Lake County, IL

2017 Hastings Lake Summary Report

LAKE COUNTY HEALTH DEPARTMENT

ECOLOGICAL SERVICES

Image courtesy of Lake County Forest Preserve District

Hastings Lake 2017

Hastings Lake is a glacial lake located in unincorporated Lake County within Lake Villa Township. The lake has a surface area of 74.06 acres and a maximum depth of 25.7 feet based on the 2008 morphometric survey. The Lake County Forest Preserve District owns the lake bottom and manages the lake for recreation. The 268 acre preserve features open fields, dense woodlands and wetlands. Visitors can utilize the lake and preserve for aesthetics, trails, and shoreline fishing. Carry-in boats, kayaks and canoes can launch on a sandy shoreline, however there is no developed boat ramp and no trailer parking. Hastings Lake is also listed as an ADID (advanced identification) wetland by the U.S. Environmental Protection Agency. This indicates that the lake and surrounding natural environments have the potential to have high quality aquatic resources based on water quality and hydrology values.

In 2017, the Lake County Health Department - Ecological Services (LCHD-ES) monitored Hastings Lake as part of routine water quality sampling. Two water samples were collected once a month from May through September. Due to Hasting Lake's maximum depth, the lake does stratify throughout the season. Water chemistry can be significantly different between the epilimnion (warm upper layer) and hypolimnion (cool bottom layer) within the lake. Therefore, two water samples were collected at the deepest point in the lake; three feet below the surface and 3 feet above the bottom (Appendix A). Samples were analyzed for nutrients, solid concentrations and other chemical parameters. Additionally, LCHD-ES conducted an aquatic

Ecological Services Water Quality Specialists

Alana Bartolai
abartolai2@lakecountyil.gov

Ecological Services
847-377-8020

Gerard Urbanozo
gurbanozo@lakecountyil.gov

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LAKE FACTS

MAJOR WATERSHED:
Des Plaines

SUB-WATERSHED:
North Mill Creek

SURFACE AREA:
74.06 Acres

SHORELINE LENGTH:
1.5 Miles

MAXIMUM DEPTH:
25.7 Feet

AVERAGE DEPTH:
9.5 Feet

LAKE VOLUME:
709.3 Acre-Feet

WATERSHED AREA:
2129 Acres

LAKE TYPE:
Glacial

CURRENT USES:
Hiking, Fishing, Aesthetics. Historically used as a YMCA camp.

ACCESS:
Public access via Hastings Lake Forest Preserve

HASTINGS LAKE SUMMARY

Following is a summary of the water quality sampling, shoreline survey and aquatic macrophyte survey from the 2017 monitoring season on Hastings Lake. The complete data sets can be found in Appendix A & B of this report, and discussed in further detail in the following sections. Included in the Appendix is an "Understanding Your Lake Data" guide that will help with additional questions about water chemistry results.

- Average water clarity as measured by Secchi depth in 2017 was 4.18 feet. This is a 17.1% increase since 2010 (3.52 ft.) and is above the Lake County median Secchi depth of 3.00 ft.
- Water clarity is influenced by the amount of particles in the water column; this is measured by total suspended solids (TSS) concentration. The average epilimnion TSS concentrations on Hastings Lake was 7.0 mg/L in 2017, which is below the Lake County median of 8.2 mg/L. TSS have increased since the 2010 sampling date by 29.5%.
- Nutrient availability indicated that Hastings Lake was phosphorus limited with an average TN:TP ratio of 19:1
- In 2017, the average total epilimnion phosphorus concentration was 0.075 mg/L. This is above the Illinois Environmental Protection Agency (IEPA) water quality standard of 0.050 mg/L. TP concentrations have increased by 44% since the 2010 sampling.
- Trophic State Index based on 2017 total phosphorus concentrations (TSIp) for Hastings Lake is 66.3, meaning Hastings Lake is considered a eutrophic lake.
- A dissolved oxygen (DO) concentration of 5.0 mg/L is considered adequate to support fisheries. DO concentrations dropped below 5.0 mg/L in the hypolimnion of the lake, which is not uncommon for deep glacial lakes.
- The aquatic macrophyte survey showed that 49.4% of all sampling sites had plant coverage on Hastings Lake.
- In 2017, a total of 7 plant species and 1 macro-algae (Chara) were present in Hastings Lake. This was a decrease in plant diversity since the 2010 sampling where 9 species were observed.
- The most dominant aquatic plants in Hastings Lake were Eurasian Watermilfoil (46%) and White Water Lily (30%).
- Eurasian watermilfoil is an aquatic invasive species observed in Hastings Lake that reached dense mats during peak summer.
- Based on the shoreline assessment, only 7% of Hastings Lake had some degree erosion along the shoreline. This low percentage of erosion is due to the extensive emergent plant population that protects the shoreline.
- Based on the shoreline assessment, 90% of the shoreline had good shoreline buffer, where >25 feet of the shoreline had minimal impervious surfaces and abundant native vegetation.

WATERSHED & LANDUSE

Hastings Lake is part of the North Mill Creek-Dutch Gap Canal watershed and is a subwatershed of the larger Des Plaines River Basin. Hasting's Lake receives water from Slough Lake and Crooked Lake from the west inlet and Lake Linden which drains into Hastings Lake from the south inlet. Hasting's Lake has a fairly large watershed, approximately 2129 acres that carries stormwater and pollutants into Hastings Lake (Figure 1). The primary external sources affecting Hastings Lake were from the following land uses: single family homes (31.3%), water (15.2%), and Forest and Grasslands (13.6%).

Based on the amount of impervious surfaces each land use contributes varied amounts of runoff. Because impervious surfaces (parking lots, roads, buildings, compacted soil) do not allow rain to infiltrate into the ground, more runoff is generated than in the undeveloped condition. The major sources of runoff for Hastings Lake were Water (39.5%), single family homes (24.5%) and transportation (21.0%) (Table 1). Runoff is referring to the amount of water making its way to the lake, however, each land use contributes different amount of pollutant loads. The water land use does not have high pollutants associated with it since it refers to the rainfall falling directly on the lake. Pollutants in rainfall are mostly related to atmospheric deposition and while contribute pollutants do so at a lower quantity than other landuses in urbanized areas. For example, the transportation land use, and other impervious surfaces, contain higher pollutants that are carried to the lake by runoff. The Lake is surrounded by wetland, forest, and grassland which help to absorb runoff and nutrients before it enters the lake. Typically water quality declines as pollutants accumulate from the top to the bottom of the watershed. However, the water quality actually improves as it travels downstream to Hastings Lake. Slough Lake is at the top of the watershed and historically had a duck farm contributing to the poor water quality. Water leaving Slough Lake travels through a wetland which may filter some of the pollutants. It then enters Crooked Lake which has a good aquatic plant abundance which also acts a filter. In addition, a large wetland complex borders Hastings Lake which acts as a buffer against upstream impacts. However, Hastings Lake still suffers from high nutrient concentrations.

Hastings Lake is in the North Mill Creek Sub-watershed of the Des Plaines River Watershed

Figure 1: *Hastings Lake 2017 Land Use and Watershed Boundary*

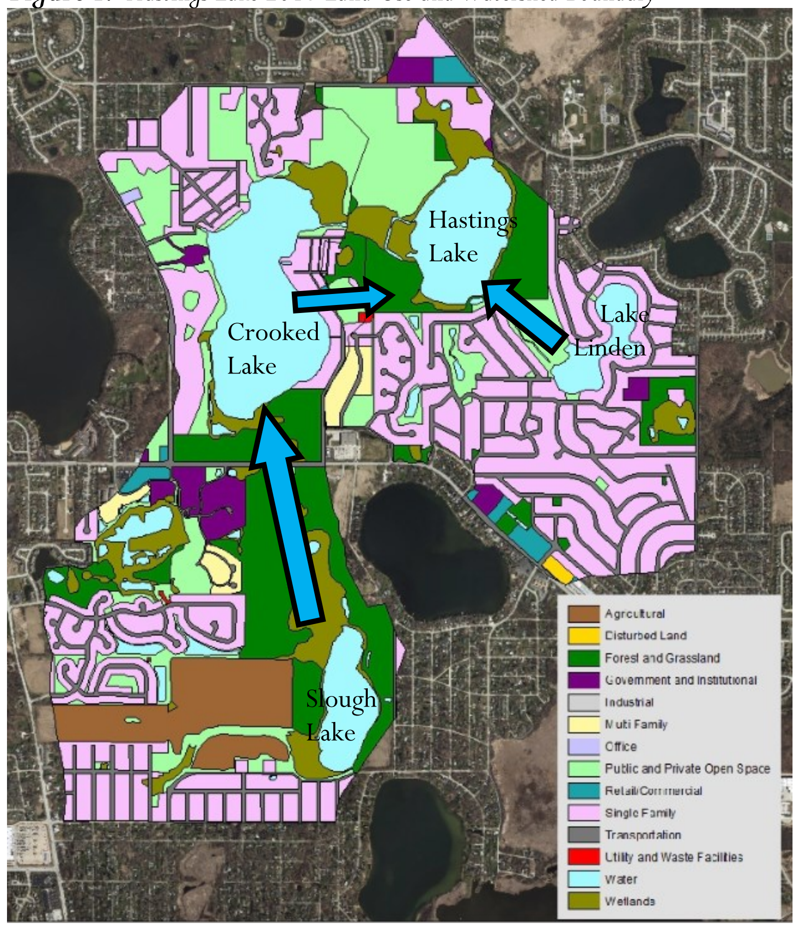


Table 1: *Hastings Lake 2017 Land Use and Estimated Runoff*

Land Use	Acreage	% of Total	% Total of Estimated Runoff
Agricultural	107.72	5.1%	0.7%
Disturbed Land	3.13	0.1%	0.0%
Forest and Grassland	288.74	13.6%	1.8%
Government and	48.36	2.3%	3.0%
Multi Family	28.45	1.3%	1.0%
Office	1.58	0.1%	0.2%
Public and Private Open Space	266.96	12.6%	4.9%
Retail/Commercial	22.89	1.1%	2.4%
Single Family	666.61	31.3%	24.5%
Transportation	202.31	9.5%	21.0%
Utility and	1.41	0.1%	0.1%
Water	323.02	15.2%	39.5%
Wetlands	165.78	7.8%	1.0%
Total Acres	**2126.97**	100.0%	100.0%

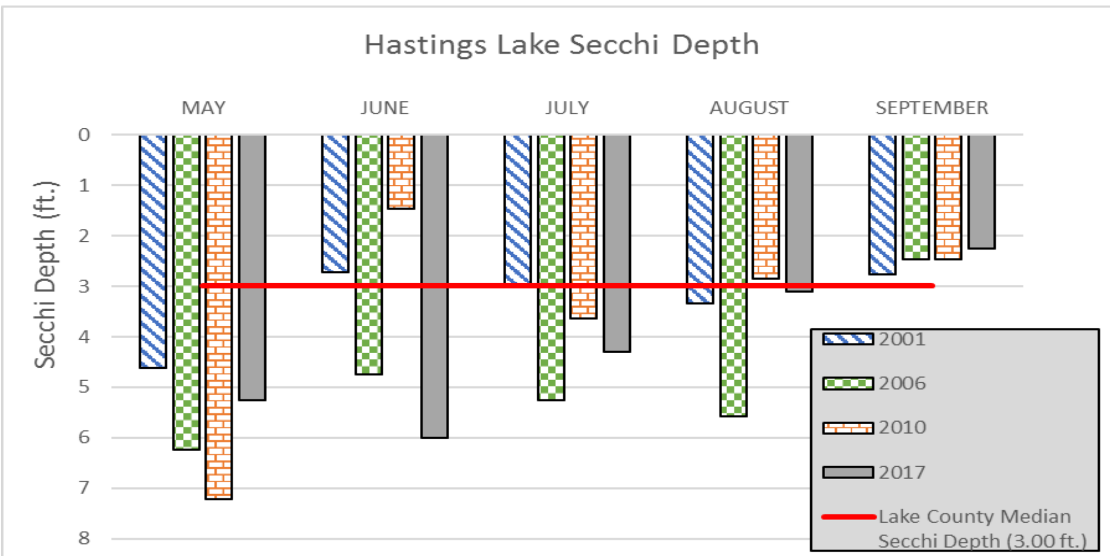
WATER CLARITY

Water Clarity is typically measured with a Secchi disk and is primarily used as an indicator of algal abundance and general lake productivity. Although it is only indicator, Secchi disk depth is the simplest and one of the most effective tools for estimating a lakes' productivity. It can also provide an indirect measurement of the amount of suspended materials in the water. A number of factors can interfere with light penetration and reduce water clarity. This includes: algae, water color, re-suspended bottom sediments, eroded soil, and invasive species.

The 2017 average water clarity for Hastings Lake based on Secchi Depth was 4.18 feet. This is a 17.1% increase since the 2010 water quality sampling, which had a Secchi Depth of 3.52 feet. As seen in Figure 2, Secchi depth on Hastings Lake fluctuates, with 2006 and 2017 being better water clarity. The fluctuation in water clarity is also correlated to aquatic plant coverage on the lake. Average seasonal water clarity on Hastings Lake is greater than the Lake County Median Secchi depth.

Hastings Lake average Secchi depth was 4.18 ft., which is above the Lake County median Secchi depth of 3.00 ft.

Figure 2: *Hastings Lake Secchi Depth by Year*



VOLUNTEER LAKE MONITORING PROGRAM (VLMP)

The VLMP was established in 1981 by the Illinois Environmental Protection Agency (IEPA) to be able to collect information on Illinois inland lakes, and to provide an educational program for citizens. The volunteers are primarily lakeshore residents, lake owners/managers, members of environmental groups, and citizens with interest in a particular lake. The VLMP relies on volunteers to gather information on their chosen lake. The primary measurement by volunteers is Secchi depth (water clarity). The sampling season is May through October with measurements taken twice a month.

Hastings Lake is participating in the VLMP program. Participating provides annual data that helps document water quality impacts and support lake management decisions.

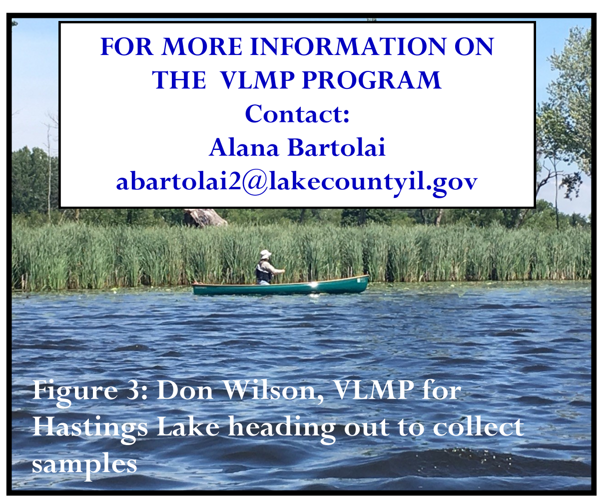


Figure 3: Don Wilson, VLMP for Hastings Lake heading out to collect samples

TOTAL SUSPENDED SOLIDS

The Total Suspended Solids (TSS) parameter represents the concentration of all organic and inorganic materials suspended in the lakes water column, which includes both sediment and algal cells. Typical inorganic components of TSS are referred to as non-volatile suspended solids (NVSS) and originate from weathering and erosion of rocks and solids in the lakes watershed. The organic portion of TS are referred to as volatile suspended solids (TVS) and are mostly composed of algae and other organic matter such as decaying plants.

2017 TSS concentrations in the eplimnion of Hastings Lake averaged 7.0 mg/L, which is below the Lake County median of 8.3 mg/L. It is also an increase in TSS since 2010. Algae blooms were noted in August and September and these are the months with the highest TSS concentrations and lowest Secchi readings. Secchi depth and TSS are inversely related (Figure 3). The hypolimnetic TSS concentration average 5.0 mg/L (Table 2). 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. In 2017, the median surface NVSS was 2.39 mg/L, therefor there is no TSS impairment on Hastings Lake.

Figure 3: *Total Suspended Solid Concentrations vs. Secchi Depth in Hastings Lake, 2017.*

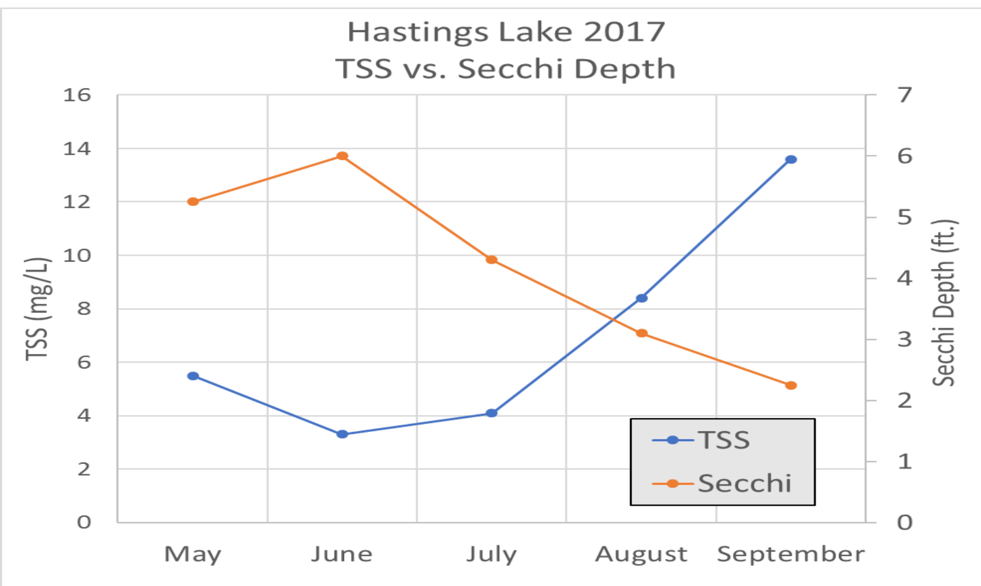


Table 2: *Solid concentrations on Hastings Lake, 2017*

2017 Epilimnion solid concentrations on Hastings Lake

DATE	DEPTH	TSS (mg/L)	TS (mg/L)	TVS (mg/L)
17-May-17	3	5.5	NA	106
14-Jun-17	3	3.3	550	114
18-Jul-17	3	4.1	763	NA
16-Aug-17	3	8.4	415	63
13-Sep-17	3	13.6	521	139
	average	*7.0*	*562*	*168*

2017 Hypolimnion solid concentrations on Hastings Lake

DATE	DEPTH	TSS (mg/L)	TS (mg/L)	TVS (mg/L)
17-May	16	5.0	527	116
14-Jun	23	5.8	578	115
18-Jul	24	3.1	594	134
16-Aug	23	6.6	572	107
13-Sep	23	4.4	530	88
	average	*5.0*	*560*	*112*

TSS

Total Suspended Solids

TSS are particles of algae or sediment suspended in the water column.

TVS

Total Volatile Solids

TVS represents the fraction of total solids that are organic in nature, such as algae cells.

NVSS

Non-Volatile Suspended Solids

NVSS represents the non-organic clay and sediments that are suspended in the water column.

TDS

Total Dissolved Solids

TDS are the amount of dissolved substance such as salts or minerals in the water after evaporation.

NUTRIENTS: PHOSPHORUS

In a lake, the primary nutrients needed for aquatic plant growth are phosphorus (P) and nitrogen (N). Sources of phosphorus can be external, internal, or both. External sources include: human and animal waste, soil erosion, detergents, sewage treatment plants, septic systems, and runoff from lawns. Internal sources of phosphorus originate with the lake and are typically linked to the lake sediment. When phosphorus is bound to sediments it is generally not available for use by algae, however, various chemical and biological processes can allow phosphorus to be released from the sediment, making it available in the water column.

Hasting's Lake is listed as impaired waters by the IEPA for Total Phosphorus (TP), which is determined based on a critical value of 0.05 mg/L occurring at least once during the monitoring season. The average total phosphorus concentrations in the epilimnion of Hasting's Lake was 0.075 mg/L for 2017. The highest TP concentration occurred in September at 0.155 mg/L and the lowest concentration was in July at 0.049 mg/L. The 2017 concentration is a 44% increase in TP since the 2010 sampling (Figure 4).

While TP concentrations are a better overall indicator of a lake's nutrient status because it's concentration remain more stable than other forms of phosphorus, soluble reactive phosphorus (SRP) is another parameter included in the water chemistry analysis. SRP is a dissolved form of phosphorus that is readily available for plant and algae growth. SRP can vary throughout the season and is dependent on how plants and algae absorb and release it. SRP can give an indication of how much phosphorus is available for uptake but does not indicate how much phosphorus is present in the water column. Typically SRP values are below the detection limit, however in Hasting's Lake SRP was above the detection limit in the epilimnion in every month.

WHAT HAS BEEN DONE TO REDUCE PHOSPHORUS LEVELS IN ILLINOIS?

