	19.0
53	Seven Acre Lake	17.0	15.5
54	Lake Miltmore	16.8	18.7
55	Petite Lake	16.8	18.7
56	Channel Lake	16.8	18.7
57	McDonald Lake 1	16.7	17.7

Lake County average Floristic Quality Index (FQI) ranking 2000-2014.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
58	Highland Lake	16.7	18.9
59	Bresen Lake	16.6	17.8
60	Almond Marsh	16.3	17.3
61	Owens Lake	16.3	17.3
62	Windward Lake	16.3	17.6
63	Grays Lake	16.1	16.1
64	White Lake	16.0	17.0
65	Dunns Lake	15.9	17.0
66	Dog Bone Lake	15.7	15.7
67	Osprey Lake	15.5	17.3
68	Heron Pond	15.1	15.1
69	North Churchill Lake	15.0	15.0
70	Hastings Lake	15.0	17.0
71	Lake Tranquility (S1)	15.0	17.0
72	Forest Lake	14.8	15.9
73	Dog Training Pond	14.7	15.9
74	Grand Ave Marsh	14.3	16.3
75	Nippersink Lake	14.3	16.3
76	Taylor Lake	14.3	16.3
77	Manning's Slough	14.1	16.3
78	Tower Lake	14.0	14.0
79	Dugdale Lake	14.0	15.1
80	Eagle Lake (S1)	14.0	15.1
81	Crooked Lake	14.0	16.0
82	Spring Lake	14.0	15.2
83	Lake Matthews	13.9	15.5
84	Longview Meadow Lake	13.9	13.9
85	Bishop Lake	13.4	15.0
86	Ames Pit	13.4	15.5
87	Mary Lee Lake	13.1	15.1
88	Old School Lake	13.1	15.1
89	Summerhill Estates Lake	12.7	13.9
90	Buffalo Creek Reservoir 1	12.5	11.4
91	Buffalo Creek Reservoir 2	12.5	11.4
92	McDonald Lake 2	12.5	12.5
93	Rollins Savannah 1	12.5	12.5
94	Stone Quarry Lake	12.5	12.5
95	Kemper Lake 1	12.2	13.4
96	Pond-A-Rudy	12.1	12.1
97	Stockholm Lake	12.1	13.5
98	Lake Carina	12.1	14.3
99	Lake Leo	12.1	14.3
100	Lambs Farm Lake	12.1	14.3
101	Grassy Lake	12.0	12.0
102	Flint Lake Oulet	11.8	13.0
103	Albert Lake	11.5	10.3
104	Rivershire Pond 2	11.5	13.3
105	Antioch Lake	11.3	13.4
106	Hook Lake	11.3	13.4
107	Briarcrest Pond	11.2	12.5
108	Lake Naomi	11.2	12.5
109	Pulaski Pond	11.2	12.5
110	Lake Napa Suwe	11.0	11.0
111	Redwing Marsh	11.0	11.0
112	West Meadow Lake	11.0	11.0
113	Lake Minear	11.0	13.9
114	Nielsen Pond	10.7	12.0
115	Lake Holloway	10.6	10.6

Lake County average Floristic Quality Index (FQI) ranking 2000-2014.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
116	Sylvan Lake	10.6	10.6
117	Gages Lake	10.2	12.5
118	College Trail Lake	10.0	10.0
119	Valley Lake	9.9	9.9
120	Werhane Lake	9.8	12.0
121	Loch Lomond	9.4	12.1
122	Columbus Park Lake	9.2	9.2
123	Lake Lakeland Estates	9.2	9.2
124	Waterford Lake	9.2	9.2
125	Bluff Lake	9.1	11.0
126	Lake Fairfield	9.0	10.4
127	Lake Louise	9.0	10.4
128	Fischer Lake	9.0	11.0
129	Lake Fairview	8.5	6.9
130	Timber Lake (South)	8.5	6.9
131	East Meadow Lake	8.5	8.5
132	South Churchill Lake	8.5	8.5
133	Kemper Lake 2	8.5	9.8
134	Lake Christa	8.5	9.8
135	Lake Farmington	8.5	9.8
136	Lucy Lake	8.5	9.8
137	Bittersweet Golf Course #13	8.1	8.1
138	Lake Linden	8.0	8.0
139	Sand Lake	8.0	10.4
140	Countryside Lake	7.7	11.5
141	Fairfield Marsh	7.5	8.7
142	Lake Eleanor	7.5	8.7
143	Banana Pond	7.5	9.2
144	Slocum Lake	7.1	5.8
145	Lucky Lake	7.0	7.0
146	North Tower Lake	7.0	7.0
147	Lake Forest Pond	6.9	8.5
148	Ozaukee Lake	6.7	8.7
149	Leisure Lake	6.4	9.0
150	Peterson Pond	6.0	8.5
151	Little Bear Lake	5.8	7.5
152	Deer Lake Meadow Lake	5.2	6.4
153	ADID 127	5.0	5.0
154	Island Lake	5.0	5.0
155	Liberty Lake	5.0	5.0
156	Oak Hills Lake	5.0	5.0
157	Slough Lake	5.0	5.0
158	International Mining and Chemical Lake	5.0	7.1
159	Diamond Lake	3.7	5.5
160	Lake Charles	3.7	5.5
161	Big Bear Lake	3.5	5.0
162	Sand Pond (IDNR)	3.5	5.0
163	Harvey Lake	3.3	5.0
164	Half Day Pit	2.9	5.0
165	Lochanora Lake	2.5	5.0
166	Echo Lake	0.0	0.0
167	Hidden Lake	0.0	0.0
168	St. Mary's Lake	0.0	0.0
169	Willow Lake	0.0	0.0
170	Woodland Lake	0.0	0.0
	Mean	**14.1**	**15.2**
	Median	**13.4**	**15.0**

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

RANK	LAKE NAME	TP AVE	TSIp
1	Lake Carina	0.0100	37.35
2	Sterling Lake	0.0100	37.35
3	Cedar Lake	0.0130	41.14
4	Indpendence Grove	0.0130	41.14
5	Lake Zurich	0.0135	41.68
6	Druce Lake	0.0140	42.00
7	Windward Lake	0.0160	44.13
8	Sand Pond (IDNR)	0.0165	44.57
9	West Loon	0.0170	45.00
10	Pulaski Pond	0.0180	45.83
11	Banana Pond	0.0200	47.35
12	Gages Lake	0.0200	47.35
13	Lake Kathryn	0.0200	47.35
14	Lake Minear	0.0200	47.35
15	Highland Lake	0.0202	47.49
16	Lake Miltmore	0.0210	48.00
17	Timber Lake (North)	0.0210	48.05
18	Cross Lake	0.0220	48.72
19	Dog Training Pond	0.0220	48.72
20	Sun Lake	0.0220	48.72
21	Deep Lake	0.0230	49.36
22	Lake of the Hollow	0.0230	49.36
23	Round Lake	0.0230	49.36
24	Stone Quarry Lake	0.0230	49.36
25	Little Silver Lake	0.0250	50.57
26	Bangs Lake	0.0260	51.13
27	Lake Leo	0.0260	51.13
28	Cranberry Lake	0.0270	51.68
29	Dugdale Lake	0.0270	51.68
30	Peterson Pond	0.0270	51.68
31	Fourth Lake	0.0360	53.00
32	Lambs Farm Lake	0.0310	53.67
33	Old School Lake	0.0310	53.67
34	Grays Lake	0.0310	54.00
35	Harvey Lake	0.0320	54.50
36	Hendrick Lake	0.0340	55.00
37	Honey Lake	0.0340	55.00
38	Sand Lake	0.0380	56.00
39	Third Lake	0.0384	56.00
40	Sullivan Lake	0.0370	56.22
41	Ames Pit	0.0390	56.98
42	Diamond Lake	0.0390	56.98
43	East Loon	0.0400	57.34
44	Schreiber Lake	0.0400	57.34
45	Waterford Lake	0.0400	57.34
46	Hook Lake	0.0410	57.70

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

RANK	LAKE NAME	TP AVE	TSIp
47	Nielsen Pond	0.0450	59.04
48	Seven Acre Lake	0.0460	59.36
49	Turner Lake	0.0460	59.36
50	Willow Lake	0.0460	59.36
51	East Meadow Lake	0.0480	59.97
52	Lucky Lake	0.0480	59.97
53	Old Oak Lake	0.0490	60.27
54	College Trail Lake	0.0500	60.56
55	Hastings Lake	0.0520	61.13
56	Butler Lake	0.0530	61.40
57	West Meadow Lake	0.0530	61.40
58	Wooster Lake	0.0530	61.40
59	Lucy Lake	0.0550	61.94
60	Lake Linden	0.0570	62.45
61	Lake Christa	0.0580	62.70
62	Owens Lake	0.0580	62.70
63	Briarcrest Pond	0.0580	63.00
64	Lake Barrington	0.0600	63.10
65	Redhead Lake	0.0608	63.20
66	Lake Lakeland Estates	0.0620	63.66
67	Lake Naomi	0.0620	63.66
68	Lake Tranquility (S1)	0.0620	63.66
69	Lake Catherine	0.0620	63.76
70	Liberty Lake	0.0630	63.89
71	North Tower Lake	0.0630	63.89
72	Werhane Lake	0.0630	63.89
73	Countryside Glen Lake	0.0640	64.12
74	Davis Lake	0.0650	64.34
75	Leisure Lake	0.0650	64.34
76	St. Mary's Lake	0.0670	64.78
77	Channel Lake	0.0680	64.91
78	Buffalo Creek Reservoir 1	0.0680	65.00
79	Mary Lee Lake	0.0680	65.00
80	Little Bear Lake	0.0680	65.00
81	Timber Lake (South)	0.0720	65.82
82	Lake Helen	0.0720	65.82
83	Grandwood Park Lake	0.0720	65.82
84	Crooked Lake	0.0710	66.00
85	ADID 203	0.0730	66.02
86	Broberg Marsh	0.0780	66.97
87	Redwing Slough	0.0822	67.73
88	Tower Lake	0.0830	67.87
89	Countryside Lake	0.0800	68.00
90	Lake Nippersink	0.0800	68.00
91	Woodland Lake	0.0800	68.00