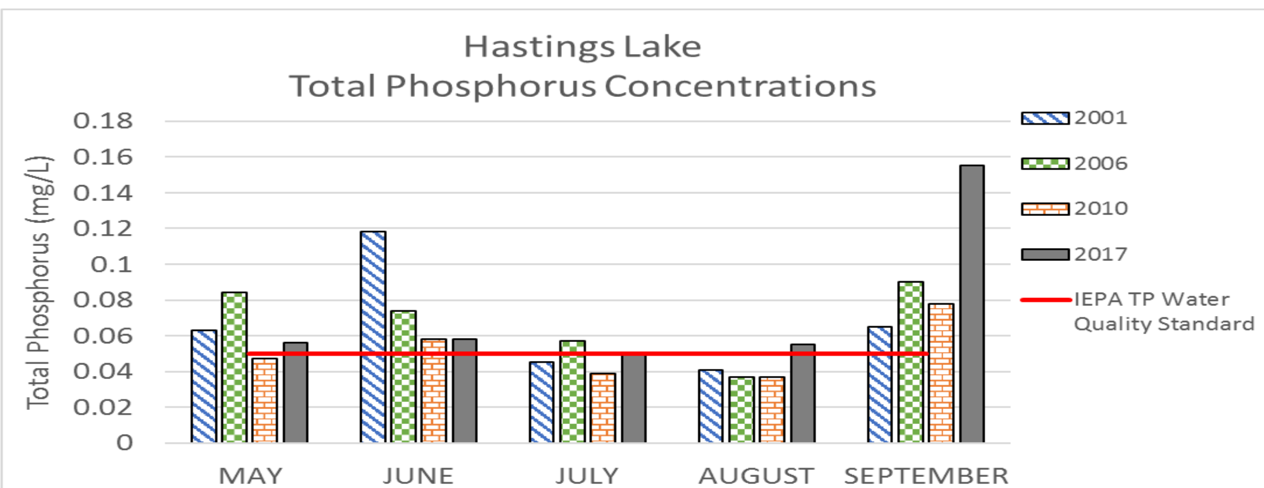
2005-2008: *common carp removal by IDNR*

January 2009: *Lindenhurst passed an ordinance prohibiting the use of lawn fertilizers containing phosphorus.*

July 2010—*The state of Illinois passed a law to reduce the amount of phosphorus content in dishwashing and laundry detergent*

July 2010: *The state of Illinois passed another law restricting the use of lawn fertilizers containing phosphorus by commercial applicators.*

Figure 4: *Phosphorus Concentrations in Hastings Lake monitored by LCHD*



TROPHIC STATE INDEX

Total phosphorus is also used to calculate the Trophic State Index (TSI) value. Trophic states describe the overall productivity of a lake and refers to the amount of nutrient enrichment. This has implications for the biological, chemical and physical conditions of the lake. Lakes are classified into four main categories: oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic. These range from nutrient poor and least productive (oligotrophic) to most nutrient rich and most productive (eutrophic). In 2017, Hastings Lake had a TSIp value of 66.3, which categorizes it as eutrophic. Based on the TSIp, Hasting's Lake is ranked 89 out of 175 lakes studied by the LCHD-ES from 2000 –2017 (Appendix B).

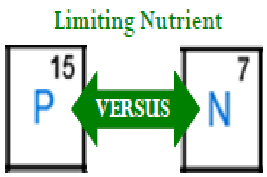
LAKE COUNTY AVERAGE TSIP = 65.7

HASTINGS LAKE TSIP = 66.3

TROPHIC STATE: EUTROPHIC

RANK= 89/175

NUTRIENTS: NITROGEN



Nitrogen in the form of nitrate (NO3-), nitrite (NO2-), or ammonium (NH4+) is a nutrient needed for plant and algal growth. Sources of nitrogen include septic systems, animal feed lots, agricultural fertilizers, manure, industrial wastewaters, sanitary landfills and atmospheric deposition. Nitrate/Nitrite concentrations in the epilimnion of Hastings Lake were below detectable concentrations for the entire monitoring season. Total Kjeldahl Nitrogen (TKN), an organically associated form of nitrogen averaged 1.36 mg/L, greater than the Lake County Median. While there are no impairments on Hastings Lake for nitrogen, nitrogen does play a significant role on the water body.

Typically lakes are either phosphorus or nitrogen limited. This means that one of the nutrients is in shorter supply and any addition of that nutrient to the lake will result in an increase of plant/or algal growth. Most lakes in Lake County are phosphorus limited. To compare the availability of nitrogen and phosphorus, a ratio of total nitrogen to total phosphorus (TN:TP) is used. Hastings Lake had an average TN:TP of 19:1, however, most months including May, June, and August were the TN:TP ratio was greater than 20:1 indicating a phosphorus limited system. September had the lowest TN:TP ratio at 14:1.

TN:TP Ratio

<10:1 = nitrogen limited

>20:1= phosphorus limited

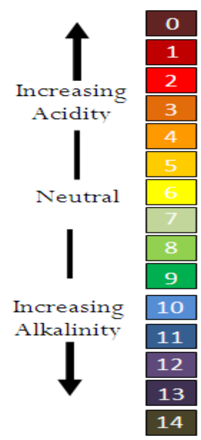
TN:TP Ratio on Hastings Lake is 19:1

Hastings Lake is mostly Phosphorus Limited

PH

pH is a measure of the hydrogen ion concentration of water. As the hydrogen ions are removed, pH increases. A well buffered lake also means that daily fluctuations of CO2 concentrations result in only minor changes in pH throughout the day. Aquatic organisms benefit from stable pH. Each organism has an ideal pH threshold, but most aquatic organisms prefer pH of 6.5—8.0. pH values <6.5 or >9.0 cause a water quality impairment.

Hastings Lake had an average pH in 2017 was 8.69. In September, the average pH was 9.03; causing a water quality impairment. High pH values are often occur in the presence of blue-green algae blooms. In September, blue-green algae blooms were noted on Hastings Lake and this corresponds with the higher pH concentration.The formation of blooms can have effects on the chemistry of water, especially on its pH and dissolved oxygen. During photosynthesis, algae remove carbon dioxide (CO2) from the water, which increases the hydroxide (OH−) levels, resulting in an increase in pH.



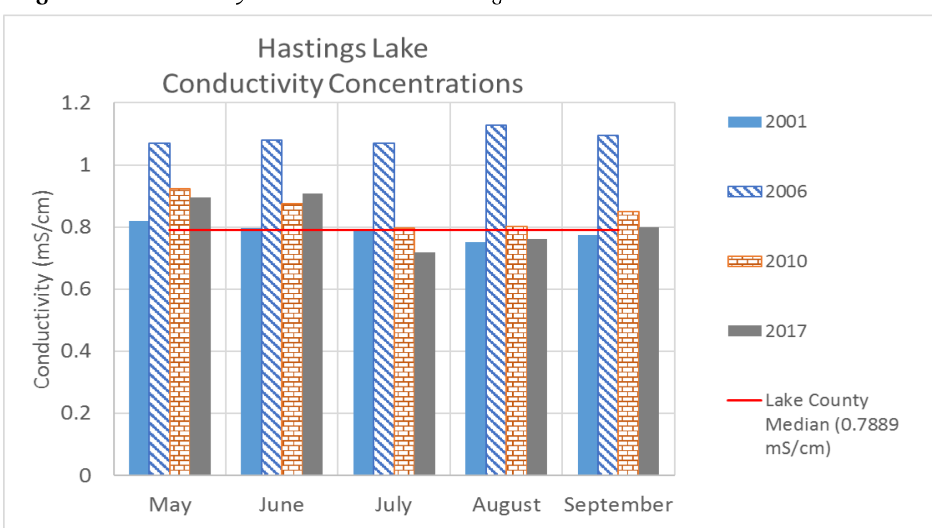
The pH scale ranges from 0 to 14. A pH of 7 is considered neutral. Substances with a pH of less than 7 are acidic, and greater than 7 are basic.

CONDUCTIVITY

Conductivity is the measure of different chemical ions in solution. As the concentration of these ions increases, conductivity increases. The conductivity of a lake is dependent on the lake and watershed geology, size of the watershed flowing into the lake, land use, evaporation, and bacterial activity.

In 2017, Hastings Lake average conductivity concentration was 0.8162 mS/cm. This is slightly higher than the Lake County median conductivity concentration of 0.8491 mS/cm. This value is a 4% decrease since the 2010 concentrations (Figure 5).

Figure 5: *Conductivity Concentrations in Hastings Lake*



CHLORIDES

One of the most common dissolved solids is road salt used in winter road deicing. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocynaide salts. Hasting Lake's chloride concentration averaged 171 mg/L which is above the Lake County median of 127 mg/L (Figure 6). The United States Environmental Protection agency has determined that chloride concentrations higher than 230 mg/L can disrupt aquatic systems. While Hasting's Lake chloride concentration is below the aquatic life criteria, recent research has indicated organisms can get stressed at values lower than 230 mg/L. Chloride ions do not break down and accumulate within a watershed. High chloride concentrations may make it difficult for many of our native plant species to survive while many of our invasive species such as Eurasian Watermilfoil, Cattail, and Common Reed are tolerant to high chloride levels. Chloride concentrations did increase since the and 2010 sampling.

The LCHD-ES and Lake County Stormwater Management Commission (LCSMC) have been holding annual trainings targeting deicing maintenance personnel for both public and private entities to hopefully reduce the amount of chloride being introduced into our environment while maintaining safe passageways. Almost all deicing products contain chloride so it is important to read an follow product labels for proper application. For instance, at 10°F Fahrenheit, rock salt is not at all effective in melting ice and will blow away before it melts anything. Additionally calling your local township office to ask them if they are taking actions to minimize deicers on their properties or supporting changes in their deicing policy to minimize salt usage is encouraged. Since Hasting's Lake has such a large watershed, chlorides is a concern and efforts should be made in the watershed for efficient de-icing practices.

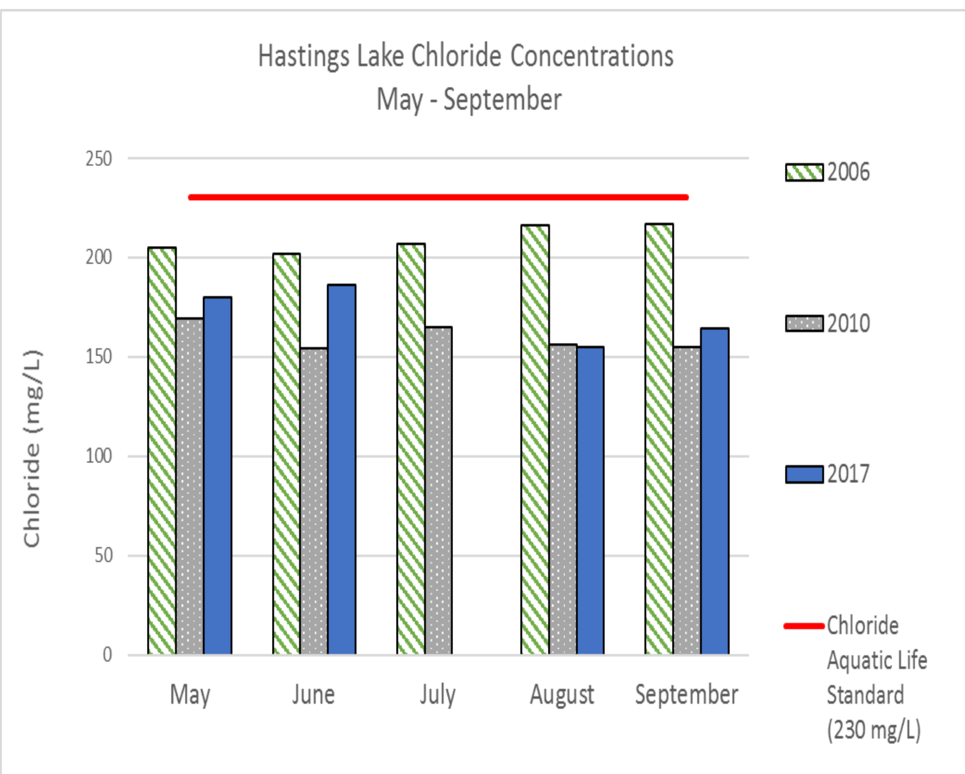
THE CRITICAL VALUE FOR CHLORIDES IN AQUATIC SYSTEMS IS 230 MG/L.

230 mg/L = 1 teaspoon of salt added to 5 gallons of water.

ICE FACTS

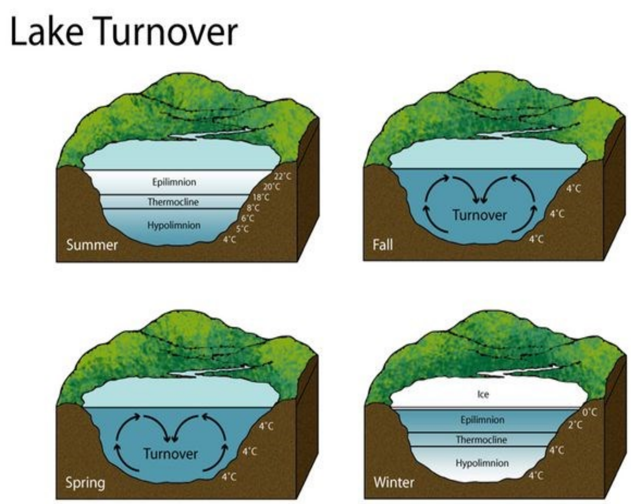
- Deicers melt snow and ice. They provide no traction on top of snow and ice.
- Anti-icing prevents the bond from forming between pavement and ice.
- De-icing works best if you plow/shovel before applying material.
- Pick the right material for the pavement temperatures.
- Sand only works on top of snow as traction. It provides no melting.
- Anti-icing chemicals must be applied prior to snow fall.
- NaCl (Road Salt) does not work on cold days, less than 15° F.
- NaCl is more effective at warmer temperatures—when it is warmer out, you do not need to put as much road salt down to melt ice efficiently.

Figure 6: *Hastings Lake Chloride Concentrations*



STRATIFICATION

Figure 7: Lake Turnover/Stratification diagram

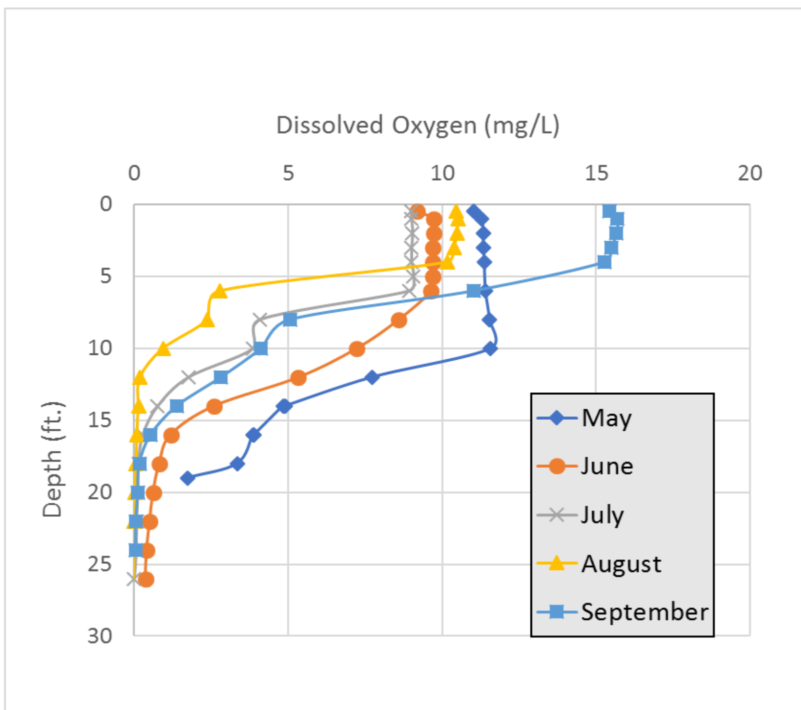


Lake stratification is a result of variations in density caused by temperature (or salinity) and can prevent warm and cold water from mixing. A lake's water quality and ability to support fish are affected by the extent to which the water mixes. Lakes that experience stratification have the water column divided in three zones: epilimnion (warm surface layer), thermocline (transition zone between warm and cold water) and hypolimnion (cold bottom water) (Figure 7). Stratification traps nutrients released from bottom sediments in the hypolimnion and prevents mixing. Lakes in lake county are either dimictic or polymictic. Dimictic means there are only two lake turnovers (spring and fall), whereas polymictic means that the thermocline is never that strong so the lake can go mix multiple times throughout the season.

Monthly depth profiles of water temperature, dissolved oxygen, conductivity, and pH were taken every foot from the lake surface to the lake bottom on Hastings Lake. The relative thermal resistance to mixing (RTRM) value can be calculated from this data and indicates if a lake stratifies, how strong the stratification is, and at what depth the thermocline occurs. In Hastings Lake, the lake stratified for all sampling months based on RTRM values greater than 20.

DISSOLVED OXYGEN

Figure 8: Hastings Lake 2017 DO Profile



A dissolved oxygen (DO) concentration of 5.0 mg/L is considered adequate to support a fishery since fish can suffer oxygen stress below this concentration. Dissolved oxygen (DO) dropped below 5 mg/L in the hypolimnion of the lake which is not uncommon for glacial stratified lakes. (Figure 8).

Anoxic conditions, where DO concentrations are <1 mg/L, occurred June - September. Typically in deeper, thermally stratified lakes, oxygen production is greatest in the epilimnion, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters (Figure 8). Volume of Hastings lake that was anoxic ranged from 7.8% (June) to 34.7% (August) when DO dropped below 1 mg/L at depths greater than 10 ft.

HARMFUL ALGAL BLOOMS

Algae are important to freshwater ecosystems and most species of algae are not harmful. Algae can grow quickly in water and are often associated with increased concentrations of nutrients such as nitrogen and phosphorus. Harmful algal blooms (HABs), also known as Blue-green algae or cyanobacteria, are a type of algae that can bloom and produce toxins. They are called harmful algal blooms because exposure to these blooms can result in adverse health effects to human and animals. Certain environmental conditions such as elevated levels of nutrients, warmer temperatures, still water, and plentiful sunlight can promote the growth of cyanbacteria to higher densities. However, their presence does not mean that toxins are present. It is still unclear what triggers HABs to produce the toxins. HABs tend to occur in late summer and early fall. Due to the potential presence of toxins, the IEPA and the LCHD have initiated a program to collect HABs from beaches and test for presence of microcystin, a common toxin produced by HABs. Table 3 shows guidelines for microcystin toxins based on the World Health Organization. EPA is in the process of releasing microcystin toxin criteria for recreational waters.

In 2017, filamentous and blue-green algae blooms were noted on Hastings Lake. Filamentous algae was noted early in the season (May) and Blue-Green Algae blooms were noted later in the season (September). This is typical timing of these blooms in high-nutrient lakes.

While Hastings Lake does not have a public swimming beach, the Lake County Forest Preserve District should educate themselves and LCFPD users on blue-green algae blooms. It is recommended to report any potential blue-green algae blooms by calling the Lake County Health Department so that the bloom can be tested. Blue-green algae blooms can be toxic to pets who drink from the water as well as to human health. Also, there should be a clear communication protocol amongst the LCFPD to disseminate information regarding the presence of blue-green algae.

FOR MORE INFORMATION ON BLUE-GREEN ALGAE:
www.epa.state.il.us/water/surface-water/blue-green-algae.html

TO REPORT BLUE-GREEN ALGAE BLOOM:
Lake County Health Department 847-377-8030

Anabaena Sp.

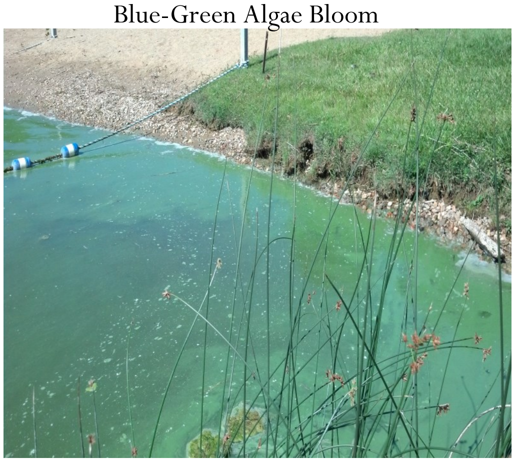
Microcystis Sp.

Aphanizomenon Sp.

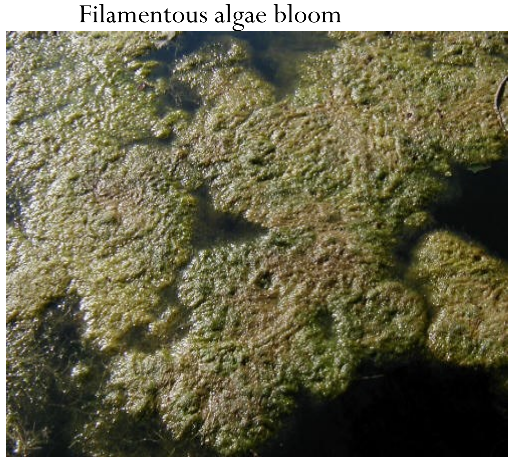
Table 3: *World Health Organization Microcystin Toxin Guidelines*

Relative Probability of Acute Health Effects	Cyanobacteria (cells/mL)	Microcystin-LR (µg/L)	Chlorophyll-a (µg/L)
Low	< 20,000	<10	<10
Moderate	20,000-100,000	10-20	10-50
High	100,000-10,000,000	20-2,000	50-5,000
Very High	> 10,000,000	>2,000	>5,000

Blue-Green Algae Bloom



Filamentous algae bloom



BATHYMETRIC MAPS

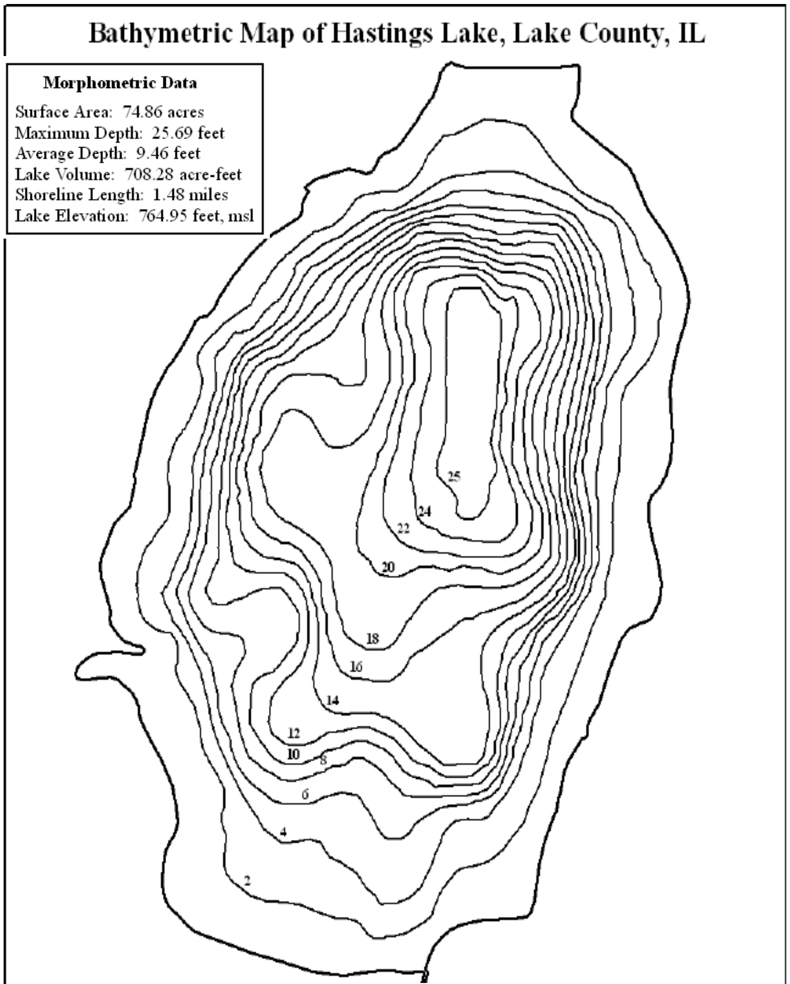


Figure 9: *Bathymetric Map of Hastings Lake*

Bathymetric maps are also known as depth contour maps and 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 can then be used to determine the volume of lake that goes anoxic, how much of the lake bottom can be inhabited by plants, and is essential in the application of whole-lake herbicide treatments, harvesting activities and alum treatments of your lake. Other common uses for the map include sedimentation control, fish stocking, and habitat management.

The LCHD-ES collects field data for bathymetrics using a Lowrance HDS-5 Gen2; Lowrance cites accuracy measures of approximately 5m however actual accuracy is typically better than this conservative estimate and has been discovered to be sub-meter (CIBiobase,2013). Once collected, the data was analyzed and imported into ArcGiS 10.2 for further analysis. In ArcGIS 10.2, the contours and volumes were generated from the triangular irregular network (TIN).

Hastings Lake had a bathymetric survey conducted in 2008 by LCHD (Figure 9). The maximum depth was 25.69 ft. and average depth was 9.46 ft. Lake volume was estimated 708.28 acre-feet. LCHD recommends updating bathymetric map every 10 years. For a complete list of the morphometric table for Hastings Lake refer to Appendix B.

WATER LEVEL & JULY 2017 FLOODS

On July 11-12th, Lake County was inundated with very heavy rain. Lake County experienced rainfall amounts between 3.4 - 7.2 inches of rain in a 24-hour period. The rainfall resulted in several different kinds of flooding countywide. Flash flooding and sewer backups began as the heavy rain overwhelmed storm-water infrastructure. River flooding began in the Fox, Des Plaines, and Skokie rivers and established record crest levels (Figure 10). Many lakes experienced high lake levels and increased nutrient levels. Hasting's Lake water level rose 1 foot between June and July.

Figure 10: *River crests as a result of the July Flooding in Lake County, Lake County Stormwater Management Commission*

2017 Lake Levels on Hastings Lake

2017	Level	Seasonal Change	Monthly Change	Rain
June	42.00			4.08"
July	30.00	12.00	12.00	9.73"
August	40.20	1.80	-10.20	3.62"
September	40.68	1.32	-0.48	0.2"

SHORELINE EROSION

Erosion is the natural process of weathering and transport of solids (sediment, soil, rock and other particles) in the environment . In lakes, shorelines are impacted by waves and ice movement which displaces soil particles. Disturbed shorelines caused by human activity such as replacing native plants with turfgrass, increasing impervious pavement which increases runoff will accelerate erosion. Eroded materials cause turbidity, sedimentation, nutrients, and pollutants to enter a lake. Excess nutrients are the primary cause of algal blooms and increased aquatic plant growth and once in the lake, sediments, nutrients and pollutants are harder and more expensive to remove.

A shoreline erosion assessment was conducted on Hastings Lake 2017 (Figure 11). Hastings Lake was divided into reaches, and the shoreline evaluated for none, slight, moderate and severe erosion based on exposed soil and tree/plant roots, failing infrastructure and undercut banks. Based on the 2017 data, 93% of Hasting's Lake shoreline has no erosion and only 7% with some degree of erosion. There is little erosion on Hastings Lake, likely a result of the increase of emergent plants established around the lake shoreline. Figures 12-13 represent the some typical shoreline conditions on Hastings Lake.

Where erosion is occurring, tends to be public access points (near piers/fishing area) and in the back channel where wave energy may be greater. To see the complete dataset of shoreline erosion broken down by

Figure 11: *Shoreline Erosion Condition Hastings Lake, 2017*

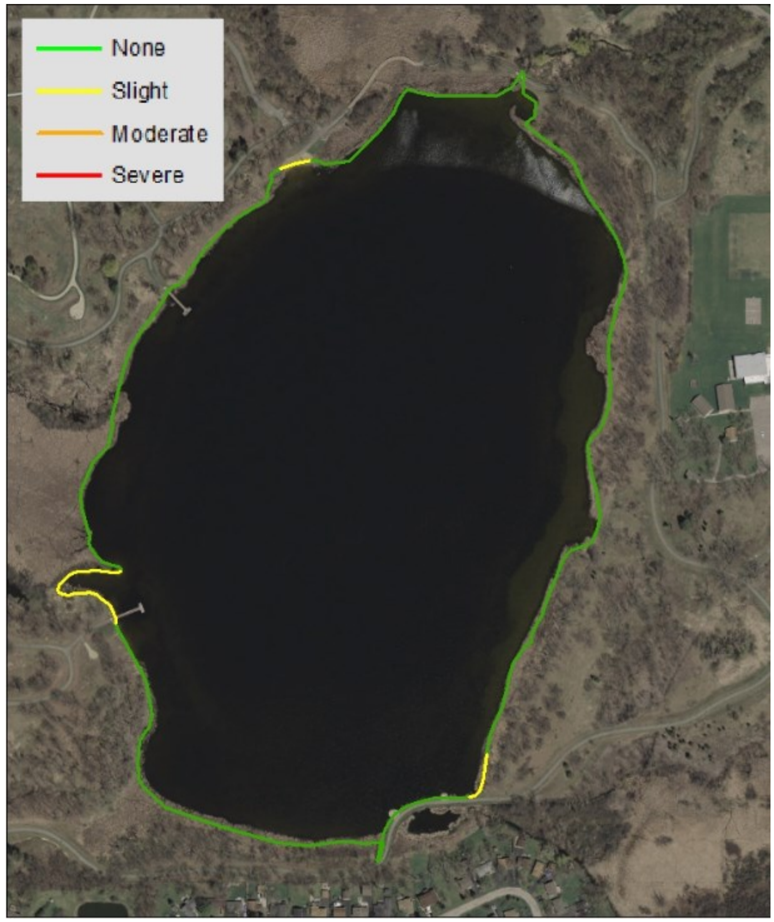


Figure 12: *example of slight shoreline erosion on Hastings Lake near accessible lake areas*

Figure 13: *Example of riprap located along shoreline to minimize erosion*

SHORELAND BUFFERS

A shoreland buffer helps stabilize the sediment near the lakes edge which prevents soil erosion. The buffer will also filter out pollutants and unwanted nutrients from entering the lake. Buffer strips should be at least 25 feet wide and can include native wildflowers, native grasses, and native wetland plants. Wider buffers may be needed for areas with a greater slope or additional runoff issues. Areas that are already severely or moderately eroding, a buffer strip of native plants may need to be bolstered for additional stability. Many LCFPD lakes have re-established buffers or do not mow to lakes edge to allow native grasses to grow. Hastings Lake has had restoration around the lake and has decent buffer coverage along most of the shoreline.

A shoreland buffer condition of Hastings Lake was assessed by looking at the land within 25 feet of the lake's edge on aerial images in ArcGIS. Shoreland buffer's were classified into three categories; poor, fair or good based on the amount of unmowed grasses, forbs, tree trunks and shrubs, and impervious surfaces within that 25 foot range. In 2017, Hastings Lake had 5% of the shoreline with poor buffer, 5% with fair, and 90% with good buffer (Figure 14). Figures 15-16 represent that the typical buffer conditions around Hastings Lake. For a complete list of buffer condition by reach, refer to Appendix B.

Figure 14: *Shoreline Buffer Condition on Hastings Lake*

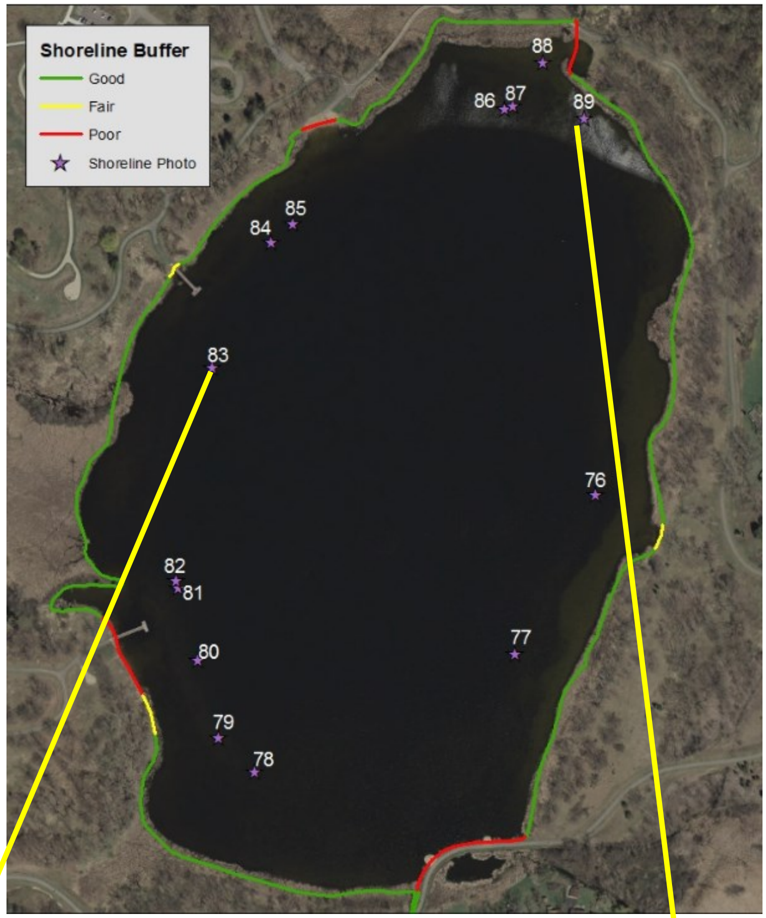


Figure 15: *Example of good buffer coverage with native plants in bloom around Hastings Lake.*

Figure 16: *Buffer of emergent plants and forest/shrubs.*

AQUATIC PLANTS

Aquatic plants are a critical component of a lakes ecosystem as they compete against algae for nutrients, improve water quality and provide fish habitat. **Their presence is natural and normal in lakes.** An aquatic macrophyte survey was conducted on Hastings Lake in late July 2017. Sampling sites were based on a grid system created by mapping software, with each site located 60 meters apart for a total of 87 sites. At each site, overall plant abundance was ranked and plant species were identified and ranked. In addition to the plant rake survey, the lake was mapped using Sonar and CIBiobase as more accurate measure for overall aquatic plant biovolume. Based on the aquatic plant rake survey, plants occurred at 43 of the 87 sites (49.4 % total lake coverage) with plants found at depths up to 9.4 feet (Figure 17). Out of the sample points that did have plants the majority had 60-90% plant coverage; meaning there was a high-density plant coverage on the littoral zone of the lake.

There were a total of 7 aquatic plant species and one macro-algae found in Hastings Lake. Eurasian Watermilfoil was the most dominant plant species found at 46% of the sampling sites (Table 4). The next most abundant plant was White Water Lily observed at 30% of the sampling sites. The number of plant species (diversity) decreased since the 2010 sampling. In 2010, EWM and White Water Lily were still the most abundant plants observed. Flatstem Pondweed as observed in 2010 but not in 2017. For a complete list of aquatic plant species and density found in Hastings Lake, refer to the aquatic plant table found in Appendix B.

Figure 17: *Plant Biovolume Hastings Lake, August 2017*

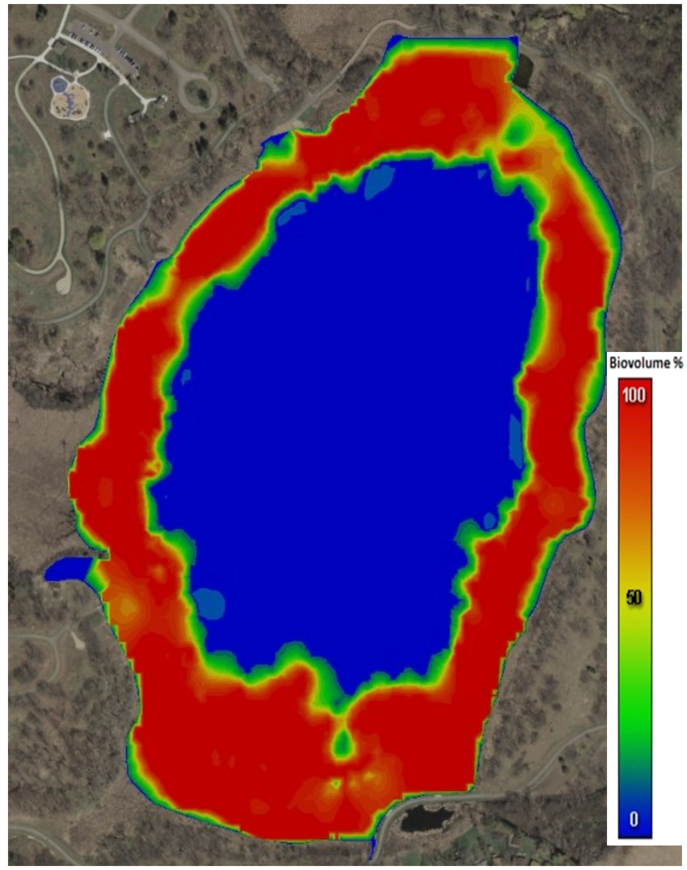


Table 4: *Hastings Lake 2017 Plant Rake Density*

Plant Density	Chara	Coontail	Duckweed	Elodea	Eurasian Watermilfoil	Spatterdock	Watermeal	White Water Lily
Absent	86.0	74.0	78.0	85.0	47.0	85.0	85.0	61.0
Present	0.0	2.0	1.0	1.0	5.0	0.0	0.0	3.0
Common	0.0	2.0	4.0	0.0	5.0	1.0	0.0	7.0
Abundant	0.0	4.0	4.0	1.0	13.0	1.0	2.0	12.0
Dominant	1.0	5.0	0.0	0.0	17.0	0.0	0.0	4.0
% Plant Occurrence	1%	15%	10%	2%	46%	2%	2%	30%

FLORISTIC QUALITY INDEX

Floristic Quality Index (FQI) is an assessment tool designed to evaluate the closeness the flora of an area is to that of undisturbed conditions . It can be used to (1) identity natural areas, (2) compare the quality of different sites, (3) monitor long term floristic trends and (4) monitor habitat restoration efforts. Each aquatic plant in a lake is assigned a value based on the species sensitivity. A high FQI number indicates that a large number of sensitive, high quality plants species are present in the lake. The average FQI for Lake County lakes from 2000-2017 was 13.7 Hastings Lake has an FQI of 11.2 ranking it 107/171 lakes in the county.

LAKE COUNTY AVERAGE FQI = 13.8

HASTINGS LAKE FQI = 14.0

RANK =78/171

AQUATIC PLANTS SPECIES: 7

NATIVE PLANT SPECIES: 6

INVASIVE SPECIES: EURASIAN WATERMILFOIL

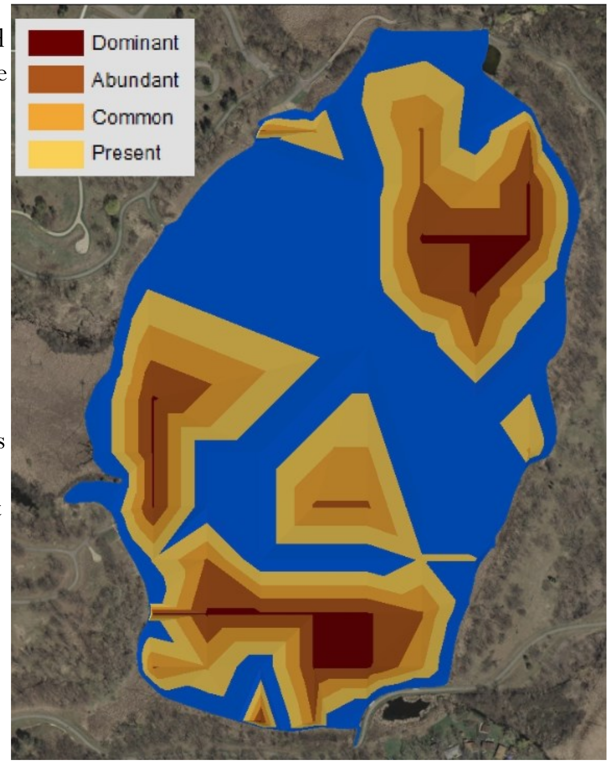
Eurasian Watermilfoil (EWM) is a feathery submerged aquatic plant that can quickly form thick mats in shallow areas of lakes and rivers in North America. These mats can interfere with swimming and entangle propellers, which hinders boating fishing, and waterfowl hunting. Matted milfoil can displace native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

Unfortunately, EWM is a dominant species in Hastings Lake found at 46% of the sampling sites. This is roughly the same abundance as 2010. Populations were most dense in the northern and southern portions (Figure 18).

illustration provided by:
IFAS, Center for Aquatic Plants
University of Florida, Gainesville, 1990

An aquatic plant management plan is critical to maintaining the health of the lake and a balanced aquatic plant community. The plan should be based on the management goals of the lake and involve usage issues, habitat maintenance/restoration, and limitations of the lake. The primary focus of the plan must include the removal of invasive species largely targeting EWM. Follow up is critical to achieve long-term success.

***Figure 18:** Hastings Lake Eurasian Watermilfoil Plant Rake Density, 2017*



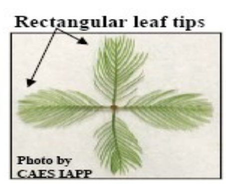
MYRIOPHYLLUM SPICATUM EXOTIC*

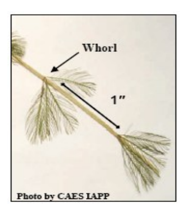
COMMON NAMES:
EURASIAN WATERMILFOIL

ORIGIN: EXOTIC
EUROPE AND ASIA. FOUND THROUGHOUT LAKE COUNTY AND ILLINOIS

IMPORTANCE:
THIS INVASIVE PLANT SPREADS RAPIDLY, CROWDING OUT NATIVE SPECIES, CLOGGING WATERWAYS, AND BLOCKING SUNLIGHT AND OXYGEN FROM UNDERLYING WATERS.

LOOK ALIKES:
NORTHERN WATERMILFOIL
WHICH HAS FEWER THAN 12 LEAFLET PAIRS PER LEAF, AND GENERALLY HAS STOUTER STEMS.





KEY FEATURES:

STEM: LONG, OFTEN ABUNDANTLY BRANCED STEMS FORM A REDDISH OR OLIVE-GREEN SURFACE MAT IN SUMMER.

LEAF: LEAVES ARE RECTANGULAR WITH ≥12 PAIRS OF LEAFLETS PER LEAF AND ARE DISSECTED GIVING A FEATHERY APPEARANCE, ARRANGED IN A WHORL, WHORLS ARE 1 INCH APART.

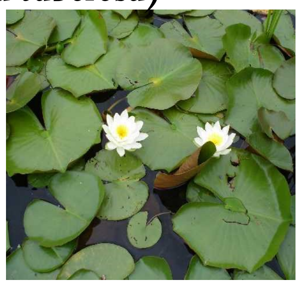
FLOWER: SMALL PINKISH MALE FLOWERS THAT OCCUR ON REDDISH SPIKES, FEMALE FLOWERS LACK PETALS AND SEPALS AND 4 LOBED PISTIL.

AQUATIC PLANTS —DOMINANT PLANTS

The most dominant plants found in Hastings Lake were: Eurasian Watermilfoil (46%), White Water Lily (30%), and Coontail (15%). EWM and White Water Lily were found in approximately the same abundance as the 2010 survey, however, Coontail has decreased from 22% in 2010 to 15% in 2017.

The diversity and extent of plant populations can be influenced by a variety of factors. Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow. When the light level in the water column falls below 1% of surface light level, plants can no longer grow. The 1% surface light level is roughly at 2 times the average Secchi depth or can be measured with a photosynthetically active radiation (PAR) sensor. For Hastings Lake, the 1% light level based on average Secchi values was approximately 8.4 feet. Plants were found up to 9.4 feet in Hastings Lake. Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates.

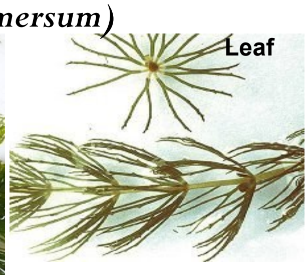
White Water Lily (*Nymphaea tuberosa*)



Description

American white water lily is a floating aquatic plant with large, fagrant, white flowers and flat, round, floating leaves. The leaves have long stems are bright green above and reddish or purplish underneath. There is one flower per stem. White Water Lilies provide good habitat for fish and macroinvertebrates.

Coontail (*Ceratophyllum demersum*)



Description

American white water lily is a floating aquatic plant with large, fragrant, white flowers and flat, round, floating leaves. The leaves have long stems are bright green above and reddish or purplish underneath.