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

RANK	LAKE NAME	TP AVE	TSIp
92	Lake Fairview	0.0890	68.00
93	Potomac Lake	0.0850	68.21
94	White Lake	0.0862	68.42
95	Grand Ave Marsh	0.0870	68.55
96	North Churchill Lake	0.0870	68.55
97	McDonald Lake 1	0.0880	68.71
98	Pistakee Lake	0.0880	68.71
99	Rivershire Pond 2	0.0900	69.04
100	South Churchill Lake	0.0900	69.04
101	McGreal Lake	0.0910	69.20
102	Lake Charles	0.0930	69.40
103	Deer Lake	0.0940	69.66
104	Eagle Lake (S1)	0.0950	69.82
105	International Mine and Chemical Lake	0.0950	69.82
106	Valley Lake	0.0950	69.82
107	Buffalo Creek Reservoir 2	0.0960	69.97
108	Fish Lake	0.0960	69.97
109	Lochanora Lake	0.0960	69.97
110	Big Bear Lake	0.0960	69.97
111	Fox Lake	0.1000	70.52
112	Nippersink Lake - LCFP	0.1000	70.56
113	Sylvan Lake	0.1000	70.56
114	Petite Lake	0.1020	70.84
115	Longview Meadow Lake	0.1020	70.84
116	Lake Marie	0.1030	70.93
117	Dunn's Lake	0.1070	71.53
118	Lake Forest Pond	0.1070	71.53
119	Long Lake	0.1070	71.53
120	Grass Lake	0.1090	71.77
121	Spring Lake	0.1100	71.93
122	Kemper 2	0.1100	71.93
123	Bittersweet Golf Course #13	0.1100	71.93
124	Bluff Lake	0.1120	72.00
125	Middlefork Savannah Outlet 1	0.1120	72.00
126	Osprey Lake	0.1110	72.06
127	Bresen Lake	0.1130	72.32
128	Round Lake Marsh North	0.1130	72.32
129	Deer Lake Meadow Lake	0.1160	72.70
130	Lake Matthews	0.1180	72.94
131	Taylor Lake	0.1180	72.94
132	Island Lake	0.1210	73.00

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

RANK	LAKE NAME	TP AVE	TSIp
133	Columbus Park Lake	0.1230	73.54
134	Echo Lake	0.1250	73.77
135	Lake Holloway	0.1320	74.56
136	Antioch Lake	0.1450	75.91
137	Lakewood Marsh	0.1510	76.50
138	Pond-A-Rudy	0.1510	76.50
139	Forest Lake	0.1540	76.78
140	Slocum Lake	0.1500	77.00
141	Middlefork Savannah Outlet 2	0.1590	77.00
142	Grassy Lake	0.1610	77.42
143	Salem Lake	0.1650	77.78
144	Half Day Pit	0.1690	78.12
145	Lake Eleanor	0.1810	79.11
146	Lake Farmington	0.1850	79.43
147	Lake Louise	0.1850	79.43
148	ADID 127	0.1890	79.74
149	Lake Napa Suwe	0.1940	80.00
150	Patski Pond	0.1970	80.33
151	Dog Bone Lake	0.1990	80.48
152	Summerhill Estates Lake	0.1990	80.48
153	Redwing Marsh	0.2070	81.05
154	Stockholm Lake	0.2082	81.13
155	Bishop Lake	0.2160	81.66
156	Ozaukee Lake	0.2200	81.93
157	Kemper 1	0.2220	82.08
158	Hidden Lake	0.2240	82.19
159	McDonald Lake 2	0.2250	82.28
160	Fischer Lake	0.2280	82.44
161	Oak Hills Lake	0.2790	85.35
162	Loch Lomond	0.2950	86.16
163	Heron Pond	0.2990	86.35
164	Rollins Savannah 1	0.3070	87.00
165	Fairfield Marsh	0.3260	87.60
166	ADID 182	0.3280	87.69
167	Slough Lake	0.3860	90.03
168	Manning's Slough	0.3820	90.22
169	Rasmussen Lake	0.4860	93.36
170	Albert Lake, Site II, outflow	0.4950	93.67
171	Flint Lake Outlet	0.5000	93.76
172	Rollins Savannah 2	0.5870	96.00
173	Almond Marsh	1.9510	113.00

NPDES PERMITS EDITED FROM 2009 UPPER FOX RIVER/ CHAIN O'LAKES WATERSHED TMDL STAGE 1 REPORT

Permit Name	NPDES Number	Name of TMDL	Outfall	Outfall description	DAF (MGD)	DMF (MGD)	Receiving Water	TMDL Segment ID
ANTIOCH PACKING HOUSE INC.	IL0067733	Fox Chain O' Lakes	1	Non-contact cooling water	NA	NA	Sequoit Creek	Lake Tranquility UTW; Marie Lake
VILLAGE OF ANTIOCH	IL0020354	Fox Chain O' Lakes	1	STP	1.6	3.0	Sequoit Creek	Lake Tranquility UTW; Marie Lake
VILLAGE OF ANTIOCH	IL0020354	Fox Chain O' Lakes	A01	Excess Flow Outfall	NA	NA	Sequoit Creek	Lake Tranquility UTW; Marie Lake RTR
BAXTER HEALTHCARE CORPORATION	IL0024074	Fox Chain O' Lakes	1	Treated Industrial Wastewater	0.38	NA	Unnamed Ditch Tributary to Squaw Creek	Long Lake RTJ
BAXTER HEALTHCARE CORPORATION	IL0024074	Fox Chain O' Lakes	2	Stormwater Runoff	NA	NA	Unnamed Ditch Tributary to Squaw Creek	Long Lake RTJ
BAXTER HEALTHCARE CORPORATION	IL0024074	Fox Chain O' Lakes	3	Stormwater Runoff	NA	NA	Unnamed Ditch Tributary to Squaw Creek	Long Lake RTJ
BAXTER HEALTHCARE CORPORATION	IL0024074	Fox Chain O' Lakes	4	Stormwater Runoff	NA	NA	Unnamed Ditch Tributary to Squaw Creek	Long Lake RTJ
BAXTER HEALTHCARE CORPORATION	IL0024074	Fox Chain O' Lakes	5	Stormwater Runoff	NA	NA	Unnamed Ditch Tributary to Squaw Creek	Long Lake RTJ
CAMP HENRY HORNER-INGLESIDE	IL0054615	Fox Chain O' Lakes	1	STP	0.014	0.035	Wooster Lake	Wooster Lake RTZH
CAMP HICKORY-INGLESIDE	IL0046043	Fox Chain O' Lakes	1	STP	0.014	0.035	Sqaw Creek tributary to Fox River	Long Lake RTJ
DAHL ENTERPRISES INC	ILG840040	Fox Chain O' Lakes	1	Stormwater Runoff, groundwater seepage	0.45	NA	unnamed tributary to Loon Lake	Marie Lake RTR
FOX LAKE GRADE SCHOOL DIST 114	IL0076597	Fox Chain O' Lakes	1	Sand Filter Backwash	NA	NA	Wetlands Tributary to Nippersink Lake	Nippersink Lake RTUA; Lake Pistakee RTU; Redhead Lake