Coontail is a dark olive-green, rootless submerged perennial plant that often forms dense colonies. Leaves are relatively stiff, whorled with many forks and small teeth along one edge. The tips of branches are crowded with leaves giving it a "coontail" resemblance. Coontail reproduces by seeds and fragmentation. The fruits of coontail are consumed by ducks and it is considered good wildlife food.

AQUATIC PLANTS: WHERE DO THEY GROW?

Littoral Zone– the area that aquatic plants grow in a lake.

Algae– have no true roots, stems, or leaves and range in size from tiny, one- celled organisms to large, multicelled plant -like organisms.

Submerged Plants– have stems and leaves that grow entirely underwater, although some may also have floating leaves.

Floating-leaf Plants– are often rooted in the lake bottom, but their leaves and flowers lay flat on the water surface.

Emergent Plants– are rooted in the lake bottom, but their leaves and stems extend out of the water.

AQUATIC PLANT MANAGEMENT OPTIONS

Two sided rake for manual harvesting

Aquatic plants are essential for maintaining a balanced, healthy lake, but sometimes plants can create a nuisance for recreation, lake aesthetics, and invasive plant species can outcompete native plant species. Aquatic plant management is both controlling undesirable species while encouraging desirable species in important habitat areas. For Hastings Lake and most of the Lake County Forest Preserve District lakes there has been little intervention in plant management, meaning plants are intentionally not controlled or manipulated but allowed to grow as environmental conditions dictate. This is generally a good strategy for low nutrient likes (oligotrophic and mesotrophic) however, eutrophic lakes with high abundance of invasive species, such as Hastings Lake, may require some control. The main types of plant control include: mechanical harvesting, manual harvesting, and herbicides. Mechanical harvesting involves the use of specially designed machines that cut and remove plant material from a lake. Harvesting only reduces the height of aquatic plants in the water column. Manual or hand harvesting is the most environmentally friendly is best for small scale operations. The most common control tool in aquatic plant management is the use of herbicides registered by the U.S. environmental Protection Agency. Below is a table that briefly summarizes some pros and cons of the different aquatic plant management techniques. This is not a comprehensive list and should only be used as a guide to understanding different management options available.

Management Options	Pros	Cons
Mechanical	Cost competitive with chemical controls	Undesirable plants may fragment, spread and colonize new areas
	Removes nutrients from the lake but may be minimal compared with input	Desirable plants such as pondweeds may be suppressed
	Removes organic material from the lake	Limited operation in shallow water and around docks and rafts
	May provide some selective control	Machine breakdowns can disrupt operations
		Drifting plant fragments may accumulate at nuisance levels in quiet water areas
Hand Harvesting	Low Cost	Lab intensive
	Excellent control in small areas	Not suitable for large areas
	Low environmental impact	
Herbicides	Costs are reasonable in many situations	Involves the introduction of pesticides into shared water resources
	Range of products and combinations available provides flexibility in management options	Potential for misuse
	Some products are highly selective for nuisance species	May contribute to the buildup of organic material
	Can provide complete control of plants for swimming beaches	Algal blooms are possible following large herbicide treatments
		Fish kills may occur with misuse of certain products
		Large treatments may encourage shifts in plant communities
		Water use restrictions may be need to be imposed
		Does not address the cause of cultural eutrophication

FISH HABITAT

Fish depend on aquatic plants to provide habitat and forage for food and most freshwater fish rely on aquatic plants at some point during their life stage. The plant composition and density can play an important role in the nesting, growth, and foraging success of these fish. While many fish require some aquatic vegetation for growth, excessive amounts of aquatic vegetation can negatively impact growth by reducing foraging success. The parameters of an ideal fish habitat change base on the size and species of fish, the type of lake, structures present in the lake and many other factors. An example of in-lake fish habitat that would be beneficial in Hastings Lake is coarse woody habitat (CWH) or large woody debris. CWH often happens naturally as trees or large branches fall into the lake and this creates food, shelter, and breeding areas for aquatic insects, fish, turtles, and waterfowl.

Bluegills and young of the year game fish often seek shelter in and around CWH. Larger logs with branching limbs provide shade and protection for the smaller fish. Black Bass species (smallmouth and largemouth) often build spawning nests in proximity to CWH, particularly large logs (Hunt and Annett 2002; Lawson et al. 2011; Weis and Sass 2011).

FISHERIES

Common carp were causing water quality problems win the lake was first acquired by the LCFPD in 2003, so a carp removal project was initiated. Overall, 620 carp at approximately 1500 lbs were removed by 2008. In addition to carp removal, the IDNR fisheries biologist recommended predator stockings. In 2015, IDNR re-assessed the fisheries on Hastings Lake. The fishery has rebounded and now supports a more balanced combination of sport fish and pan fish. In 2015, 10 fish species were detected including: largemouth bass, bluegill, black crappie, yellow perch, northern pike, yellow bass, black crappie, pumpkinseed sunfish, and black bullhead. Statewide fishing regulations apply at Hastings Lake and can be found at http://www.ifishillinois.org. For more information on the 2015 fish survey, refer to the IDNR.

Carp are considered to be one of the most damaging invasive fish species. They are also highly tolerant of poor water quality. The common carp 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. 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 increases turbidity and nutrient concentrations. Increase in nutrients causes algal blooms and reduction in light penetration that impacts aquatic plants.

The spawning ritual involves a lot of thrashing in shallow water contributing to turbidity problems.

Site specific fishing regulations on Hastings Lake:

- All fish species: two pole and line fishing only.
- Largemouth bass: 15” minimum length limit, 6 fish daily creel limit.
- Walleye: 14” minimum length limit; 6 fish daily creel limit.
- Northern Pike: 24” minimum length limit; 3 fish per day creel.

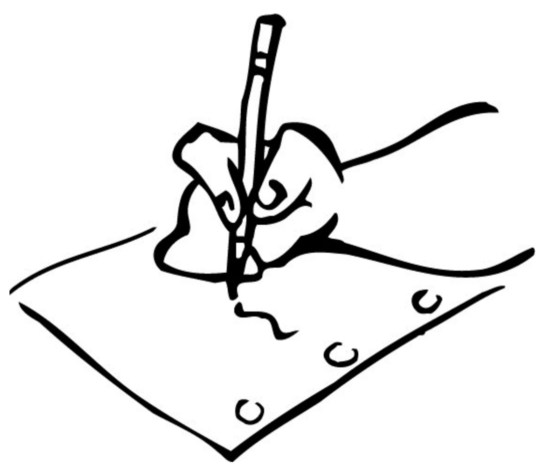
Lake management plans

It is recommended that a long term Lake Management Plans be developed to effectively manage lake issues. The Lake County Forest Preserve District can have a separate lake management plan for all lakes within their jurisdiction. All stakeholders should participate in the development of the plan and include homeowners, recreational users, lake management associations, park districts, townships or any other entity involved in managing Hastings Lake. Lake Management plans should educate the public about specific lake issues, provide a concise assessment of the problem, outline methods and techniques that will be employed to control the problems and clearly define the goals of the program. Mechanisms for monitoring and evaluation should be developed as well and information gathered during these efforts should be used to implement management efforts (Biology and Control of Aquatic Plants, Gettys et al., 2009).

What are the steps in creating a Lake Management Plan?

1. **Getting Started**: Identify lake stakeholders and communication pathways
2. **Setting Goals:** Getting the effort organized, identifying problems to be addressed, and agreeing on the goals
3. **Problem Assessment & Analysis**: collecting baseline information to define the past and existing conditions. Synthesize the information, quantifying and comparing the current conditions to desired conditions, researching opportunities and constraints and setting direction to achieve goals.
4. **Alternatives:** List all possible management alternatives and evaluate their strengths, weakness, and general feasibility.
5. **Recommendations:** Prioritize management options, setting objectives and drafting the plan
6. **Project Management:** Management of assets, detailed records of expenses and time
7. **Implementation:** adopting the plan, lining up funding, and scheduling activities for taking action to achieve goals.
8. **Monitor & Modify:** Develop a mechanism for tracking activities and adjusting the plan as it evolves.

Follow these steps when getting started with writing Lake Management Plans. While each step is necessary, the level of effort and detail for each step will vary depending on the project's goals, size of the lake, and number of stakeholders.



LAKE RECOMMENDATIONS

Hastings Lake's management is administered by the Lake County Forest Preserve. To improve overall quality of Hastings Lake, the LCHD-ES has the following recommendations:

- It is recommended that the Lake County Forest Preserve create a lake management plan for the lakes within their forest preserves. Management plans can include restoration activities (such as carp removal, shoreline restoration, and more) as well as guidelines for how to manage aquatic plants. This will be useful for many reasons, but one being where lakes where the LCFPD only owns a small portion of lake bottom, and needs to have a plan in writing to address other homeowner concerns.
- Focus on an aquatic plant management that targets the removal of Eurasian Watermilfoil and promotes native plant growth.
- Re-assess Hastings Lake fish population with a fish survey to determine if common carp remain in high population.

LakeCounty
Health Department and Community Health Center

ECOLOGICAL SERVICES

Senior Biologist: Mike Adam

madam@lakecountyil.gov

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

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

For more information visit us at:

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

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

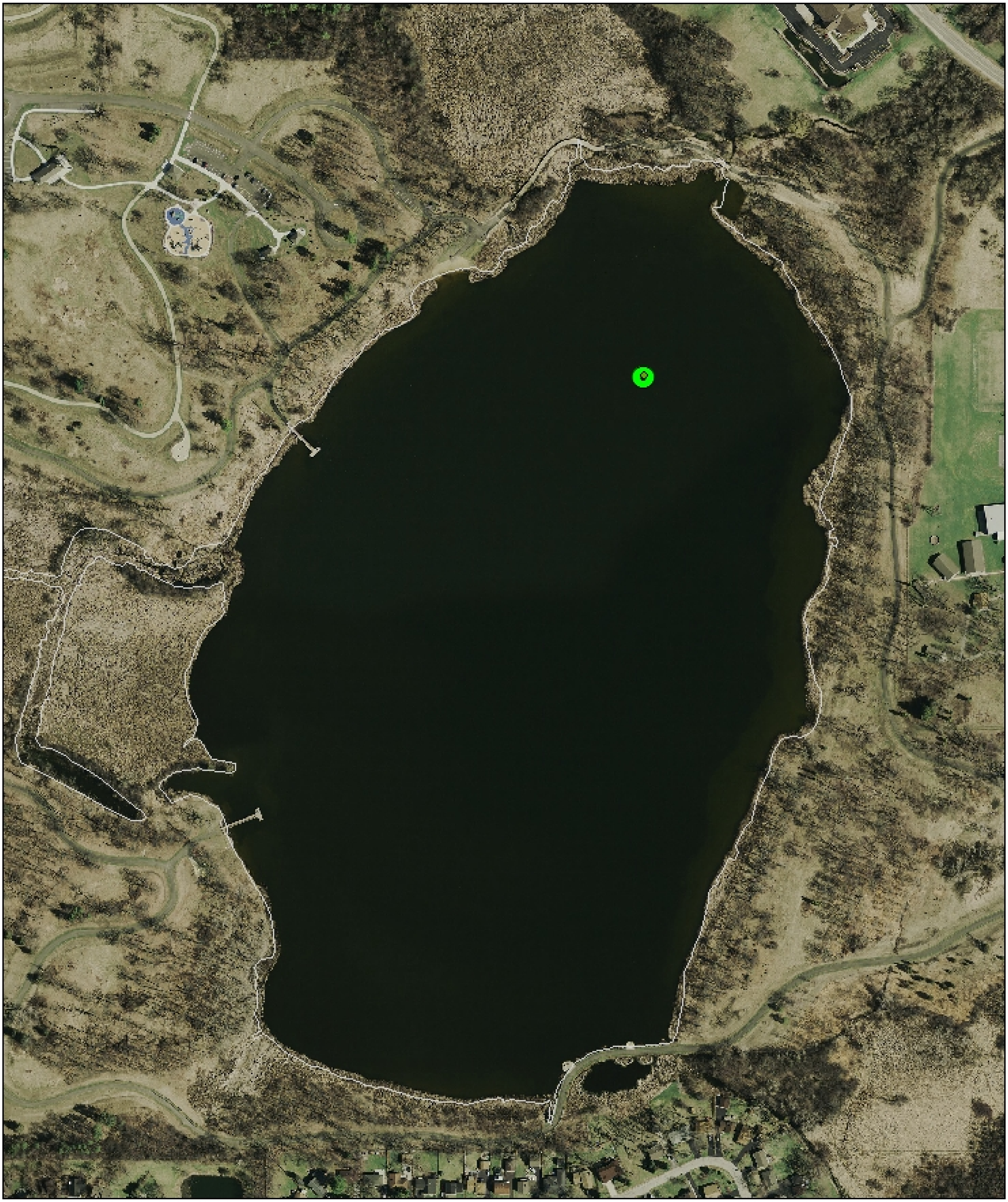
Environmental Service's goal is to monitor the quality of the county's surface water in order to:

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

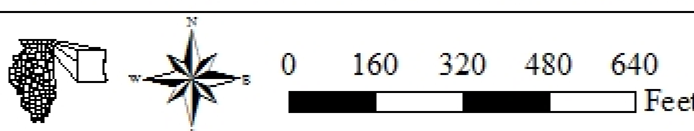
Services provided are either of a technical or educational nature and are provided by a professional staff of scientists to government agencies (county, township and municipal), lake property owners' associations and private individuals on all bodies of water within Lake County.

Appendix A:
Figures

Hastings Water Quality Sampling Location

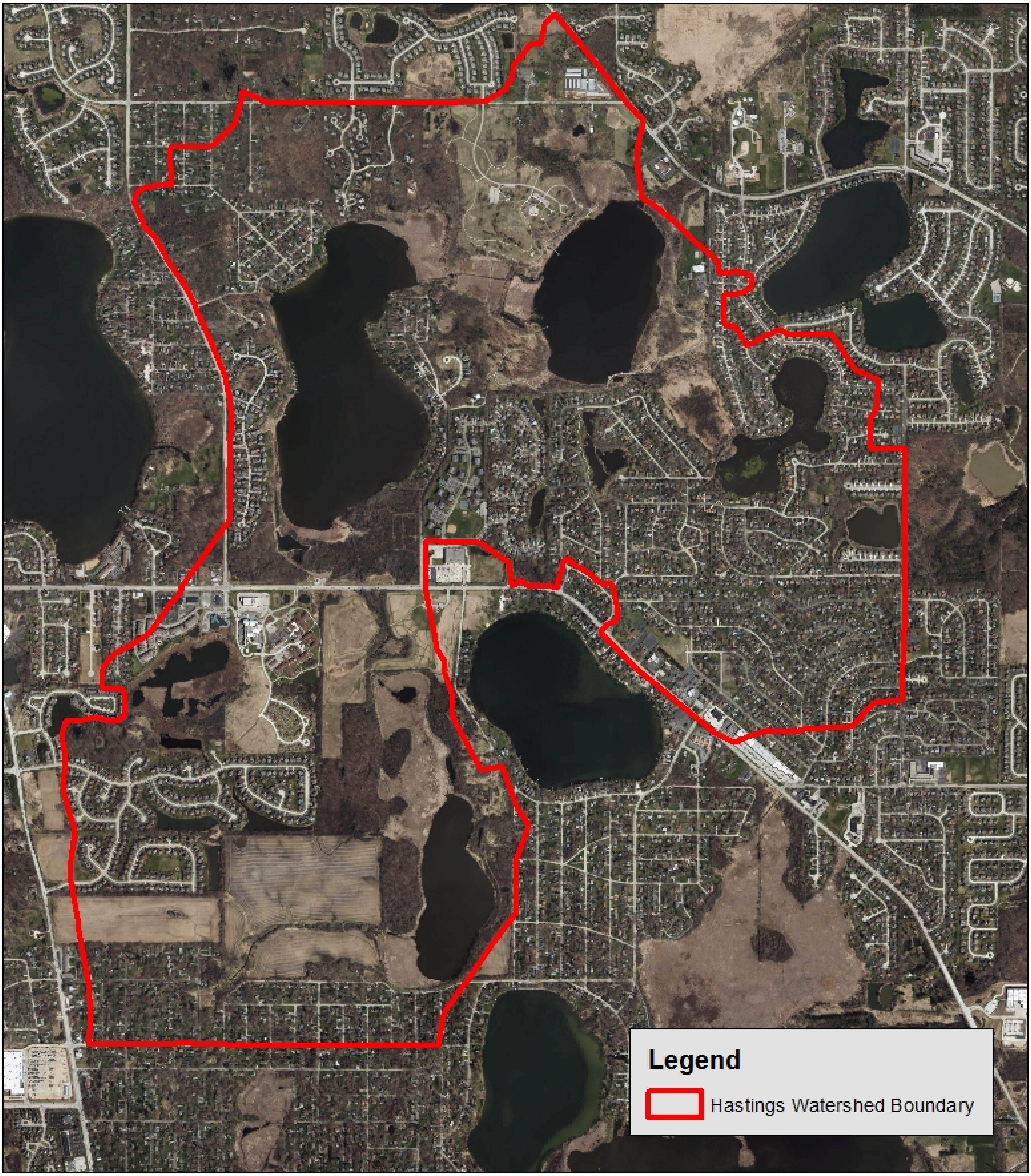


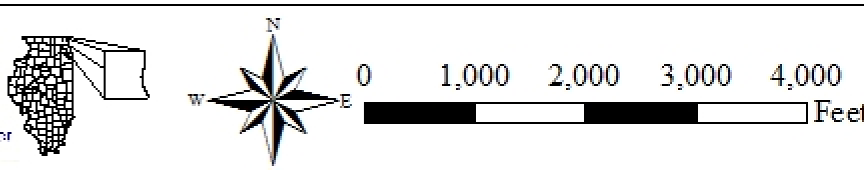
LakeCounty
Health Department and
Community Health Center