NPDES PERMITS EDITED FROM 2009 UPPER FOX RIVER/ CHAIN O'LAKES WATERSHED TMDL STAGE 1 REPORT

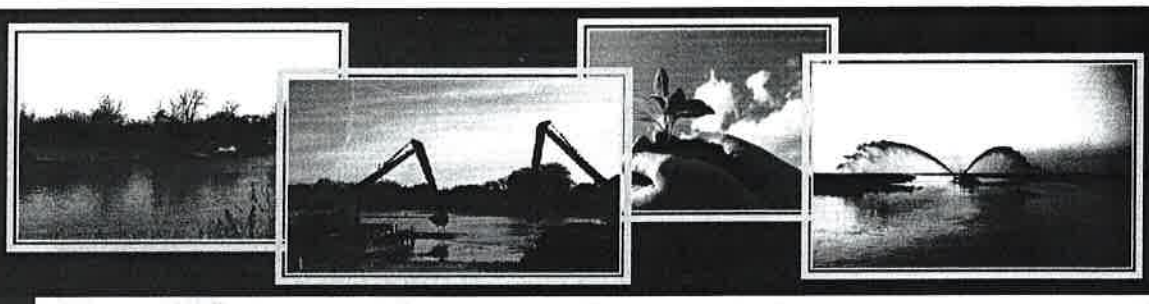
Permit Name	NPDES Number	Name of TMDL	Outfall	Outfall description	DAF (MGD)	DMF (MGD)	Receiving Water	TMDL Segment ID
FOX LAKE GRADE SCHOOL DIST 114	IL0076597	Fox Chain O' Lakes	2	Carbon Filter Backwash	NA	NA	Wetlands Tributary to Nippersink Lake	Nippersink Lake RTUA; Lake Pistakee RTU; Redhead Lake RTV
VILLAGE OF FOX LAKE-NW REGIONAL WRF	IL0020958	Fox Chain O' Lakes	1	STP	9.0	22.5	Fox River	Fox River DT-23
VILLAGE OF FOX LAKE-TALL OAKS STP	IL0045144	Fox Chain O' Lakes	1	STP	0.50	1.25	Unnamed tributary to Dunns Lake	Dunns Lake VTH; Nippersink RTUA; Lake Pistakee RTU; Redhead Lake RTV
FREMONT SCHOOL-DISTRICT 79	IL0034746	Fox Chain O' Lakes	1	STP	0.01	0.04	Unnamed tributary to Sqaw Creek	Long Lake RTJ
VILLAGE OF HEBRON	IL0026433	Fox Chain O' Lakes	1	WWTP	0.158	0.288	Unnamed tributary of North Branch of Nippersink Creek	Nippersink Lake RTUA; Lake Pistakee RTU; Redhead Lake RTV
INTERMATIC INC.	IL0059145	Fox Chain O' Lakes	1	Non-contact cooling water and Combined A01 and B01 Wastewater	0.478	NA	Nippersink Creek	Nippersink Lake RTUA; Lake Pistakee RTU; Redhead Lake RTV
INTERMATIC INC.	IL0059145	Fox Chain O' Lakes	A01	Treated Phosphating Wastewater	0.0033	NA	Nippersink Creek	Nippersink Lake RTUA; Lake Pistakee RTU; Redhead Lake RTV

NPDES PERMITS EDITED FROM 2009 UPPER FOX RIVER/ CHAIN O'LAKES WATERSHED TMDL STAGE 1 REPORT

Permit Name	NPDES Number	Name of TMDL	Outfall	Outfall description	DAF (MGD)	DMF (MGD)	Receiving Water	TMDL Segment ID
INTERMATIC INC.	IL0059145	Fox Chain O' Lakes	B01	Treated Sanitary Wastewater	0.0076	NA	Nippersink Creek	Nippersink Lake RTUA; Lake Pistakee RTU; Redhead Lake RTV
KOENEMANN SAUSAGE COMPANY	IL0038067	Fox Chain O' Lakes	1	Treated sanitary, process, non-contact cooling water and Stormwater	0.0054	NA	Unnamed tributary to Fish Lake	Unnamed tributary; Fish-Duncan Lake VTK
VILLAGE OF RICHMOND	IL0026093	Fox Chain O' Lakes	1	STP	0.50	1.625	North Branch of Nippersink Creek	Nippersink Lake RTUA; Lake Pistakee RTU; Redhead Lake RTV
VILLAGE OF SPRING GROVE	IL0074985	Fox Chain O' Lakes	1	STP	0.075	0.1875	Nippersink Creek	Nippersink Lake RTUA; Lake Pistakee RTU; Redhead Lake RTV
SURGIPATH MEDICAL INDUSTRIES, INC	IL0070645	Fox Chain O' Lakes	1	Contact Cooling Water	0.06	NA	Wetlands Tributary to North Branch of Nippersink Creek	Nippersink Lake RTUA; Lake Pistakee RTU; Redhead Lake RTV
VILLAGE OF WOODSTOCK	IL0031861	Fox Chain O' Lakes	1	STP	3.5	10.5	Silver Creek	Nippersink Lake RTUA; Lake Pistakee RTU; Redhead Lake RTV

Appendix C:

References and Rules



Fox Waterway Agency

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LAKE & RIVER SEDIMENT QUALITY

To support the reuse of lake and river sediment, the Fox Waterway Agency (FWA) assures the quality of the soils through frequent testing. It is important to the Agency that materials that are available to the public are environmentally safe.