Ecological Services
Product Number HST7
Revised 05/2017

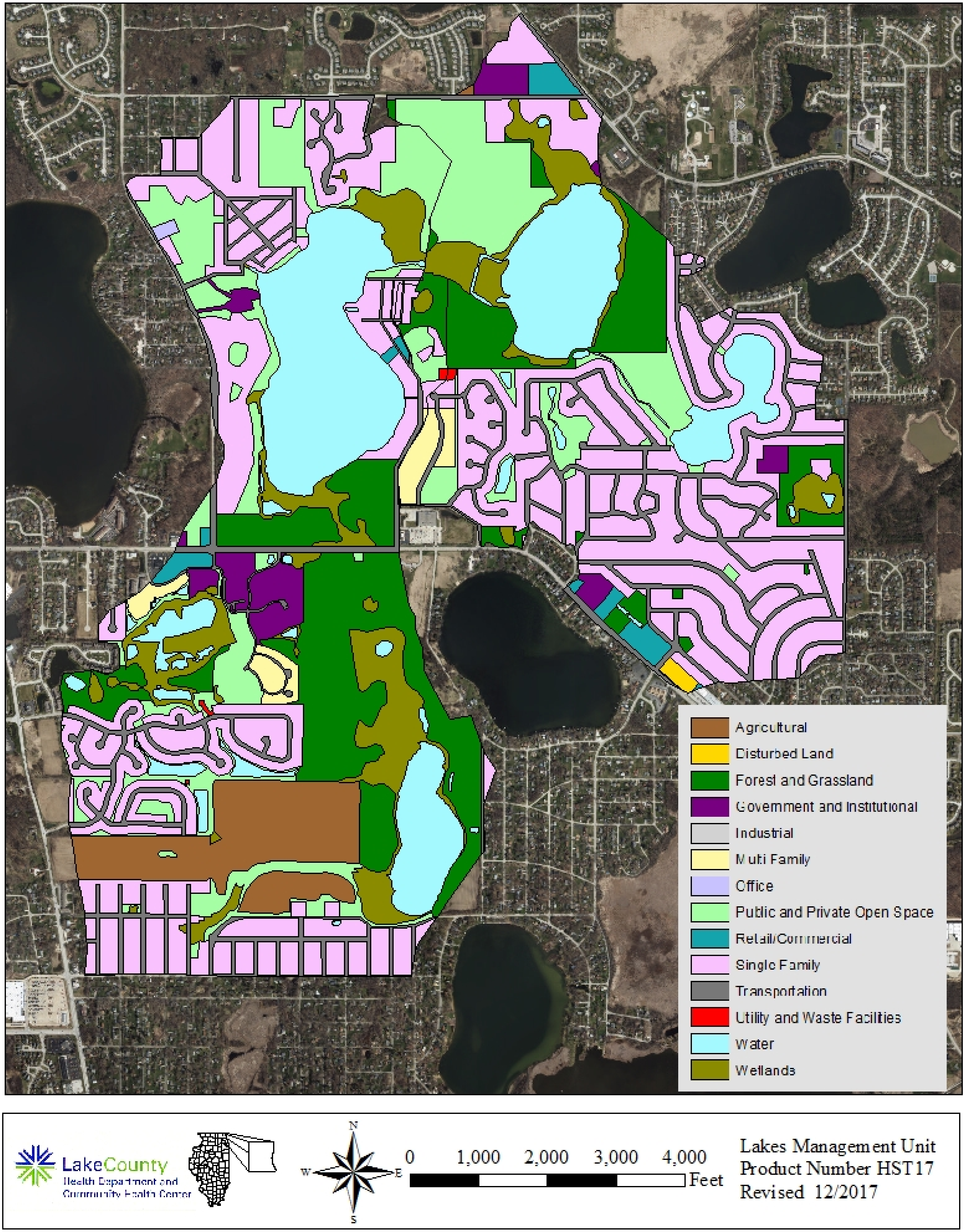
Hastings Watershed Boundary





Lakes Management Unit
Product Number HST17
Revised 12/2017

Hastings Land Use 2017

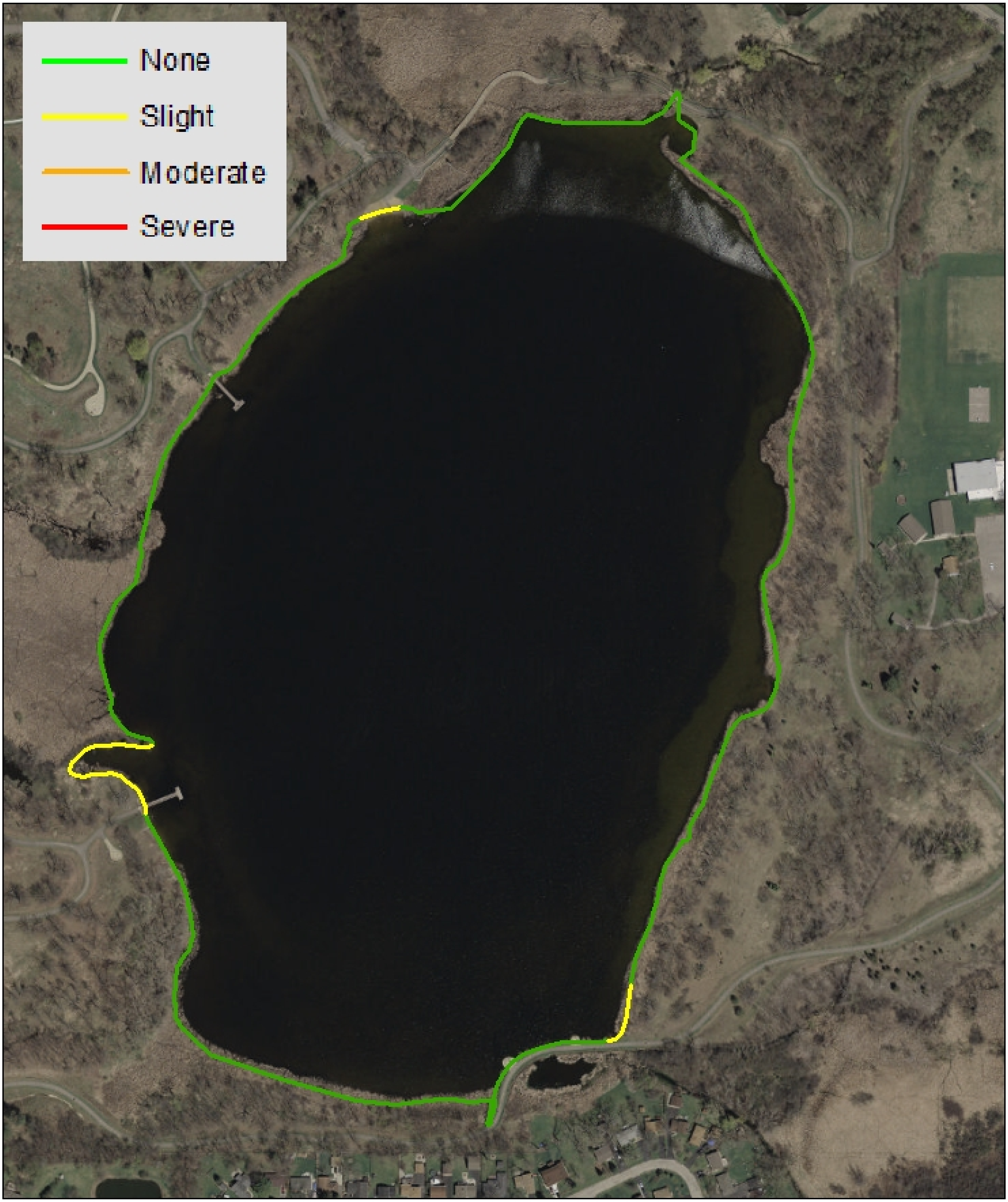


Hastings Shoreline Reaches 2017

LakeCounty Health Department and Community Health Center

Ecological Services
Product Number HST17
Revised 08/2017

Hastings Lake Shoreline Erosion Condition, 2017

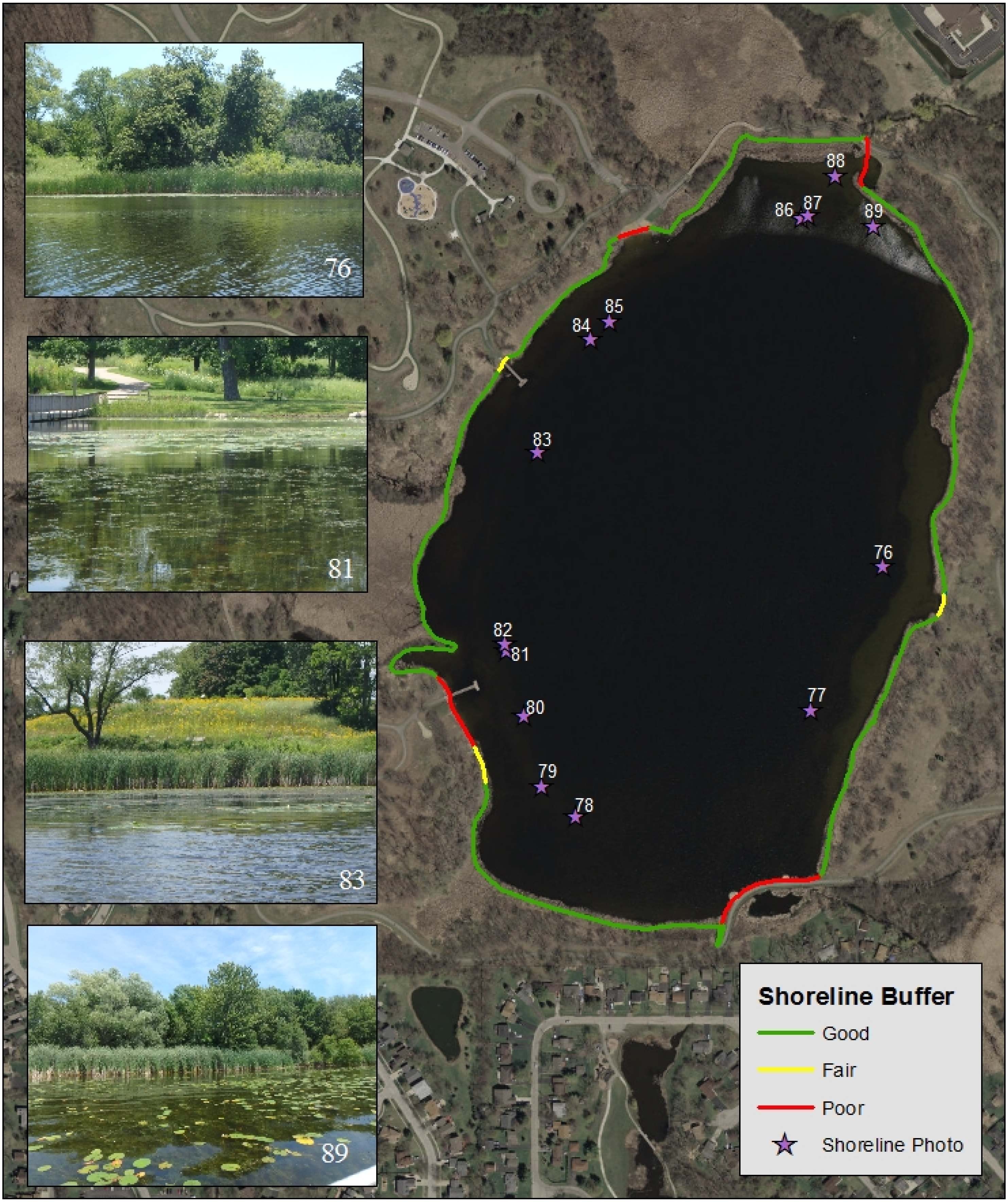


LakeCounty
Health Department and Community Health Center

0 150 300 450 600 Feet

Ecological Services
Product Number HST17
Revised 10/2017

Hastings Lake Shoreline Buffer, 2017



LakeCounty
Health Department and Community Health Center

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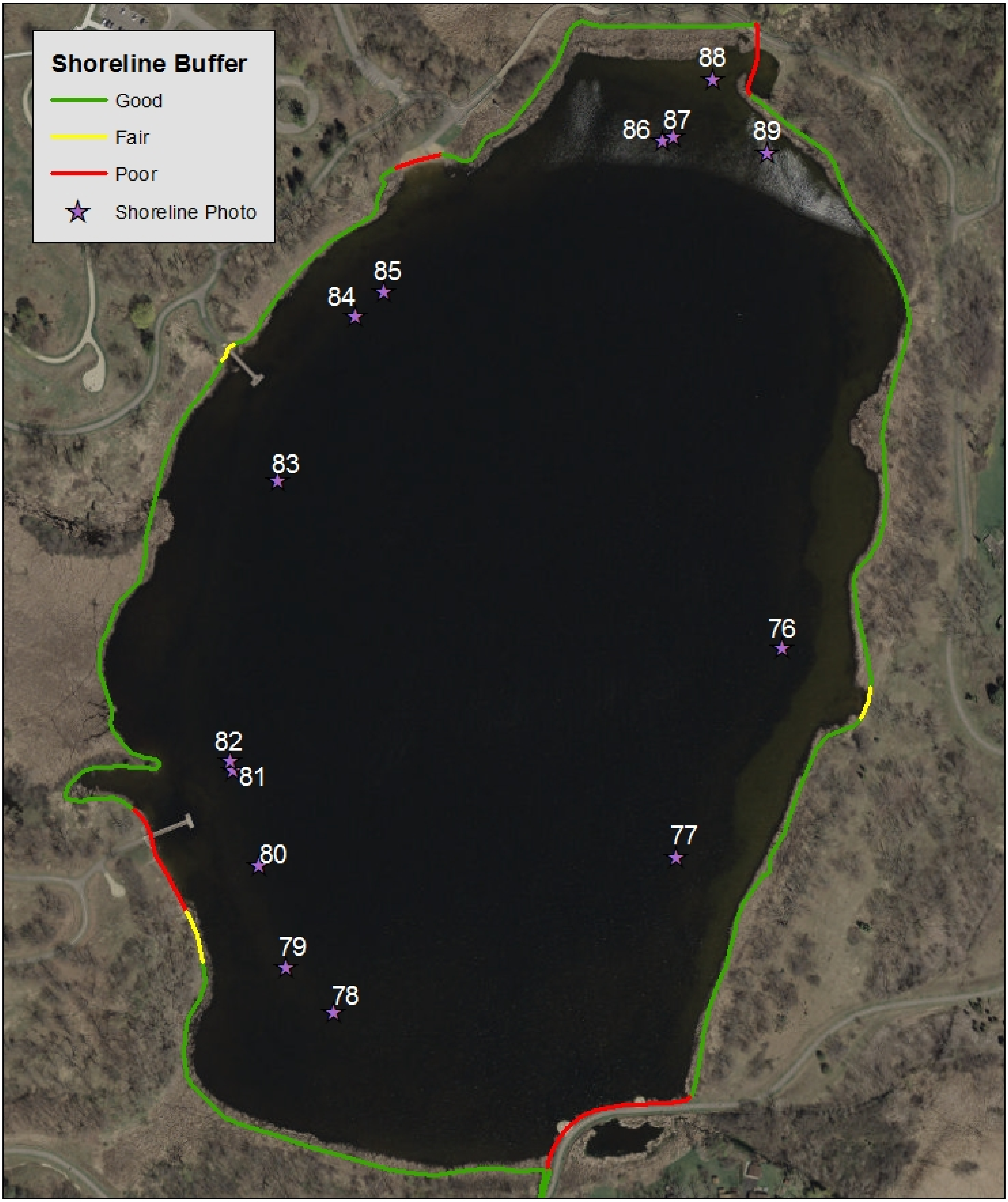
Ecological Services
Product Number HST17
Revised 10/2017

Hastings Lake Shoreline Buffer Condition, 2017



LakeCounty Health Department and Community Health Center

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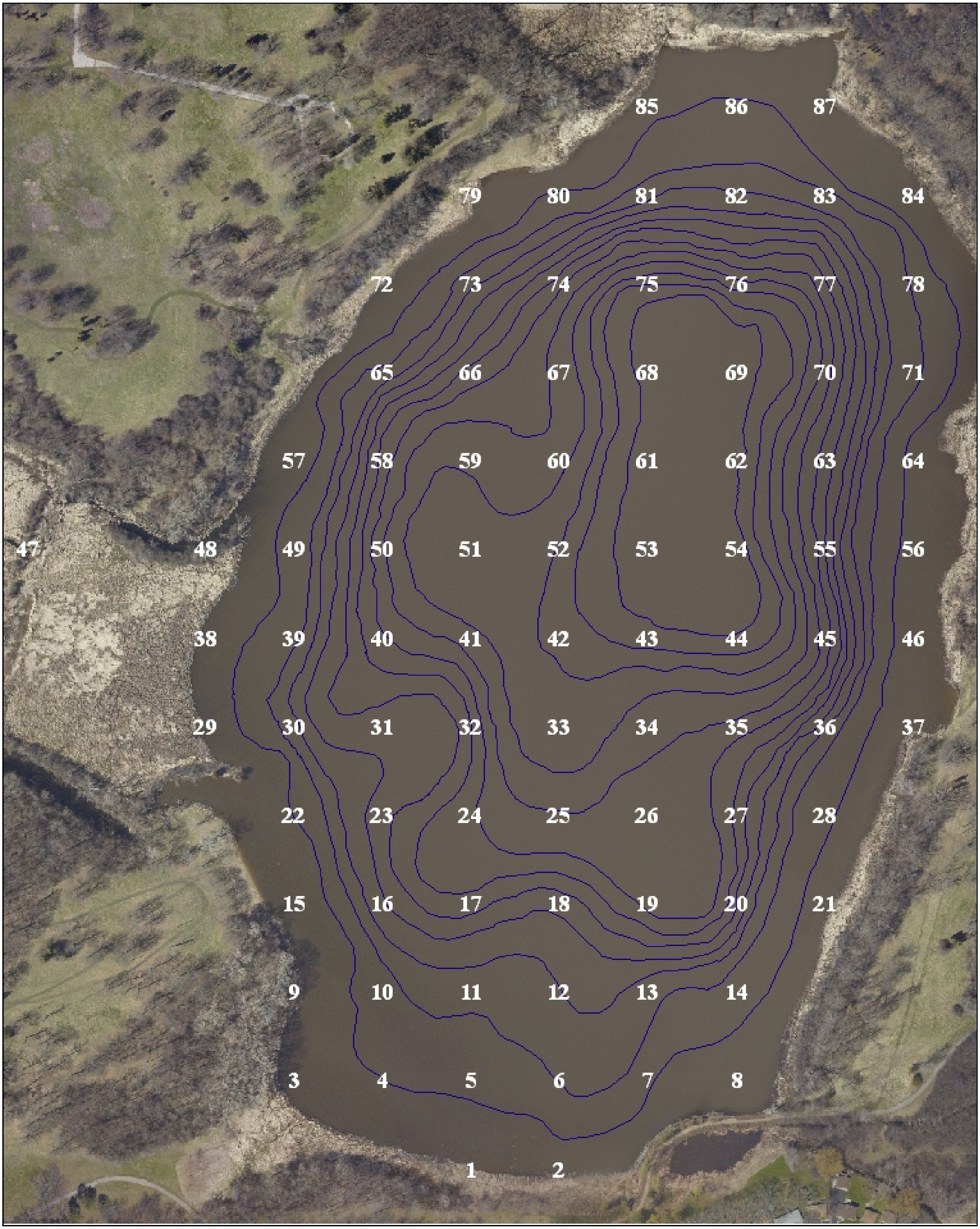
Ecological Services
Product Number HST17
Revised 10/2017



LakeCounty Health Department and Community Health Center

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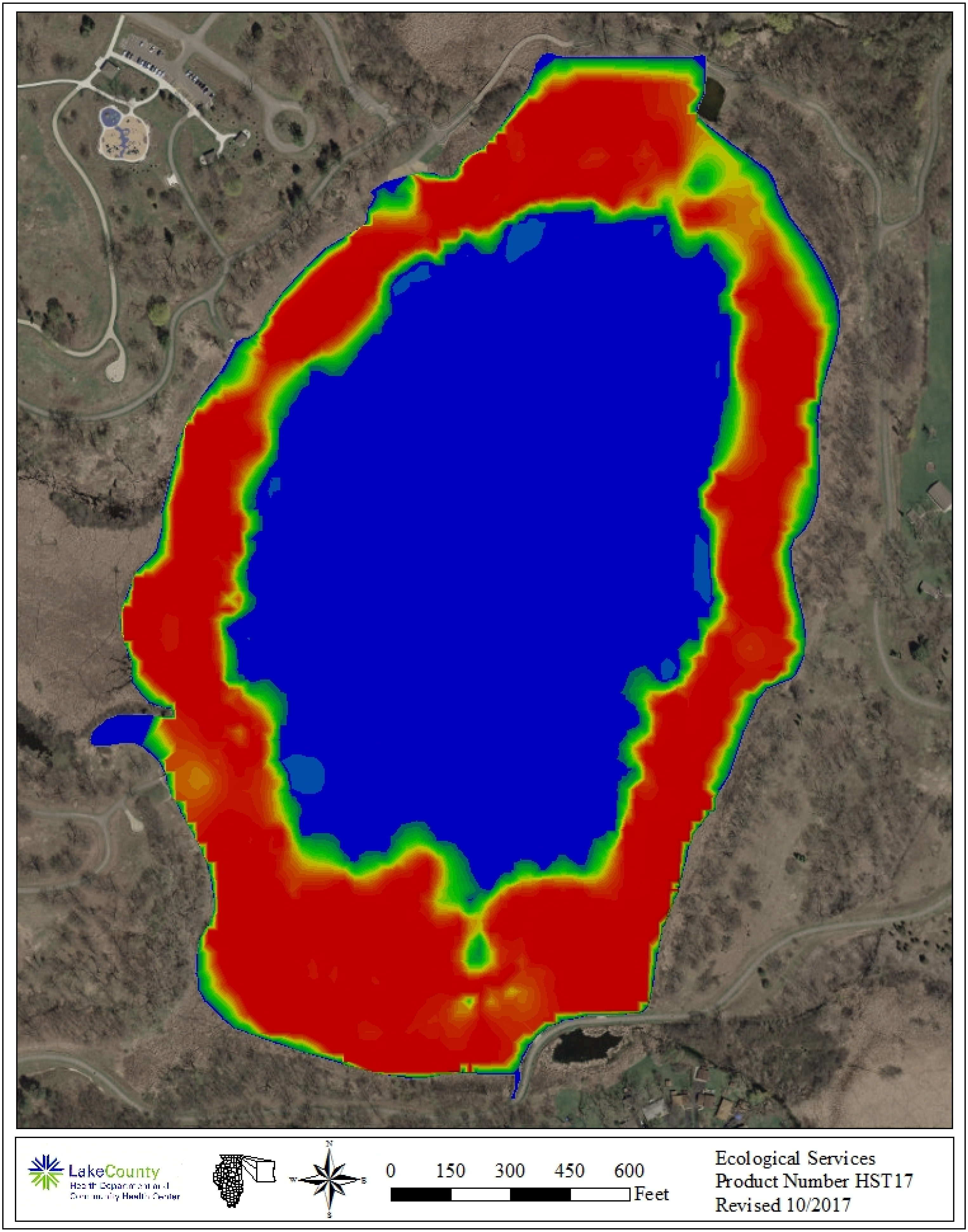
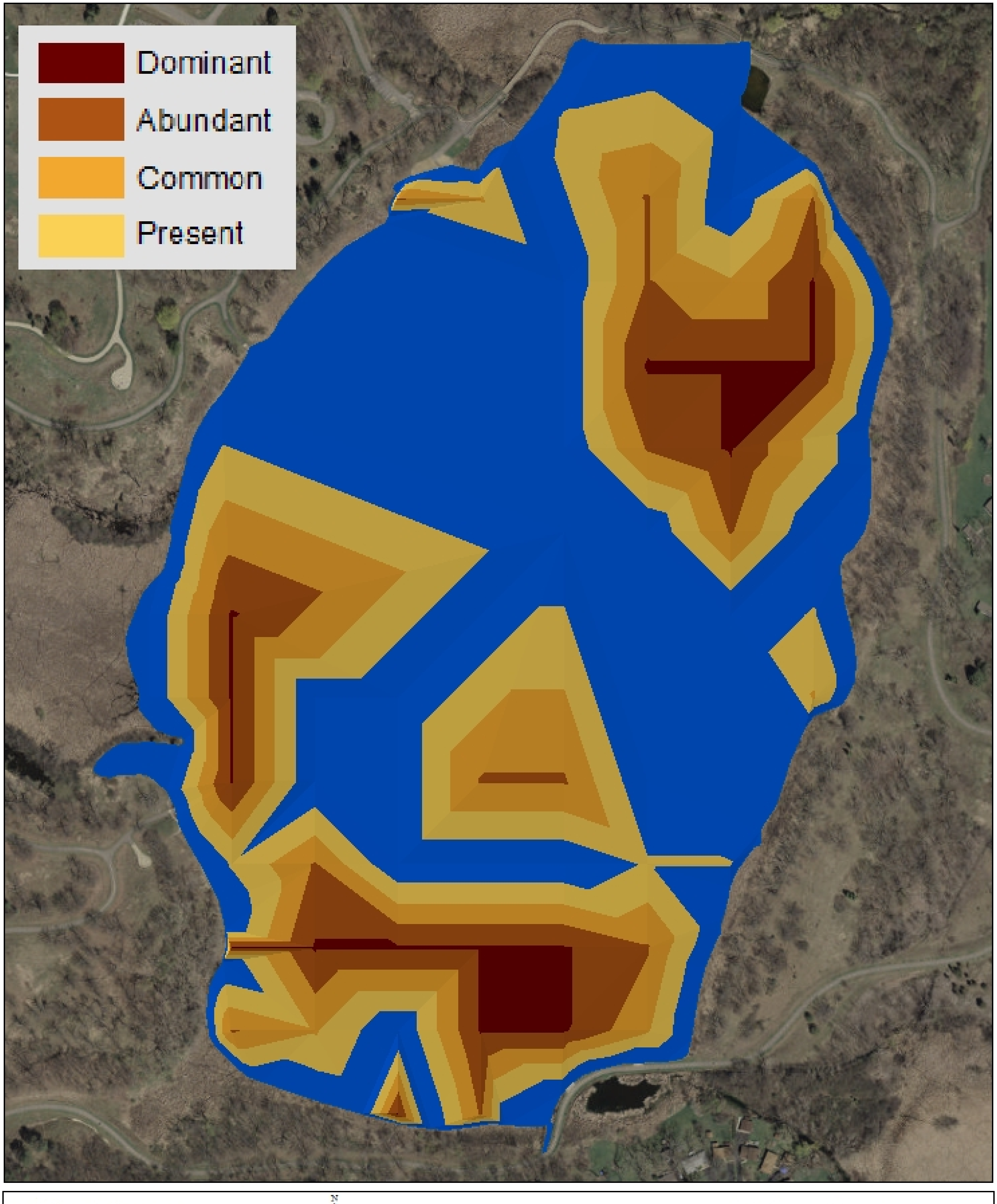
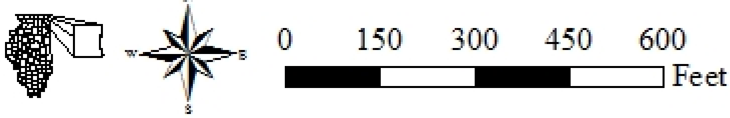
Enviornmental Services
Product Number HST.PG10
Revised 3/2010

Hastings Lake Plant Biovolume, July 2017



Hastings Lake Eurasian Watermilfoil Plant Density, July 2017



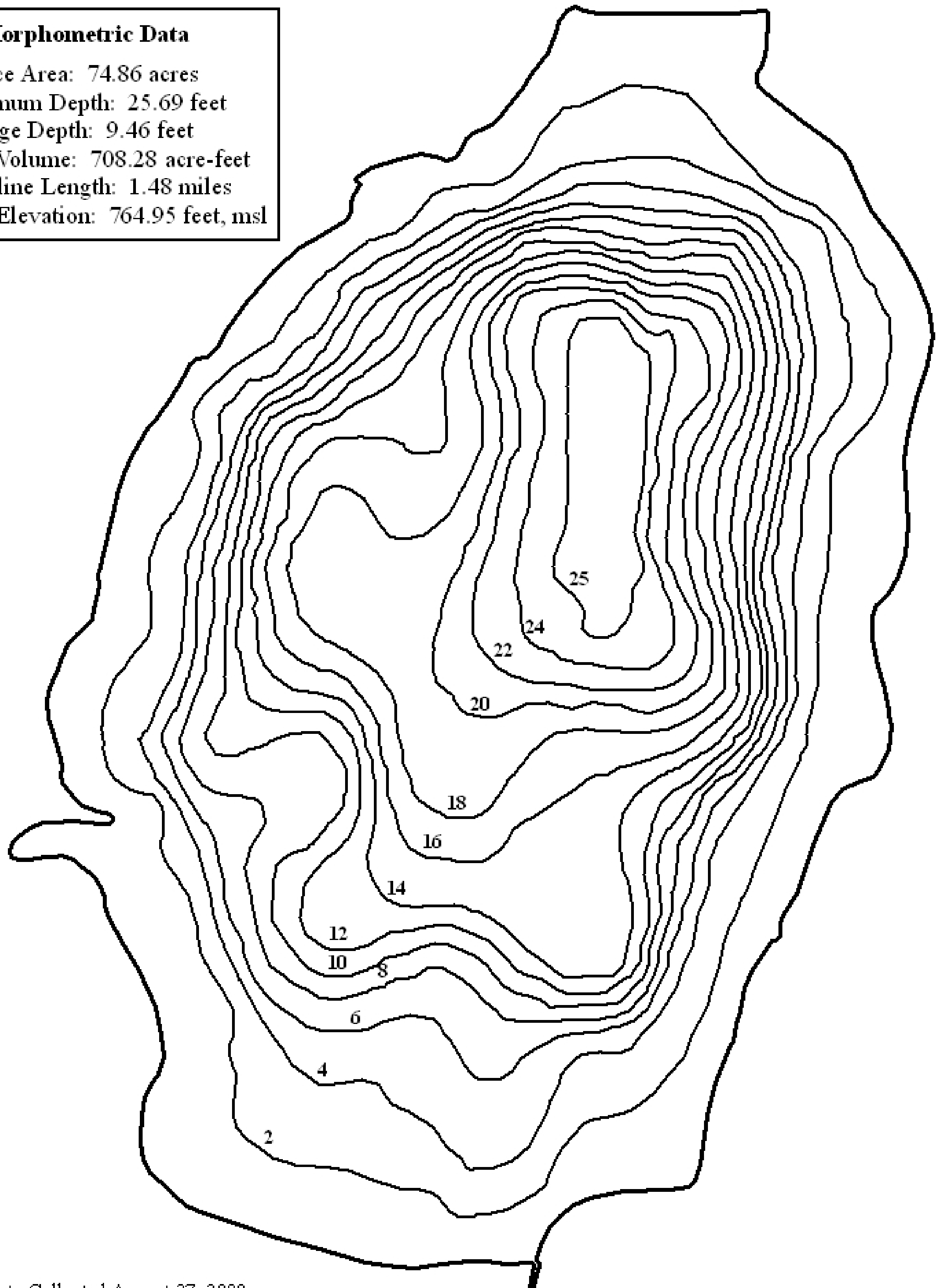


Ecological Services
Product Number HST17
Revised 10/2017

Bathymetric Map of Hastings Lake, Lake County, IL

Morphometric Data

Surface Area: 74.86 acres
Maximum Depth: 25.69 feet
Average Depth: 9.46 feet
Lake Volume: 708.28 acre-feet
Shoreline Length: 1.48 miles
Lake Elevation: 764.95 feet, msl



Survey Data Collected August 27, 2008

This map is intended for water quality reference only, not intended for navigational, swimming, or diving purposes.

LakeCounty Health Department and Community Health Center

0 150 300 450 600 Feet

Lakes Management Unit
Product Number HST.BM08
Revised 9/2008

Appendix B:
Tables

Water Quality Summary Table for Hastings Lake
2001, 2006, 2010, and 2017

2017	**Epilimnion**															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	3	180	1.17	<0.1	<0.05	0.056	0.0081	497	180	5.5	NA	106	5.25	0.8950	8.59	11.35
14-Jun	3	159	1.10	<0.1	<0.05	0.058	0.0065	504	186	3.3	550	114	6.00	0.9080	8.66	9.70
18-Jul	3	137	0.87	<0.1	<0.05	0.049	0.0059	408	NA	4.1	763	NA	4.30	0.7170	8.39	9.00
16-Aug	3	146	1.46	<0.1	<0.05	0.055	0.0150	430	155	8.4	415	63	3.10	0.7610	8.78	10.39
13-Sep	3	155	2.21	<0.1	<0.05	0.155	0.0051	450	164	13.6	521	139	2.25	0.8000	9.03	15.50
	Average	155	1.36	<0.1	<0.05	0.075	0.0081	458	171	7.0	562	106	4.18	0.8162	8.69	11.19

2010	**Epilimnion**															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
12-May	3	184	1.07	<0.1	<0.05	0.047	0.006	511	169	4.7	542	126	7.21	0.9220	8.59	8.79
9-Jun	3	164	1.10	<0.1	<0.05	0.058	<0.005	487	154	4.6	511	121	1.46	0.8750	8.64	7.90
14-Jul	3	159	1.12	<0.1	0.066	0.039	<0.005	448	165	5.6	506	111	3.63	0.7970	8.73	9.28
11-Aug	3	151	1.15	<0.1	<0.05	0.037	<0.005	451	156	5.3	477	112	2.85	0.8026	8.86	11.11
15-Sep	3	160	1.44	<0.1	<0.05	0.078	<0.005	474	155	5.7	496	122	2.46	0.8490	8.56	10.05
	Average	164	1.18	<0.1[k]	<0.0532[k]	0.052	<0.005[k]	474	160	5.2	506	118	3.52	0.8491	8.68	9.43

2006	**Epilimnion**															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	3	173	1.91	0.103	<0.05	0.084	<0.005	585	205	4.4	638	161	6.23	1.0700	8.32	10.73
21-Jun	3	180	1.68	<0.1	<0.05	0.074	<0.005	590	202	7.3	653	166	4.75	1.0790	8.41	11.55
19-Jul	3	178	1.71	<0.1	<0.05	0.057	<0.005	585	207	5.8	669	178	5.25	1.0700	8.54	6.35
16-Aug	3	165	1.53	<0.1	<0.05	0.037	<0.005	615	216	4.6	646	164	5.57	1.1280	8.53	7.49
20-Sep	3	164	2.09	0.203	<0.05	0.090	<0.005	599	217	8.8	664	173	2.46	1.0960	7.86	4.34
	Average	172	1.78	0.121[k]	<0.05[k]	0.068	<0.005[k]	595	209	6.2	654	168	4.85	1.0886	8.33	8.09

2001	**Epilimnion**															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N[*]	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
16-May	3	169	0.58	<0.1	<0.05	0.063	<0.005	492	NA	6.3	528	149	4.62	0.8185	8.44	9.21
20-Jun	3	160	1.24	<0.1	<0.05	0.118	<0.005	500	NA	12.0	525	150	2.72	0.7973	8.40	10.20
25-Jul	3	138	1.12	<0.1	<0.05	0.045	<0.005	498	NA	6.5	517	140	2.99	0.7929	8.55	7.65
22-Aug	3	134	0.97	<0.1	<0.05	0.041	<0.005	496	NA	6.0	500	156	3.35	0.7503	8.45	7.32
19-Sep	3	138	1.32	<0.1	<0.05	0.065	<0.005	457	NA	7.3	488	148	2.76	0.7725	8.24	6.72
	Average	148	1.05	<0.1[k]	<0.05[k]	0.066	<0.005[k]	489	114	7.6	512	149	3.29	0.7863	8.42	8.22

Water Quality Summary Table for Hastings Lake
2001, 2006, 2010, and 2017

2017	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	16	181	1.150	<0.1	<0.05	0.075	<0.005	512	179	5.0	527	116	NA	0.9230	8.09	3.85
14-Jun	23	173	0.927	<0.1	<0.05	0.064	<0.005	529	180	5.8	578	115	NA	0.9570	8.03	0.45
18-Jul	24	203	2.300	NA	<0.05	0.342	0.260	524	187	3.1	594	134	NA	0.9470	7.32	0.06
16-Aug	23	209	3.160	2.29	<0.05	0.463	0.430	535	185	6.6	572	107	NA	0.9690	7.02	0.00
13-Sep	23	203	3.680	2.51	<0.05	0.506	0.410	550	177	4.4	530	88	NA	1.0000	6.93	0.06
	Average	194	2.243	1.23[k]	<0.05	0.290	0.222[k]	530	182	5.0	560	112	NA	0.9592	7.48	0.88

2010	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
12-May	22	188	1.02	<0.1	<0.05	0.047	<0.005	510	169	8.3	544	123	NA	0.9200	8.55	8.36
9-Jun	21	183	1.01	0.123	<0.05	0.059	0.020	506	156	4.2	537	121	NA	0.9125	7.55	0.27
14-Jul	19	197	1.88	0.732	0.693	0.243	0.176	475	159	5.6	536	115	NA	0.8500	7.33	0.22
11-Aug	19	210	2.95	1.940	<0.05	0.337	0.287	516	160	4.6	547	134	NA	0.9319	7.11	0.19
15-Sep	19	162	1.75	<0.1	<0.05	0.084	<0.005	479	155	5.4	497	119	NA	0.8575	8.01	1.16
	Average	203	3.68	<0.599[k]	<0.268[k]	0.358	0.280[k]	604	207	4.8	658	166	NA	0.8944	7.71	2.04

2006	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	23	176	2.33	0.605	<0.05	0.143	0.064	585	203	3.0	616	143	NA	1.0700	7.86	1.16
21-Jun	22	191	2.47	1.100	<0.05	0.212	0.145	597	201	2.3	660	174	NA	1.0930	7.54	0.09
19-Jul	21	212	3.58	2.210	<0.05	0.367	0.294	597	203	3.4	679	182	NA	1.0930	7.83	0.19
16-Aug	22	271	7.88	6.890	<0.05	0.974	0.895	650	210	4.1	693	171	NA	1.1990	6.91	0.34
20-Sep	21	165	2.16	0.259	<0.05	0.093	<0.005	591	216	11.0	642	161	NA	1.0810	7.75	3.01
	Average	203	3.68	2.213	<0.05[k]	0.358	0.280[k]	604	207	4.8	658	166	NA	1.1072	7.58	0.96

2001	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
16-May	25	180	0.60	0.433	<0.05	0.117	0.049	483	NA	6.6	530	141	NA	0.8580	6.82	0.02
20-Jun	23	173	2.29	0.910	<0.05	0.223	0.147	507	NA	6.2	527	144	NA	0.8336	6.86	0.05
25-Jul	23	220	4.62	2.920	<0.05	0.467	0.380	544	NA	6.0	546	158	NA	0.8907	6.55	0.04
22-Aug	22	251	6.73	5.390	<0.05	1.240	1.110	564	NA	3.8	559	166	NA	0.9039	6.43	0.00
19-Sep	23	205	5.26	4.320	<0.05	1.270	0.398	510	NA	5.8	532	148	NA	0.9643	6.36	0.00
	Average	206	3.90	2.795	<0.05[k]	0.663	0.417	522	NA	5.7	539	151	NA	0.8901	6.60	0.02

Water Quality Summary Table for Hastings Lake
2001, 2006, 2010, and 2017

Glossary
ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH_3-N = Ammonia nitrogen, mg/L
NO_2+NO_3-N = Nitrate + Nitrite nitrogen, mg/L
NO_3-N = Nitrate nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
Cl^- = Chloride, 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
DO = Dissolved oxygen, mg/L

k = Denotes that the actual value is known to be less than the value presented.
NA= Not applicable
* = Prior to 2006 only Nitrate - nitrogen was analyzed

Hastings Lake 2017 Multiparameter Data

Date	Depth	Depth Text	Temp	spCond	DO	DO%	pH	BGA
MMDDYY	feet	feet	°C	mS/cm	mg/L	Sat	Units	RFU
5/17/2017	0.708661	0.5	17.07	0.895	11.01	114.4	8.63	3.6
5/17/2017	1.220472	1	17.07	0.895	11.29	117.2	8.61	2.2
5/17/2017	1.988189	2	17.08	0.895	11.33	117.7	8.61	2.3
5/17/2017	3.070866	3	17.07	0.895	11.35	117.9	8.59	4.6
5/17/2017	4.058399	4	17.07	0.896	11.37	118.2	8.57	5.1
5/17/2017	6.069554	6	16.99	0.896	11.41	118.3	8.57	2.4
5/17/2017	8.28084	8	16.96	0.896	11.54	119.6	8.57	3.3
5/17/2017	10.13123	10	16.97	0.897	11.57	120	8.56	3.8
5/17/2017	12.07677	12	11.24	0.919	7.73	70.7	8.39	1.5
5/17/2017	13.95997	14	9.88	0.923	4.89	43.3	8.19	1.5
5/17/2017	14.22572	14	9.89	0.923	4.83	42.8	8.18	1.5
5/17/2017	15.85958	16	9.67	0.924	3.89	34.3	8.09	1.1
5/17/2017	16.20079	16	9.69	0.923	3.85	34	8.09	1.3
5/17/2017	18.13976	18	9.5	0.924	3.35	29.4	8.04	2
5/17/2017	18.83202	19	9.2	0.87	1.73	15.1	7.92	0.4

Date	Depth	Depth Text	Temp	spCond	DO	DO%	pH	BGA
MMDDYY	feet	feet	°C	mS/cm	mg/L	Sat	Units	RFU
6/14/2017	0.41	0.5	22.59	0.910	9.20	106.7	8.53	2712
6/14/2017	1.03	1	22.60	0.910	9.71	112.6	8.63	1687
6/14/2017	2.02	2	22.53	0.909	9.72	112.6	8.65	972
6/14/2017	3.06	3	22.48	0.908	9.70	112.3	8.66	1705
6/14/2017	4.04	4	22.41	0.910	9.69	112.0	8.66	4458
6/14/2017	5.08	5	22.33	0.910	9.68	111.7	8.65	-986
6/14/2017	6.09	6	22.31	0.910	9.63	111.0	8.66	3580
6/14/2017	8.08	8	21.79	0.913	8.58	97.9	8.63	5046
6/14/2017	10.06	10	18.99	0.921	7.65	82.7	8.58	1980
6/14/2017	10.08	10	19.17	0.918	7.22	78.3	8.55	67
6/14/2017	12.12	12	15.88	0.931	5.33	54.0	8.47	2826
6/14/2017	14.09	14	13.76	0.936	2.59	25.0	8.36	3316
6/14/2017	16.07	16	12.34	0.945	1.18	11.1	8.26	5322
6/14/2017	18.08	18	10.64	0.953	0.81	7.3	8.19	3294
6/14/2017	20.02	20	10.12	0.953	0.61	5.5	8.12	4030
6/14/2017	22.09	22	9.85	0.955	0.50	4.4	8.07	3003
6/14/2017	24.01	24	9.60	0.959	0.40	3.6	7.99	3250
6/14/2017	25.76	26	9.48	0.960	0.36	3.1	7.93	7490

Hastings Lake 2017 Multiparameter Data

Date	Depth	Depth Text	Temp	spCond	DO	DO%	pH	BGA
MMDDYY	feet	feet	°C	mS/cm	mg/L	Sat	Units	RFU
7/18/2017	0.50	0.5	20.9	0.718	9.01	101.0	8.37	
7/18/2017	1.32	1	20.9	0.718	9.00	101.0	8.35	3.3
7/18/2017	2.20	2	20.87	0.717	9.03	101.2	8.39	3
7/18/2017	2.94	3	20.83	0.717	9.00	100.8	8.39	1.8
7/18/2017	4.06	4	20.77	0.718	9.00	100.7	8.39	5
7/18/2017	5.16	5	20.73	0.720	9.06	101.3	8.41	2.9
7/18/2017	6.05	6	20.48	0.727	8.92	99.2	8.22	4.2
7/18/2017	7.99	8	20.13	0.729	4.07	44.9	7.77	4.2
7/18/2017	10.00	10	19.61	0.725	3.85	42.0	7.64	
7/18/2017	12.00	12	19.06	0.768	1.76	18.5	7.59	
7/18/2017	14.00	14	18.55	0.828	0.76	7.4	7.6	
7/18/2017	16.12	16	16.73	0.900	0.27	2.8	7.6	8.7
7/18/2017	17.95	18	15.03	0.921	0.13	1.3	7.49	6.4
7/18/2017	19.81	20	14.36	0.925	0.11	1.1	7.46	3.4
7/18/2017	22.13	22	13.01	0.940	0.07	0.7	7.38	2.5
7/18/2017	23.88	24	12.13	0.947	0.06	0.5	7.32	3.4
7/18/2017	26.13	26	11.51	0.955	0.00	0.0	7.29	4.3

Date	Depth	Depth Text	Temp	spCond	DO	DO%	pH	BGA
MMDDYY	feet	feet	°C	mS/cm	mg/L	Sat	Units	RFU
8/16/2017	0.52	0.5	20.44	0.760	10.45	116.2	8.75	7028
8/16/2017	1.23	1	20.45	0.760	10.51	116.8	8.77	9327
8/16/2017	2.12	2	20.46	0.760	10.49	116.6	8.78	6777
8/16/2017	3.05	3	20.41	0.761	10.39	115.5	8.78	7243
8/16/2017	4.15	4	20.38	0.761	10.16	112.8	8.75	6954
8/16/2017	6.27	6	19.82	0.770	2.77	30.4	7.89	10697
8/16/2017	8.17	8	19.43	0.773	2.38	26.0	7.81	6897
8/16/2017	10.08	10	19.13	0.776	0.94	10.2	7.67	5374
8/16/2017	12.13	12	18.54	0.784	0.19	2.0	7.57	4862
8/16/2017	14.13	14	17.29	0.840	0.13	1.3	7.48	7771
8/16/2017	16.09	16	15.92	0.909	0.09	0.9	7.4	2763
8/16/2017	18.09	18	14.4	0.946	0.06	0.6	7.23	5091
8/16/2017	20.04	20	13.51	0.956	0.03	0.3	7.12	2721
8/16/2017	22.10	22	12.78	0.965	0	0.0	7.05	3432
8/16/2017	24.14	24	12.24	0.974	-0.01	-0.1	6.99	5641
8/16/2017	25.98	26	11.76	0.986	-0.02	-0.2	6.96	11348

Hastings Lake 2017 Multiparameter Data

Date	Depth	Depth Text	Temp	spCond	DO	DO%	pH	BGA
MMDDYY	feet	feet	°C	mS/cm	mg/L	Sat	Units	RFU
9/13/2017	0.45	0.5	16.15	0.800	15.44	157.3	8.98	5499
9/13/2017	1.05	1	16.15	0.800	15.7	159.9	9.00	3001
9/13/2017	2.05	2	16.15	0.801	15.66	159.5	9.01	3690
9/13/2017	3.03	3	16.13	0.800	15.5	157.9	9.03	4354
9/13/2017	4.07	4	16.09	0.801	15.27	155.3	9.02	4064
9/13/2017	6.05	6	15.86	0.808	11.01	111.5	8.66	3094
9/13/2017	8.07	8	15.63	0.817	5.05	50.9	8.14	1762
9/13/2017	10.03	10	15.57	0.818	4.12	41.4	8.03	2132
9/13/2017	12.06	12	15.45	0.821	2.82	28.3	7.89	1084
9/13/2017	14.02	14	15.38	0.822	1.39	13.9	7.77	-3007
9/13/2017	16.06	16	15.28	0.826	0.54	5.4	7.68	1555
9/13/2017	18.05	18	15.07	0.836	0.17	1.7	7.60	1740
9/13/2017	20.12	20	14.56	0.869	0.12	1.2	7.43	365
9/13/2017	22.07	22	13.18	0.989	0.06	0.6	7.01	888
9/13/2017	24.02	24	12.32	1.011	0.05	0.5	6.85	3651