While sediment sampling occurs as part of day-to-day operations, Hey and Associates, Inc. was retained in 2005 to specifically test for a wider range of parameters from dredged materials collected from several lakes. The lab results showed that for virtually all of the chemical constituents that have comparable Illinois EPA classifications, FWA sediments are in the "Low to Normal" range. While total Kjeldahl nitrogen and potassium crept into the "Elevated-Highly Elevated" range, both of these substances are plant nutrients for which higher levels are actually beneficial for landscape and horticultural purposes. Levels of constituents that are typically of concern--such as arsenic, cadmium, lead, and mercury--were all within "Normal" limits.

By making dredged material available for reuse, landscapers and homeowners have been able to replenish depleted Illinois land, which demonstrates the value of these nutrient rich reclaimed Wisconsin soils.

Illinois Lake Sediment Classification*

Constituent	FWA Sediment Result	Low	Normal	Elevated	Highly Elevated
Total Volatile Solids	16%	--	--	--	--
Total Solids	61%	--	--	--	--
Total Kjeldahl Nitrogen as N	5,400 mg/kg	<1,300	1,300 to <5,357	5,357 to <11,700	11,700 or >
Total Phosphorus as P	270 mg/kg	<394	394 to <1,115	1,115 to <2,179	2,179 or >
Ammonia Nitrogen as N	170 mg/kg	--	--	--	--
Arsenic	12 mg/kg	<4.1	4.1 to <14	14 to <95.5	95.5 or >
Cadmium	<0.5 mg/kg	n/a	<5	5 to <14	14 or >
Chromium	20 mg/kg	<13	13 to <27	27to <49	49 or >
Copper	14 mg/kg	<16.7	16.7 to <100	100 to <590	590 or >
Lead	18 mg/kg	<14	14 to <59	59 to <339	399 or >
Manganese	320 mg/kg	<500	500 to <1,700	1,700 to <5,500	5<500 or >
Molybdenum	<0.5 mg/kg	--	--	--	--
Nickel	14 mg/kg	<14.3	14.3 to <31	31 to <43	43 or >
Potassium	3,000 mg/kg	<410	410 to <2,100	2,100 to <2,797	2,797 or >
Selenium	<2.5 mg/kg	--	--	--	--
Zinc	51 mg/kg	<59	59 to <145	145 to <1,100	1,100 or >
Mercury	0.11 mg/kg	n/a	<0.15	0.15 to <0.701	0.701 or >
pH	7.73 units	--	--	--	--

** Sediment classification from: Mitzelfelt, Jeffrey D. September 1996. Sediment Classification for Illinois Inland Lakes (1996 Update). Illinois Environmental Protection Agency, Bureau of Water.*

TITLE 17: CONSERVATION
CHAPTER I: DEPARTMENT OF NATURAL RESOURCES
SUBCHAPTER b: FISH AND WILDLIFE

PART 895
FOX CHAIN O'LAKES AQUATIC PLANT MANAGEMENT

Section

895.10 Summary and Purpose
895.20 Applicability
895.30 Definitions
895.40 Application for Letter of Permission
895.50 Issuance of Letter of Permission
895.60 Supervision
895.70 Conditions of Letter of Permission
895.80 Exemptions

AUTHORITY: Implementing and authorized by Section 7 of the Rivers, Lakes, and Streams Act [615 ILCS 5/7], and by Sections 1-15, 1-20, 1-150, 5-5 and 20-35 of the Fish and Aquatic Life Code [515 ILCS 5/1-15, 1-20, 1-150, 5-5 and 20-35].

SOURCE: Adopted at 25 Ill. Reg. 9031, effective July 3, 2001.

Section 895.10 Summary and Purpose

This Part is established to implement the management of aquatic plants within the Fox Chain O' Lakes (FCOL) public waters. The intent is to minimize the risks that citizens utilizing the public waters may be unwittingly exposed to aquatic herbicides and that threatened or endangered species of plants and animals may be harmed or destroyed, a balanced aquatic plant community being recognized to be a vital and necessary component of a healthy aquatic ecosystem. The Department may allow the management of nuisance-causing aquatic plants with chemicals registered and labeled for aquatic use by the United States Environmental Protection Agency (USEPA). Other non-chemical methods, determined to be effective by the Department, may also be authorized.

Section 895.20 Applicability

Any person sponsoring or conducting chemical or non-chemical treatment for the management of aquatic plants in the FCOL public waters shall obtain a Letter of Permission (LOP) from the Department.

Section 895.30 Definitions

"Applicant" - The person, company, or organization that proposes to apply aquatic herbicides or non-chemical treatments to the FCOL public waters.

"Client" - The person who contracts with the pest control operator for the described aquatic plant management treatment.

"Chemicals" - All USEPA approved and registered aquatic herbicides.

"Chemical treatment" - The single, one-time use of a USEPA approved and registered aquatic herbicide to destroy or limit the growth of aquatic plants.

"Department" - The Illinois Department of Natural Resources.