Hastings Lake 2017 Land Use

Land Use	Acreage	% of Total
Agricultural	107.72	5.1%
Disturbed Land	3.13	0.1%
Forest and Grassland	288.74	13.6%
Government and Institutional	48.36	2.3%
Multi Family	28.45	1.3%
Office	1.58	0.1%
Public and Private Open Space	266.96	12.6%
Retail/Commercial	22.89	1.1%
Single Family	666.61	31.3%
Transportation	202.31	9.5%
Utility and Waste Facilities	1.41	0.1%
Water	323.02	15.2%
Wetlands	165.78	7.8%
Total Acres	**2126.97**	100.0%

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Agricultural	107.72	0.05	14.8	0.7%
Disturbed Land	3.13	0.05	0.4	0.0%
Forest and Grassland	288.74	0.05	39.7	1.8%
Government and Institutional	48.36	0.50	66.5	3.0%
Multi Family	28.45	0.30	23.5	1.0%
Office	1.58	0.85	3.7	0.2%
Public and Private Open Space	266.96	0.15	110.1	4.9%
Retail/Commercial	22.89	0.85	53.5	2.4%
Single Family	666.61	0.30	550.0	24.5%
Transportation	202.31	0.85	472.9	21.0%
Utility and Waste Facilities	1.41	0.30	1.2	0.1%
Water	323.02	1.00	888.3	39.5%
Wetlands	165.78	0.05	22.8	1.0%
TOTAL	**2126.97**		**2247.4**	100.0%

Lake volume	**708.91**	**acre-feet**
Retention Time (years)= lake volume/runoff	**0.32**	**years**
	115.14	**days**

Hastings Lake Shoreline Erosion Condition, 2017

Reach	No Erosion		Slight Erosion		Moderate Erosion		Severe Erosion		Total	Lateral Recession Rate
	ft.	%	ft.	%	ft.	%	ft.	%	ft.	ft/yr
HST01	580.97	100%	0	0%	0	0%	0	0%	581.0	0.010
HST02	0	0%	105.48	100%	0	0%	0	0%	105.5	0.025
HST03	869.04	100%	0	0%	0	0%	0	0%	869.0	0.010
HST04	781.6	100%	0	0%	0	0%	0	0%	781.6	0.010
HST05	1035.1	100%	0	0%	0	0%	0	0%	1035.1	0.010
HST06	746.13	85%	127.58	15%	0	0%	0	0%	873.7	0.012
HST07	365.11	90%	38.38	10%	0	0%	0	0%	403.5	0.011
HST08	866.15	100%	0	0%	0	0%	0	0%	866.2	0.010
HST10	688.15	100%	0	0%	0	0%	0	0%	688.2	0.010
HST11	260.13	100%	0	0%	0	0%	0	0%	260.1	0.010
HST12	1077.2	82%	241.07	18%	0	0%	0	0%	1318.3	0.013
Total	7269.6	93%	512.51	7%	0	0%	0	0%	7782.1	0.011

Hastings Lake Shoreline Buffer Condition, 2017

Reach	Good		Fair		Poor		Total
	ft.	%	ft.	%	ft.	%	ft.
HST01	569.4	98%	11.6	2%	0	0%	581.0
HST02	0.0	0%	0.0	0%	105.5	100%	105.5
HST03	869.0	100%	0.0	0%	0.0	0%	869.0
HST04	618.8	79%	162.8	21%	0.0	0%	781.6
HST05	962.8	93%	72.4	7%	0.0	0%	1035.1
HST06	873.7	100%	0.0	0%	0.0	0%	873.7
HST07	403.5	100%	0.0	0%	0.0	0%	403.5
HST08	866.2	100%	0.0	0%	0.0	0%	866.2
HST10	397.1	58%	121.5	18%	170.1	25%	688.6
HST11	170.0	65%	0.0	0%	90.2	35%	260.1
HST12	1283.8	97%	34.5	3%	0.0	0%	1318.3
Total	7014.1	90%	402.7	5%	365.7	5%	7782.6

Hastings Lake

2017 Aquatic Macrophyte Survey

Aquatic plants found at 43 sampling sites in Hastings Lake during July 2017
The maximum depth that plants were found was at 9.4 feet.

Plant Density	Chara	Coontail	Duckweed	Elodea	Eurasian Watermilfoil	Spatterdock	Watermeal	White Water Lily
Absent	86.0	74.0	78.0	85.0	47.0	85.0	85.0	61.0
Present	0.0	2.0	1.0	1.0	5.0	0.0	0.0	3.0
Common	0.0	2.0	4.0	0.0	5.0	1.0	0.0	7.0
Abundant	0.0	4.0	4.0	1.0	13.0	1.0	2.0	12.0
Dominant	1.0	5.0	0.0	0.0	17.0	0.0	0.0	4.0
% Plant Occurrence	1%	15%	10%	2%	46%	2%	2%	30%
Total Sites	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0

Distribution of Rake Density across all sampling sites.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	44	50.6%
>0-10%	3	3.4%
10-40%	2	2.3%
40-60%	4	4.6%
60-90%	20	23.0%
>90%	14	16.1%
Total Sites with Plants	43	49.4%
Total # Sites	87	100.0%

Morphometric Features of Hasting Lake ~
Data From the August 2008 Bathymetric Survey, LCHD Lakes Management Unit

Contour (Feet)	Area Enclosed (Acres)	Percent of total acres	Volume (Acre-feet)	Depth Zone (Feet)	Area (Acres)	Percent (Depth zone to total acres)	Percent (Acre-feet to Total Volume)
0	74.06	100.0%	69.15	0 - 1	9.71	13.1%	9.8%
1	64.35	86.9%	60.27	1 - 2	8.09	10.9%	8.5%
2	56.27	76.0%	53.41	2 - 3	5.66	7.6%	7.5%
3	50.61	68.3%	48.51	3 - 4	4.17	5.6%	6.8%
4	46.44	62.7%	44.89	4 - 5	3.07	4.1%	6.3%
5	43.36	58.5%	41.95	5 - 6	2.82	3.8%	5.9%
6	40.55	54.7%	39.40	6 - 7	2.28	3.1%	5.6%
7	38.27	51.7%	37.25	7 - 8	2.03	2.7%	5.3%
8	36.24	48.9%	35.07	8 - 9	2.32	3.1%	4.9%
9	33.92	45.8%	32.95	9 - 10	1.93	2.6%	4.6%
10	31.99	43.2%	31.05	10 - 11	1.87	2.5%	4.4%
11	30.12	40.7%	29.25	11 - 12	1.72	2.3%	4.1%
12	28.40	38.3%	27.46	12 - 13	1.87	2.5%	3.9%
13	26.53	35.8%	25.55	13 - 14	1.95	2.6%	3.6%
14	24.58	33.2%	23.30	14 - 15	2.53	3.4%	3.3%
15	22.05	29.8%	20.48	15 - 16	3.10	4.2%	2.9%
16	18.96	25.6%	17.75	16 - 17	2.38	3.2%	2.5%
17	16.58	22.4%	15.46	17 - 18	2.20	3.0%	2.2%
18	14.38	19.4%	13.11	18 - 19	2.49	3.4%	1.8%
19	11.89	16.0%	10.55	19 - 20	2.61	3.5%	1.5%
20	9.27	12.5%	8.66	20 - 21	1.21	1.6%	1.2%
21	8.07	10.9%	7.53	21 - 22	1.07	1.4%	1.1%
22	7.00	9.5%	6.42	22 - 23	1.14	1.5%	0.9%
23	5.87	7.9%	5.11	23 - 24	1.47	2.0%	0.7%
24	4.39	5.9%	3.17	24 - 25	2.30	3.1%	0.4%
25+	2.09	2.8%	1.18	25 +	2.09	2.8%	0.2%
			708.91		74.06	100%	100%

Maximum Depth of Lake: 25.69 Feet
Average Depth of Lake: 9.57 Feet
Volume of Lake: 708.91 Acre-Feet

Area of Lake: 74.06 Acres
Shoreline Length: 1.48 Miles
Water elevation at 764.95 feet above mean sea level

LakeCounty
Health Department and
Community Health Center

Lake County average Floristic Quality Index (FQI) ranking 2000-2017.

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	Round Lake Marsh North	29.1	29.9
6	West Loon Lake	27.1	29.5
7	Sullivan Lake	26.9	28.5
8	Bangs Lake	26.2	27.8
9	Little Silver Lake	25.2	26.7
10	Third Lake	25.1	22.5
11	Fourth Lake	24.7	27.1
12	Indpendence Grove	24.4	26.8
13	Sun Lake	24.3	26.1
14	Redwing Slough	24.0	25.8
15	Schreiber Lake	23.9	24.8
16	Lakewood Marsh	23.8	24.7
17	Sterling Lake	23.6	25.4
18	Deer Lake	23.5	24.4
19	Round Lake	23.5	25.9
20	Pistakee Lake	23.5	25.2
21	Lake Marie	23.5	25.2
22	Timber Lake (North)	23.2	24.9
23	Lake of the Hollow	23.0	24.8
24	Nippersink Lake (Fox Chain)	22.4	23.2
25	Countryside Glen Lake	21.9	22.8
26	Grass Lake	21.5	22.2
27	Davis Lake	21.4	21.4
28	Lake Catherine	20.8	21.8
29	Cross Lake	20.7	18.7
30	ADID 203	20.5	20.5
31	Broberg Marsh	20.5	21.4
32	McGreal Lake	20.2	22.1
33	Fox Lake	20.2	21.2
34	Honey Lake	20.0	20.0
35	Lake Barrington	19.9	21.8
36	Lake Kathryn	19.6	20.7
37	Druce Lake	19.1	21.8
38	Turner Lake	18.6	21.2
39	Salem Lake	18.5	20.2
40	Duck Lake	18.3	19.2
41	Wooster Lake	18.0	20.1
42	Lake Helen	18.0	18.0
43	Old Oak Lake	18.0	19.1
44	Lake Minear	18.0	20.1
45	Lake Zurich	17.7	18.9
46	Redhead Lake	17.7	18.7
47	Long Lake	17.7	15.8
48	Hendrick Lake	17.7	17.7
49	Rollins Savannah 2	17.7	17.7
50	Grandwood Park Lake	17.2	19.0
51	Seven Acre Lake	17.0	15.5
52	Lake Miltmore	16.8	18.7
53	Petite Lake	16.8	18.7
54	Channel Lake	16.8	18.7
55	Highland Lake	16.7	18.9
56	Almond Marsh	16.3	17.3
57	Owens Lake	16.3	17.3
58	Windward Lake	16.3	17.6

Lake County average Floristic Quality Index (FQI) ranking 2000-2017.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
59	Butler Lake	16.1	18.1
60	Grays Lake	16.1	16.1
61	Dunns Lake	15.9	17.0
62	Dog Bone Lake	15.7	15.7
63	Osprey Lake	15.5	17.3
64	Heron Pond	15.1	15.1
65	Ames Pit	15.1	17.6
66	North Churchill Lake	15.0	15.0
67	Forest Lake	14.8	15.9
68	Dog Training Pond	14.7	15.9
69	Summerhill Estates Lake	14.5	15.5
70	Grand Ave Marsh	14.3	16.3
71	Nippersink Lake	14.3	16.3
72	Taylor Lake	14.3	16.3
73	Manning's Slough	14.1	16.3
74	Tower Lake	14.0	14.0
75	Dugdale Lake	14.0	15.1
76	Eagle Lake (S1)	14.0	15.1
77	Spring Lake	14.0	15.2
78	Hastings Lake	14.0	15.1
79	Lake Matthews	13.9	15.5
80	Longview Meadow Lake	13.9	13.9
81	Fischer Lake	13.6	14.7
82	Bishop Lake	13.4	15.0
83	Mary Lee Lake	13.1	15.1
84	Old School Lake	13.1	15.1
85	Waterford Lake	13.1	14.3
86	Crooked Lake	13.0	14.3
87	Lake Tranquility (S1)	12.6	12.6
88	Potomac Lake	12.5	12.5
89	Buffalo Creek Reservoir 1	12.5	11.4
90	Buffalo Creek Reservoir 2	12.5	11.4
91	Rollins Savannah 1	12.5	12.5
92	Stone Quarry Lake	12.5	12.5
93	Kemper Lake 1	12.2	13.4
94	McDonald Lake 1	12.1	12.1
95	Pond-A-Rudy	12.1	12.1
96	Stockholm Lake	12.1	13.5
97	Lake Leo	12.1	14.3
98	Lambs Farm Lake	12.1	14.3
99	Bresen Lake	12.0	13.9
100	Grassy Lake	12.0	12.0
101	Flint Lake Oulet	11.8	13.0
102	Albert Lake	11.5	10.3
103	Rivershire Pond 2	11.5	13.3
104	Hook Lake	11.3	13.4
105	Briarcrest Pond	11.2	12.5
106	Lake Naomi	11.2	12.5
107	Pulaski Pond	11.2	12.5
108	Lake Napa Suwe	11.0	11.0
109	Redwing Marsh	11.0	11.0
110	West Meadow Lake	11.0	11.0
111	Nielsen Pond	10.7	12.0
112	Lake Holloway	10.6	10.6
113	Sylvan Lake	10.6	10.6
114	Echo Lake	10.4	10.4
115	Gages Lake	10.2	12.5
116	College Trail Lake	10.0	10.0

Lake County average Floristic Quality Index (FQI) ranking 2000-2017.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
117	Valley Lake	9.9	9.9
118	Werhane Lake	9.8	12.0
119	Fish Lake	9.6	10.6
120	Lake Carina	9.5	12.5
121	Columbus Park Lake	9.2	9.2
122	Lake Lakeland Estates	9.2	9.2
123	Lake Linden	9.2	9.2
124	Bluff Lake	9.1	11.0
125	Lake Fairfield	9.0	10.4
126	Des Plaines Lake	8.6	9.9
127	Antioch Lake	8.5	8.5
128	Loch Lomond	8.5	8.5
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	Lake Louise	8.4	8.4
138	Bittersweet Golf Course #13	8.1	8.1
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	Lochanora Lake	5.0	5.0
160	Diamond Lake	3.7	5.5
161	Lake Charles	3.7	5.5
162	Big Bear Lake	3.5	5.0
163	Sand Pond (IDNR)	3.5	5.0
164	Harvey Lake	3.3	5.0
165	Half Day Pit	2.9	5.0
166	White Lake	0.0	0.0
167	McDonald Lake 2	0.0	0.0
168	Hidden Lake	0.0	0.0
169	St. Mary's Lake	0.0	0.0
170	Willow Lake	0.0	0.0
171	Woodland Lake	0.0	0.0
	Mean	**13.7**	**14.7**
	Median	**13.0**	**14.2**

Lake County average TSI phosphorus (TSIp) ranking 2000-2017

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RANK	LAKE NAME	TP AVE	TSIp
1	Sterling Lake	0.0110	38.73
2	Lake Carina	0.0110	38.73
3	Indpendence Grove	0.0130	40.38
4	Cedar Lake	0.0130	41.14
5	Druce Lake	0.0140	42.21
6	Windward Lake	0.0160	44.13
7	Lake Minear	0.0164	44.49
8	Sand Pond (IDNR)	0.0165	44.57
9	West Loon	0.0170	45.00
10	Pulaski Pond	0.0180	45.83
11	Ames Pit	0.0190	46.61
12	Banana Pond	0.0200	47.35
13	Gages Lake	0.0200	47.35
14	Lake Kathryn	0.0200	47.35
15	Highland Lake	0.0202	47.49
16	Lake Miltmore	0.0210	48.05
17	Lake Zurich	0.0210	48.05
18	Cross Lake	0.0216	48.46
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	Timber Lake (North)	0.0232	49.49
26	Bangs Lake	0.0260	51.13
27	Lake Leo	0.0260	51.13
28	Lake Barrington	0.0270	51.68
29	Cranberry Lake	0.0270	51.68
30	Dugdale Lake	0.0270	51.68
31	Peterson Pond	0.0270	51.68
32	Little Silver Lake	0.0280	52.20
33	Wooster Lake	0.0290	52.71
34	Lambs Farm Lake	0.0310	53.67
35	Old School Lake	0.0310	53.67
36	Grays Lake	0.0310	53.67
37	Harvey Lake	0.0320	54.13
38	Butler Lake	0.0324	54.31
39	Hendrick Lake	0.0340	55.00
40	Fourth Lake	0.0360	55.82
41	Sullivan Lake	0.0370	56.22
42	Sand Lake	0.0380	56.60
43	Third Lake	0.0384	56.77
44	Diamond Lake	0.0390	56.98
45	East Loon	0.0400	57.34
46	Schreiber Lake	0.0400	57.34
47	Hook Lake	0.0410	57.70
48	Lake Tranquility (S1)	0.0412	57.77
49	Lake Linden	0.0420	58.05
50	Nielsen Pond	0.0450	59.04
51	Seven Acre Lake	0.0460	59.36
52	Turner Lake	0.0460	59.36

Lake County average TSI phosphorus (TSIp) ranking 2000-2017

RANK	LAKE NAME	TP AVE	TSIp
53	Willow Lake	0.0460	59.36
54	Waterford Lake	0.0470	59.67
55	East Meadow Lake	0.0480	59.97
56	Lucky Lake	0.0480	59.97
57	Old Oak Lake	0.0490	60.27
58	College Trail Lake	0.0500	60.56
59	Summerhill Estates Lake	0.0514	60.96
60	West Meadow Lake	0.0530	61.40
61	Lucy Lake	0.0550	61.94
62	Lake Christa	0.0580	62.70
63	Owens Lake	0.0580	62.70
64	Briarcrest Pond	0.0580	62.70
65	Honey Lake	0.0586	62.85
66	Crooked Lake	0.0604	63.29
67	Redhead Lake	0.0608	63.38
68	St. Mary's Lake	0.0608	63.38
69	Duck Lake	0.0610	63.43
70	Lake Lakeland Estates	0.0620	63.66
71	Lake Naomi	0.0620	63.66
72	Lake Catherine	0.0620	63.66
73	Liberty Lake	0.0630	63.89
74	North Tower Lake	0.0630	63.89
75	Werhane Lake	0.0630	63.89
76	Countryside Glen Lake	0.0640	64.12
77	Davis Lake	0.0650	64.34
78	Leisure Lake	0.0650	64.34
79	Channel Lake	0.0680	65.00
80	Buffalo Creek Reservoir 1	0.0680	65.00
81	Mary Lee Lake	0.0680	65.00
82	Little Bear Lake	0.0680	65.00
83	Potomac Lake	0.0714	65.70
84	Timber Lake (South)	0.0720	65.82
85	Lake Helen	0.0720	65.82
86	Grandwood Park Lake	0.0720	65.82
87	ADID 203	0.0730	66.02
88	Fish Lake	0.0730	66.02
89	Hastings Lake	0.0746	66.33
90	Broberg Marsh	0.0780	66.97
91	Echo Lake	0.0790	67.16
92	Countryside Lake	0.0800	67.34
93	Lake Nippersink	0.0800	67.34
94	Woodland Lake	0.0800	67.34
95	Redwing Slough	0.0822	67.73
96	Tower Lake	0.0830	67.87
97	Lake Antioch	0.0850	68.21
98	Grand Ave Marsh	0.0870	68.55
99	North Churchill Lake	0.0870	68.55
100	White Lake	0.0874	68.61
101	Pistakee Lake	0.0880	68.71
102	Lake Fairview	0.0890	68.88
103	Rivershire Pond 2	0.0900	69.04
104	South Churchill Lake	0.0900	69.04

Lake County average TSI phosphorus (TSIp) ranking 2000-2017

RANK	LAKE NAME	TP AVE	TSIp
105	McGreal Lake	0.0910	69.20
106	Lake Charles	0.0930	69.51
107	Deer Lake	0.0940	69.66
108	Eagle Lake (S1)	0.0950	69.82
109	International Mine and Chemical Lake	0.0950	69.82
110	Valley Lake	0.0950	69.82
111	McDonald Lake 1	0.0952	69.85
112	Buffalo Creek Reservoir 2	0.0960	69.97
113	Big Bear Lake	0.0960	69.97
114	Fox Lake	0.1000	70.56
115	Nippersink Lake - LCFP	0.1000	70.56
116	Sylvan Lake	0.1000	70.56
117	Petite Lake	0.1020	70.84
118	Longview Meadow Lake	0.1020	70.84
119	Lake Marie	0.1030	70.98
120	McDonald Lake 2	0.1050	71.26
121	Dunn's Lake	0.1070	71.53
122	Lake Forest Pond	0.1070	71.53
123	Long Lake	0.1070	71.53
124	Grass Lake	0.1090	71.80
125	Des Plaines Lake	0.1090	71.80
126	Spring Lake	0.1100	71.93
127	Kemper 2	0.1100	71.93
128	Bittersweet Golf Course #13	0.1100	71.93
129	Osprey Lake	0.1110	72.06
130	Bluff Lake	0.1120	72.19
131	Middlefork Savannah Outlet 1	0.1120	72.19
132	Lochanora Lake	0.1120	72.19
133	Round Lake Marsh North	0.1130	72.32
134	Deer Lake Meadow Lake	0.1160	72.70
135	Lake Matthews	0.1180	72.94
136	Taylor Lake	0.1180	72.94
137	Island Lake	0.1210	73.31
138	Columbus Park Lake	0.1230	73.54
139	Lake Holloway	0.1320	74.56
140	Fischer Lake	0.1380	75.20
141	Slocum Lake	0.1500	76.40
142	Lakewood Marsh	0.1510	76.50
143	Pond-A-Rudy	0.1510	76.50
144	Forest Lake	0.1540	76.78
145	Bresen Lake	0.1580	77.15
146	Middlefork Savannah Outlet 2	0.1590	77.24
147	Grassy Lake	0.1610	77.42
148	Salem Lake	0.1650	77.78
149	Half Day Pit	0.1690	78.12
150	Lake Louise	0.1810	79.11
151	Lake Eleanor	0.1810	79.11
152	Lake Farmington	0.1850	79.43
153	ADID 127	0.1890	79.74
154	Lake Napa Suwe	0.1940	80.11
155	Loch Lomond	0.1960	80.26

Lake County average TSI phosphorus (TSIp) ranking 2000-2017

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RANK	LAKE NAME	TP AVE	TSIp
156	Patski Pond	0.1970	80.33
157	Dog Bone Lake	0.1990	80.48
158	Redwing Marsh	0.2070	81.05
159	Stockholm Lake	0.2082	81.13
160	Bishop Lake	0.2160	81.66
161	Ozaukee Lake	0.2200	81.93
162	Kemper 1	0.2220	82.06
163	Hidden Lake	0.2240	82.19
164	Oak Hills Lake	0.2790	85.35
165	Heron Pond	0.2990	86.35
166	Rollins Savannah 1	0.3070	86.73
167	Fairfield Marsh	0.3260	87.60
168	ADID 182	0.3280	87.69
169	Manning's Slough	0.3820	89.88
170	Slough Lake	0.3860	90.03
171	Rasmussen Lake	0.4860	93.36
172	Albert Lake, Site II, outflow	0.4950	93.62
173	Flint Lake Outlet	0.5000	93.76
174	Rollins Savannah 2	0.5870	96.08
175	Almond Marsh	1.9510	113.40
	Average	***0.1107***	***65.7***

Lake County Secchi Disk Clarity Ranking, 2000-2017.