"FCOL public waters" - Channel Lake, Lake Catherine, Lake Marie, Bluff Lake, Spring Lake, Petite Lake, Grass Lake, Fox Lake, Dunn's Lake, Nippersink Lake, Pistakee Lake, Redhead Lake, Lake Mathews, Lake Jerilyn, Lac Louette (Mud Lake) and all navigable channels directly connected to these lakes that are under the jurisdiction of the Fox Waterway Agency.

"Fox Waterway Agency" - A special unit of local government created by State of Illinois statute in September 1983 and approved by referendum in November 1984 by a majority of voters residing within the agency's voting district of Lake and McHenry Counties.

"Letter of Permission" - Document drafted by the Department that specifies the location, date, and method of treatment.

"Navigable channel" - All natural and manmade channels/ponds that are connected to the public waters and are under the jurisdiction of the Fox Waterway Agency.

"Non-chemical treatment" – Utilization of plant screens, sediment covers, bottom barriers, blanketing materials that are gas-permeable, or mechanical cutting or removal

to destroy or limit the growth of aquatic plants. A non-chemical treatment may consist of a series of actions in the case of mechanical cutting or removal of aquatic plants.

"Non-target organisms" – Any plant, other than nuisance-causing aquatic plants specified on the application, or animal species within the treatment area or adjacent areas that may be adversely affected by the chemical or non-chemical treatment.

"Sensitive area" - Areas of aquatic vegetation identified by the Department as offering critical or unique fish and wildlife habitat, including seasonal or life stage requirements, or offering water quality or erosion control benefits to the body of water. This also includes areas included by the Department on the Illinois Natural Areas Inventory, or registered or dedicated pursuant to the Illinois Natural Areas Preservation Act [525 ILCS 30/1].

Section 895.40 Application for Letter of Permission

An application for a LOP is a form provided by the Department. The completed application shall be submitted to the Division of Fisheries, Springfield, IL. Any amendment or revision to an application shall be treated by the Department as a new application. The application shall contain:

a) One copy of a detailed map or sketch of the body of water with the proposed treatment area dimensions clearly shown and with pertinent information necessary to locate those properties, by name of owner, riparian to the treatment area, which may include street address, fire number where available and local telephone number;

b) A description of the uses being impaired by plants and reason for treatment;

c) A description of the plant community within the area to be treated that includes approximate percentage of abundance by species;

d) Product names of chemicals proposed for use, the method of application, and proposed date of treatment;

e) Name of the person or commercial applicator and applicator certification number of the person conducting the treatment;

f) A description of the non-chemical treatment, including type of material, product name if applicable, and proposed date of treatment;

g) A certification to the Department that a copy of the application has been provided to any affected property owners' association and to any riparian property owners adjacent to and within the treatment area;

h) A statement of alternative control methods considered for use on the proposed treatment site and their feasibility.

Section 895.50 Issuance of Letter of Permission

a) The Department shall issue or deny issuance of the requested LOP within 45 days after receipt of a complete application.

b) The LOP shall be issued for a non-chemical method or the single, one-time, use of a USEPA approved and registered aquatic herbicide to remove, destroy or limit the growth of aquatic plants. Exception: In instances where a chemical treatment is proposed to be at reduced application rates with a not-to-exceed dosage limit, over multiple applications, this will be viewed as a one-time application.

c) New applications for a LOP will be reviewed with consideration given to the cumulative effect of applications already approved for the body of water.

d) The Department may deny issuance of the requested LOP if:

1) The proposed chemical is not labeled and registered for the intended use by the USEPA;

2) The Fox Waterway Agency recommends to the Department that a LOP not be granted;

3) The Department determines the proposed treatment will result in a hazard to humans, animals or other non-targeted organisms, or will not provide

nuisance relief;

4) The Department determines that the proposed treatment will result in a significant adverse effect on the body of water or will place unreasonable restrictions on existing water uses;

5) The proposed treatment is for waters beyond 75 feet from the shore except where approval is given by the Department to maintain navigation channels, piers or other facilities used by organizations or the public, including commercial facilities;

6) The Department determines that the proposed treatment will significantly injure non-target organisms within the treatment area or adjacent areas either directly or through habitat destruction;

7) The proposed treatment is in a location known to have endangered or threatened species as determined by the Department; or

8) The proposed chemical application is in a location identified by the Department as a sensitive area, except when the applicant demonstrates to the satisfaction of the Department that treatments can be conducted in a manner that will not alter the ecological character or reduce the ecological value of the area.

Section 895.60 Supervision

Supervision by a Department representative may be required for any chemical treatment. Supervision may include inspection of the proposed treatment area, chemicals and application equipment before, during, and after treatment. The inspection may result in the determination that treatment is unnecessary or unwarranted in all or part of the proposed area, or that another chemical or non-chemical method of treatment may be more appropriate.

Section 895.70 Conditions of Letter of Permission

a) The Department may stop or limit the application of chemicals or non-chemical treatments to a body of water if at any time it determines that the treatment will be

ineffective, will result in unreasonable restrictions on current water uses, or will produce unnecessary adverse side effects on non-targeted organisms for any of the reasons set forth in Section 895.50.

b) Chemical treatments shall be performed in accordance with label directions, existing pesticide use laws, and LOP conditions.

c) Chemical treatment shall be performed by an applicator currently certified by the Illinois Department of Agriculture in the aquatic category.

d) The LOP holder will be responsible for posting those areas treated in accordance with water/fishing use restrictions stated on the chemical label. Signs shall be posted at the beginning of each treatment by the LOP holder to remain up for the period of time stated on the chemical label for water use restrictions. Posting of signs shall be in brilliant yellow background with black lettering, and conspicuous to the non-riparian public intending to use the treated water from both the water and shore, and shall state applicable label use restrictions of the chemical being used, the name of the chemical and the date of treatment.

e) The LOP applicant will be responsible for obtaining a permit from Illinois EPA in adherence with 35 Ill. Adm. Code 652.601, where applicable.

f) Failure to comply with the conditions of the LOP may result in loss of privileges for subsequent chemical and non-chemical treatments for aquatic plants in the Illinois public waters of FCOL in addition to any other remedies set out by law.

Section 895.80 Exemptions

An individual property owner who has title to a portion of the FCOL lake bottom and wishes to initiate an aquatic plant management treatment of 0.25 acre or less of the titled lake bottom need not apply for a LOP from the Department. The individual, however, is not exempt from any other applicable laws and/or ordinances.

CHAPTER 6
RESTRICTED AREAS

6.01 No Wake Areas
6.02 Unlawful Boat Anchoring
6.03 Buoy Regulations
6.04 Combustion Engines Prohibited
6.05 Swimming Area Restrictions
6.06 Designation of Restricted Waterway Areas
6.07 Designation of Emergency or Temporary Restricted Areas
6.08 Operation of Watercraft Upon Approach of an Authorized Emergency Watercraft

6.01 NO WAKE AREAS *Amended, 2009-0226-03, 2006-0914-01*

Unless more restrictive regulations are imposed at any time, it shall be unlawful for any person to operate any boat in excess of 5 miles per hour or at a sufficient speed as to create a wake in any of the following areas defined below in this Section 6.01, except that paragraph 4 shall not apply from October 16th through March 31st. A lack of actual knowledge that a zone has been declared a "no wake boating area" shall not be a defense to any charge or citation brought hereunder.

1. All areas within 150 feet from shore throughout the Chain O'Lakes, excluding the Fox River;

2. All side and secondary channels throughout the Chain O'Lakes and Fox River;

3. Squaw Creek, Sequoit Creek and Nippersink Creek;

4. The following portions of the Fox River and specifically designated lakes:

   (a) That portion of the Fox River at the Algonquin dam from the spillway to a point 3,000 feet upstream, measured in the middle of the river.

   (b) That portion of the Fox River at the McHenry dam, including the approach channels to the McHenry locks, from the south end of the seawall of the property at 2404 Riverside Drive to a point 2,000 feet upstream from the center of the spillway, measured in the center of the channel;

   (c) That portion of the Fox River at McHenry from the southern boundary of the McHenry Country Club upstream to a point 1,000 feet north of the City of McHenry park at Broad Street and Riverside Drive;

   (d) That portion of the Fox River commonly known as Johnsburg Bay from the northern end, where the upstream bank turns away from main flowage, to the southern end of the community park;

(e) That portion of Pistakee Lake northwest of a line from a point on shore southeast of the end of Bald Knob Court, to a point on shore between the properties at 3710 Pitzen Road and 3670 Grand Ridge Court;

(f) That portion of Pistakee Lake near the mouth of the Fox River from a point on shore at the northerly boundary of 914 River Terrace Drive to a point on shore of the northerly boundary of 1455 Pitzen Road south to Lewis Lane;

(g) That portion of Pistakee Lake which includes all waters southeast of the point where Bayview Lane crosses over the water and south of a line extending from the shore east of the northern end of Bayview Lane to the shore west of the intersection of Lakeshore Road and Matthews Terrace;

(h) That portion of Pistakee Lake in Meyers Bay northeast of a line extending from shore southeast of the intersection of Scenic Lane and Hilltop Road to the shore northwest of the southern end of Kings Road;

(i) That portion of Pistakee Lake in Meyers Bay northeast of a line extending from the shore south of 527 Pistakee Parkway to the shore 100 feet north of the channel at the southern boundary at 35544 Sheridan Drive, generally following the shoreline;

(j) That portion of Pistakee Lake included in an area extending out from the east shore 300 feet, from the southern boundary of the property known as 16 South Pistakee Lake Road and following a line parallel with the shore north up to the northern end of 12 North Pistakee Lake Road and then heading in a straight line to the southeast tip of what is commonly referred to as Trinski's Island and from that point to include all waters east to the shore, north to the U.S. Route 12 bridge and northwest to the Fox River channel;

(k) That portion of Pistakee Lake at the western tip of what is commonly referred to as Trinski's Island and from that point running parallel with the shore north to U.S. Route 12 and south to 100 feet south of the channel at the southern boundary of 1007 Fortress Drive;

(l) That portion of Nippersink Lake extending out 150 feet from the U.S. Route 12 bridge in the vicinity of Nippersink Boulevard and Riverview Avenue;

(m) That portion of Pistakee Lake in Pistakee Bay south of a line from a point on shore at 2713 Regner Lane, west to a point on shore at 1226 Old Bay Road;

(n) That portion of Nippersink Lake west of a line extending from the shore southeast of the end of Riverside Island Drive to the shore 300 feet southeast of the U.S. Route 12 bridge at the Fox Lake American Legion Hall;

(o) That portion of Nippersink Lake included in an area extending 300 feet out from the northern boundary of the property known as 188 Howard Avenue running parallel with the shore in a northeasterly direction to a point at the northern most tip of Point Comfort running in a northeasterly direction to a point on the shore of Crabapple Island, approximately 150 feet northeast of the western most tip, then from a point on the shore approximately 150 feet southeast of the western most tip of Crabapple Island just west of the first pier to the eastern most tip of Point Comfort, otherwise known as the Korpan's Lighthouse;

(p) That portion of Petite Lake southwest of a line extending from a point on the shore at the west boundary of 25701 Herman Avenue to a point on the shore at the east edge of the channel leading to Fox Lake, including all the channel to its exit into Fox Lake in Columbia Bay;

(q) That portion of Petite Lake southeast of a line extending from a point on the shore at the east edge of the channel leading to Fox Lake to a point on the shore at the northern boundary of 38964 Cedarcrest Lane;

(r) That portion of Petite Lake north of a line extending from a point on shore at the southeast boundary of 39303 North Lake Court (Antioch, IL) extending to the no wake channel marker continuing east to the south boundary at 39360 North Lake Avenue (Lake Villa) including all waters north to the southern Bluff Lake no wake channel marker;

(s) That portion of Bluff Lake north of a line extending from a point on the shore at 40800 North Grand Avenue west to a point on the shore to 40825 North Park Avenue;

(t) That portion of Lake Marie south of a line extending west from a point on the shore at the north end of Elime Road, including all the channel leading to Grass Lake, to the exit of the channel into Grass Lake;

(u) That portion of Grass Lake west of the western edge of the north/south preferred boating channel, and north of a line extending west from the western end of Heart O'Lakes Boulevard, west to a point on the western shoreline of Grass Lake;

(v) That portion of Grass Lake west of the western edge of the north/south preferred boating channel and south of the southern edge of the east/west preferred boating channel originating from the Fox River outlet into Grass Lake, except for a 150-foot wide non-restricted boating channel running parallel to and north of the "150-foot from shore no-wake area," ending 100 feet north of the Chain O'Lakes State Park's southernmost boundary on the west shore of Grass Lake;

APPENDIX D. METHODS FOR FIELD DATA COLLECTION AND LABORATORY ANALYSES

Water Sampling and Laboratory Analyses

Two water samples were collected once a month from May through September. Sample locations were at the deepest point in the lake (see sample site map), three feet below the surface, and 3 feet above the bottom. Samples were collected with a horizontal Van Dorn water sampler. Approximately three liters of water were collected for each sample for all lab analyses. After collection, all samples were placed in a cooler with ice until delivered to the Lake County Health Department lab, where they were refrigerated. Analytical methods for the parameters are listed in Table A1. Except nitrate nitrogen, all methods are from the Eighteenth Edition of Standard Methods, (eds. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1992). Methodology for nitrate nitrogen was taken from the 14th edition of Standard Methods. Dissolved oxygen, temperature, conductivity and pH were measured at the deep hole with a Hydrolab DataSonde® 4a. Photosynthetic Active Radiation (PAR) was recorded using a LI-COR® 192 Spherical Sensor attached to the Hydrolab DataSonde® 4a. Readings were taken at the surface and then every two feet until reaching the bottom.

Plant Sampling

In order to randomly sample each lake, mapping software (ArcMap 9.3) overlaid a grid pattern onto an aerial photo of Lake County and placed points 60 or 30 meters apart, depending on lake size. Plants were sampled using a garden rake fitted with hardware cloth. The hardware cloth surrounded the rake tines and is tapered two feet up the handle. A rope was tied to the end of the handle for retrieval. At designated sampling sites, the rake was tossed into the water, and using the attached rope, was dragged across the bottom, toward the boat. After pulling the rake into the boat, plant coverage was assessed for overall abundance. Then plants were individually identified and placed in categories based on coverage. Plants that were not found on the rake but were seen in the immediate vicinity of the boat at the time of sampling were also recorded. Plants difficult to identify in the field were placed in plastic bags and identified with plant keys after returning to the office. The depth of each sampling location was measured either by a hand-held depth meter, or by pushing the rake straight down and measuring the depth along the rope or rake handle. One-foot increments were marked along the rope and rake handle to aid in depth estimation.

Wildlife Assessment

Species of wildlife were noted during visits to each lake. When possible, wildlife was identified to species by sight or sound. However, due to time constraints, collection of quantitative information was not possible. Thus, all data should be considered anecdotal.
Some of the species on the list may have only been seen once, or were spotted during their migration through the area.

Table A1. Analytical methods used for water quality parameters.

Parameter	***Method***
Temperature	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Dissolved oxygen	Hydrolab DataSonde ®4a or YSI 6600 Sonde®
Nitrate and Nitrite nitrogen	USEPA 353.2 rev. 2.0 EPA-600/R-93/100 Detection Limit = 0.05 mg/L
Ammonia nitrogen	SM 18th ed. Electrode method, #4500 NH_3-F Detection Limit = 0.1 mg/L
Total Kjeldahl nitrogen	SM 18th ed, 4500-N_{org} C Semi-Micro Kjeldahl, plus 4500 NH_3-F Detection Limit = 0.5 mg/L
pH	Hydrolab DataSonde® 4a, or YSI 6600 Sonde® Electrometric method
Total solids	SM 18th ed, Method #2540B
Total suspended solids	SM 18th ed, Method #2540D Detection Limit = 0.5 mg/L
Chloride	SM 18th ed, Method #4500C1-D
Total volatile solids	SM 18th ed, Method #2540E, from total solids
Alkalinity	SM 18th ed, Method #2320B, patentiometric titration curve method
Conductivity	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Total phosphorus	SM 18th ed, Methods #4500-P B 5 and #4500-P E Detection Limit = 0.01 mg/L
Soluble reactive phosphorus	SM 18th ed, Methods #4500-P B 1 and #4500-P E Detection Limit = 0.005 mg/L
Clarity	Secchi disk
Color	Illinois EPA Volunteer Lake Monitoring Color Chart
Photosynthetic Active Radiation (PAR)	Hydrolab DataSonde® 4a or YSI 6600 Sonde®, LI-COR® 192 Spherical Sensor