RANK	LAKE NAME	SECCHI AVE	TSIsd
1	Lake Carina	16.96	36.31
2	Windward Lake	14.28	38.79
3	Sterling Lake	13.84	39.24
4	Cedar Lake	12.55	40.66
5	Druce Lake	12.25	41.00
6	Pulaski Pond	11.69	41.68
7	West Loon Lake	11.55	41.85
8	Lake Zurich	10.40	43.37
9	Indpendence Grove	10.31	43.49
10	Ames Pit	9.97	43.97
11	Third Lake	9.76	44.28
12	Davis Lake	9.65	44.44
13	Harvey Lake	9.47	44.72
14	Little Silver Lake	9.42	44.79
15	Old School Lake	9.40	44.82
16	Lake Kathryn	9.39	44.84
17	Dugdale Lake	9.22	45.10
18	Dog Training Pond	9.04	45.39
19	Banana Pond	8.85	45.69
20	Deep Lake	8.83	45.72
21	Stone Quarry Lake	8.81	45.76
22	Wooster Lake	8.74	45.87
23	Lake of the Hollow	8.74	45.87
24	Cross Lake	8.18	46.83
25	Bangs Lake	8.02	47.11
26	Briarcrest Pond	8.00	47.15
27	Sand Lake	7.48	48.12
28	Sand Pond (IDNR)	7.42	48.23
29	Lake Miltmore	7.35	48.37
30	Lake Leo	7.31	48.45
31	Schreiber Lake	7.25	48.57
32	Nielsen Pond	7.23	48.61
33	Honey Lake	7.17	48.73
34	Lake Minear	7.13	48.81
35	Round Lake	7.01	49.05
36	Highland Lake	6.97	49.14
37	Lake Helen	6.43	50.30
38	Sun Lake	6.33	50.52
39	Lake Barrington	6.12	51.01
40	Waterford Lake	6.11	51.03
41	Timber Lake (North)	6.03	51.22
42	Cranberry Lake	5.94	51.44
43	Lake Fairfield	5.89	51.56
44	Gages Lake	5.45	52.68
45	Owens Lake	5.30	53.08
46	Lake Linden	5.28	53.14
47	Valley Lake	5.05	53.78
48	McGreal Lake	5.04	53.81
49	Old Oak Lake	4.85	54.36
50	Peterson Pond	4.51	55.41
51	Timber Lake (South)	4.46	55.57

Lake County Secchi Disk Clarity Ranking, 2000-2017.

RANK	LAKE NAME	SECCHI AVE	TSIsd
52	Crooked Lake	4.39	55.79
53	Mary Lee Lake	4.35	55.93
54	Butler Lake	4.35	55.93
55	Deer Lake	4.20	56.45
56	Seven Acre Lake	4.18	56.51
57	Hastings Lake	4.18	56.51
58	Lambs Farm Lake	4.17	56.54
59	Grays Lake	4.08	56.86
60	Lake Naomi	4.05	56.96
61	Hook Lake	3.95	57.32
62	Turner Lake	3.92	57.43
63	Leisure Lake	3.85	57.69
64	Summerhill Estates Lake	3.84	57.73
65	North Tower Lake	3.89	57.74
66	Salem Lake	3.77	58.00
67	Lake Fariview	3.75	58.07
68	Duck Lake	3.71	58.23
69	Countryside Glen Lake	3.64	58.50
70	Fish Lake	3.57	58.78
71	Taylor Lake	3.52	58.99
72	Lochanora	3.52	58.99
73	Bishop Lake	3.47	59.19
74	Lake Lakeland Estates	3.41	59.44
75	Lake Holloway	3.40	59.49
76	Stockholm Lake	3.38	59.57
77	Crooked Lake	3.35	59.70
78	East Loon Lake	3.30	59.92
79	Lucky Lake	3.22	60.27
80	Diamond Lake	3.17	60.50
81	Liberty Lake	3.16	60.54
82	International Mining and Chemical Lake	3.08	60.91
83	Long Lake	3.05	61.05
84	Lake Christa	3.01	61.24
85	Lucy Lake	2.99	61.34
86	Lake Catherine	2.9	61.78
87	St. Mary's Lake	2.79	62.34
88	Channel Lake	2.77	62.44
89	Werhane Lake	2.71	62.76
90	Fischer Lake	2.70	62.81
91	Bresen Lake	2.69	62.86
92	East Meadow Lake	2.61	63.30
93	Buffalo Creek Reservoir 1	2.60	63.35
94	Countryside Lake	2.58	63.46
95	Kemper Lake 1	2.56	63.58
96	Bluff Lake	2.51	63.86
97	Broberg Marsh	2.50	63.92
98	Antioch Lake	2.48	64.03
99	Little Bear Lake	2.38	64.63
100	Island Lake	2.32	65.00
101	Tower Lake	2.31	65.06

Lake County Secchi Disk Clarity Ranking, 2000-2017.

RANK	LAKE NAME	SECCHI AVE	TSIsd
102	Buffalo Creek Reservoir 2	2.30	65.12
103	Woodland Lake	2.28	65.25
104	Rivershire Pond 2	2.23	65.57
105	Lake Charles	2.20	65.76
106	College Trail Lake	2.18	65.89
107	Loch Lomond	2.17	65.96
108	Redhead Lake	2.16	66.03
109	Pistakee Lake	2.15	66.09
110	Des Plaines Lake	2.14	66.16
111	Echo Lake	2.11	66.36
112	Eagle Lake (S1)	2.10	66.43
113	West Meadow Lake	2.07	66.64
114	Forest Lake	2.04	66.85
115	Grand Ave Marsh	2.03	66.92
116	Columbus Park Lake	2.03	66.92
117	Grassy Lake	2.00	67.14
118	Petite Lake	2	67.14
119	Sylvan Lake	1.98	67.28
120	Bittersweet Golf Course #13	1.98	67.28
121	Spring Lake	1.78	68.82
122	Kemper Lake 2	1.77	68.90
123	Fourth Lake	1.77	68.90
124	Nippersink Lake	1.73	69.23
125	Deer Lake Meadow Lake	1.73	69.23
126	Lake Louise	1.68	69.65
127	Willow Lake	1.63	70.09
128	Slough Lake	1.63	70.09
129	Rasmussen Lake	1.62	70.17
130	Lake Farmington	1.62	70.17
131	Half Day Pit	1.60	70.35
132	Lake Marie	1.56	70.72
133	White Lake	1.53	71.00
134	Longview Meadow Lake	1.51	71.19
135	Lake Matthews	1.48	71.48
136	Big Bear Lake	1.32	73.13
137	Fox Lake	1.28	73.57
138	Dunn's Lake	1.22	74.26
139	Lake Eleanor	1.16	74.99
140	Lake Napa Suwe	1.06	76.29
141	Rollins Savannah 1	1.05	76.43
142	Osprey Lake	1.03	76.70
143	Manning's Slough	1.00	77.13
144	Rollins Savannah 2	0.95	77.87
145	Dog Bone Lake	0.94	78.02
146	Redwing Marsh	0.88	78.97
147	Flint Lake Oulet	0.83	79.82
148	Fairfield Marsh	0.81	80.17
149	Slocum Lake	0.81	80.17
150	Oak Hills Lake	0.79	80.53
151	McDonald Lake 1	0.79	80.53
152	Grass Lake	0.78	80.71

Lake County Secchi Disk Clarity Ranking, 2000-2017.

RANK	LAKE NAME	SECCHI AVE	TSIsd
153	Lake Nippersink	0.77	80.90
154	South Churchill Lake	0.73	81.67
155	Lake Forest Pond	0.71	82.07
156	ADID 127	0.66	83.12
157	North Churchill Lake	0.61	84.26
158	Hidden Lake	0.56	85.54
159	McDonald Lake 2	0.53	86.28
160	Ozaukee Lake	0.51	86.84
	average	***4.22***	***60.74***

Appendix C:
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.

Shoreline Assessment

Shoreline Assessment Protocol

Each lake was divided into reaches in ArcGIS based on nearshore landuse. For each reach, a shoreline assessment worksheet was filled out in the field focusing on shoreline conditions (land use, slope, erosion, buffer, etc) that describe the overall reach segment of the lake.

A GPS Trimble unit was used to collect the degree of shoreline erosion along the entire length of the lake. The degree of shoreline erosion was categorically defined as none, slight, moderate, or severe. Below are brief descriptions of each category.

Table 1: Degree of Shoreline Erosion

Category	Description
None	Includes man-made erosion control such as rip-rap and sea wall.
Slight	Minimal or no observable erosion; generally considered stable; no erosion control practices will be recommended with the possible exception of small problem areas noted within an area otherwise designated as “slight”. Beaches have been included as “slight” erosion.
Moderate	Recession is characterized by past or recently eroded banks; area may exhibit some exposed roots, fallen vegetation or minor slumping of soil material; erosion control practices may be recommended although the section is not deemed to warrant immediate remedial action.
Severe	Recession is characterized by eroding of exposed soil on nearly vertical banks, exposed roots, fallen vegetation or extensive slumping of bank material, undercutting, washouts or fence posts exhibiting realignment; erosion control practices are recommended and immediate remedial action may be warranted.

Lateral recession rates were calculated on a per reach basis based on the IL EPA stream methodology, defining lateral recession into four main categories (slight, moderate, severe, and very severe). Descriptions of each category are defined in the Table 2.

Table 2: Lateral Recession Rate Categories

Lateral Recession Rate	Description	Description
0.01 – 0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetation overhanging. No exposed tree roots.
0.06 – 0.2	Moderate	Bank mostly bare with some rills and vegetation overhanging.
0.3 – 0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and streamcourse or gully may be meandering.

Shoreline Buffer Condition

Lakeshore buffer condition was assessed using a qualitative methodology that considered an area up to 25 feet inland from the shoreline for each reach. The assessment was done by viewing high resolution 2014 aerial images in ArcGIS. A 25 foot buffer was chosen based on research that indicates a 25-foot vegetated buffer is the minimum effective width for in-lake habitat maintenance (a 15 foot buffer is the minimum effective width for bank stability). Criteria used for category assignment are shown in table below.

Table 3: Shoreline Buffer Condition Categories

Category	Criteria	Percentage
Good	Unmowed grasses & forbs + tree trunks + shrubs	≥70%
	and impervious surfaces	≤5%
Fair	Unmowed grasses & forbs + tree trunks + shrubs	≥50% and <70%
	and Impervious surface	≤10%
Poor	Unmowed grasses & forbs +tree trunks + shrubs	<50%
	and Impervious surface	≥50%

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

Appendix D:
Interpreting Your Lake's Water Quality Data

Lakes possess a unique set of physical and chemical characteristics that will change over time. These in-lake water quality characteristics, or parameters, are used to describe and measure the quality of lakes, and they relate to one another in very distinct ways. As a result, it is virtually impossible to change any one component in or around a lake without affecting several other components, and it is important to understand how these components are linked.

The following pages will discuss the different water quality parameters measured by Lake County Health Department staff, how these parameters relate to each other, and why the measurement of each parameter is important. The median values (the middle number of the data set, where half of the numbers have greater values, and half have lesser values) of data collected from Lake County lakes from 2000-2010 will be used in the following discussion.

Temperature and Dissolved Oxygen:

Water temperature fluctuations will occur in response to changes in air temperatures, and can have dramatic impacts on several parameters in the lake. In the spring and fall, lakes tend to have uniform, well-mixed conditions throughout the water column (surface to the lake bottom). However, during the summer, deeper lakes will separate into distinct water layers. As surface water temperatures increase with increasing air temperatures, a large density difference will form between the heated surface water and colder bottom water. Once this difference is large enough, these two water layers will separate and generally will not mix again until the fall. At this time the lake is thermally stratified. The warm upper water layer is called the ***epilimnion***, while the cold bottom water layer is called the ***hypolimnion***. In some shallow lakes, stratification and destratification can occur several times during the summer. If this occurs the lake is described as polymictic. Thermal stratification also occurs to a lesser extent during the winter, when warmer bottom water becomes separated from ice-forming water at the surface until mixing occurs during spring ice-out.

Monthly temperature profiles were established on each lake by measuring water temperature every foot (lakes $\leq$ 15 feet deep) or every two feet (lakes > 15 feet deep) from the lake surface to the lake bottom. These profiles are important in understanding the distribution of chemical/biological characteristics and because increasing water temperature and the establishment of thermal stratification have a direct impact on dissolved oxygen (DO) concentrations in the water column. 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, and increasing water temperatures during the summer speeds up the rates of photosynthesis and decomposition in surface waters. Many of the plants or algae die at the end of the growing season. Their decomposition results in heavy oxygen consumption and can lead to an oxygen crash. In deeper, thermally stratified lakes, oxygen production is greatest in the top portion of the lake, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where sunken organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. The oxygen profiles measured during the water quality study can illustrate if this is occurring. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters. Low oxygen conditions in the upper water of a lake can also be problematic since all aquatic organisms need oxygen to live. Some oxygen may be present in the water, but at too low a concentration to sustain aquatic life. Oxygen is needed by all plants, virtually all algae and for many chemical reactions that are important in lake functioning. Most adult sport-fish such as largemouth bass and bluegill require at least 3 mg/L of DO in the water to survive. However, their offspring require at least 5 mg/L DO as they are more sensitive to DO stress. When DO concentrations drop below 3 mg/L, rough fish such as carp and green sunfish are favored and over time will become the dominant fish species.

External pollution in the form of oxygen-demanding organic matter (i.e., sewage, lawn clippings, soil from shoreline erosion, and agricultural runoff) or nutrients that stimulate the growth of excessive organic matter (i.e., algae and plants) can reduce average DO concentrations in the lake by increasing oxygen consumption. This can have a detrimental impact on the fish community, which may be squeezed into a very small volume of water as a result of high temperatures in the epilimnion and low DO levels in the hypolimnion.

Nutrients:

Phosphorus:

For most Lake County lakes, phosphorus is the nutrient that limits plant and algae growth. This means that any addition of phosphorus to a lake will typically result in algae blooms or high plant densities during the summer. The source of phosphorus to a lake can be external or internal (or both). External sources of phosphorus enter a lake through point (i.e., storm pipes and wastewater discharge) and non-point runoff (i.e., overland water flow). This runoff can pick up large amounts of phosphorus from agricultural fields, septic systems or impervious surfaces before it empties into the lake.

Internal sources of phosphorus originate within the lake and are typically linked to the lake sediment. In lakes with high oxygen levels (oxic), phosphorus can be released from the sediment through plants or sediment resuspension. Plants take up sediment-bound phosphorus through their roots, releasing it in small amounts to the water column throughout their life cycles, and in large amounts once they die and begin to decompose. Sediment resuspension can occur through biological or mechanical means. Bottom-feeding fish, such as common carp and black bullhead can release phosphorus by stirring up bottom sediment during feeding activities and can add phosphorus to a lake through their fecal matter. Sediment resuspension, and subsequent phosphorus release, can also occur via wind/wave action or through the use of artificial aerators, especially in shallow lakes. In lakes that thermally stratify, internal phosphorus release can occur from the sediment through chemical means. Once oxygen is depleted (anoxia) in the hypolimnion, chemical reactions occur in which phosphorus bound to iron complexes in the sediment becomes soluble and is released into the water column. This phosphorus is trapped in the hypolimnion and is unavailable to algae until fall turnover, and can cause algae blooms once it moves into the sunlit surface water at that time. Accordingly, many of the lakes in Lake County are plagued by dense algae blooms and excessive, exotic plant coverage, which negatively affect DO levels, fish communities and water clarity.

Lakes with an average phosphorus concentration greater than 0.05 mg/L are considered nutrient rich. The median near surface total phosphorus (TP) concentration in Lake County lakes from 2000-2010 was 0.065 mg/L and ranged from a non-detectable minimum of <0.010 mg/L on seven lakes to a maximum of 3.880 mg/L on Albert Lake. The median anoxic TP concentration in Lake County lakes from 2000-2010 was 0.174 mg/L and ranged from a minimum of 0.012 mg/L in Independence Grove Lake to a maximum of 3.800 mg/L in Taylor Lake.

The analysis of phosphorus also included soluble reactive phosphorus (SRP), a dissolved form of phosphorus that is readily available for plant and algae growth. SRP is not discussed in great detail in most of the water quality reports because SRP concentrations vary throughout the season depending on how plants and algae absorb and release it. It gives an indication of how much phosphorus is available for uptake, but, because it does not take all forms of phosphorus into account, it does not indicate how much phosphorus is truly present in the water column. TP is considered a better indicator of a lake's nutrient status because its concentrations remain more stable than soluble reactive phosphorus. However, elevated SRP levels are a strong indicator of nutrient problems in a lake.

Nitrogen:

Nitrogen is also an important nutrient for plant and algae growth. Sources of nitrogen to a lake vary widely, ranging from fertilizer and animal wastes, to human waste from sewage treatment plants or failing septic systems, to groundwater, air and rainfall. As a result, it is very difficult to control or reduce nitrogen inputs to a lake. Different forms of nitrogen are present in a lake under different oxic conditions. NH_4^+ (ammonium) is released from decomposing organic material under anoxic conditions and accumulates in the hypolimnion of thermally stratified lakes. If NH_4^+ comes into contact with oxygen, it is immediately converted to NO_2 (nitrite) which is then oxidized to NO_3^- (nitrate). Therefore, in a thermally stratified lake, levels of NH_4^+ would only be elevated in the hypolimnion and levels of NO_3^- would only be elevated in the epilimnion. Both NH_4^+ and NO_3^- can be used as a nitrogen source by aquatic plants and algae. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen plus ammonium. Adding the concentrations of TKN and nitrate together gives an indication of the amount of total nitrogen present in the water column. If inorganic nitrogen (NO_3^-, NO_2^-, NH_4^+) concentrations exceed 0.3 mg/L in spring, sufficient nitrogen is available to support summer algae blooms. However, low nitrogen levels do not guarantee limited algae growth the way low phosphorus levels do. Nitrogen gas in the air can dissolve in lake water and blue-green algae can "fix" atmospheric nitrogen, converting it into a usable form. Since other types of algae do not have the ability to do this, nuisance blue-green algae blooms are typically associated with lakes that are nitrogen limited (i.e., have low nitrogen levels).

The ratio of TKN plus nitrate nitrogen to total phosphorus (TN:TP) can indicate whether plant/algae growth in a lake is limited by nitrogen or phosphorus. Ratios of less than 10:1

suggest a system limited by nitrogen, while lakes with ratios greater than 20:1 are limited by phosphorus. It is important to know if a lake is limited by nitrogen or phosphorus because any addition of the limiting nutrient to the lake will, likely, result in algae blooms or an increase in plant density.

Solids:

Although several forms of solids (total solids, total suspended solids, total volatile solids, total dissolved solids) were measured each month by the Lakes Management Staff, total suspended solids (TSS) and total volatile solids (TVS) have the most impact on other variables and on the lake as a whole. TSS are particles of algae or sediment suspended in the water column. High TSS concentrations can result from algae blooms, sediment resuspension, and/or the inflow of turbid water, and are typically associated with low water clarity and high phosphorus concentrations in many lakes in Lake County. Low water clarity and high phosphorus concentrations, in turn, exacerbate the high TSS problem by leading to reduced plant density (which stabilize lake sediment) and increased occurrence of algae blooms. The median TSS value in epilimnetic waters in Lake County was 8.1 mg/L, ranging from below the 0.1 mg/L detection limit to 165 mg/L in Fairfield Marsh.

TVS represents the fraction of total solids that are organic in nature, such as algae cells, tiny pieces of plant material, and/or tiny animals (zooplankton) in the water column. High TVS values indicate that a large portion of the suspended solids may be made up of algae cells. This is important in determining possible sources of phosphorus to a lake. If much of the suspended material in the water column is determined to be resuspended sediment that is releasing phosphorus, this problem would be addressed differently than if the suspended material was made up of algae cells that were releasing phosphorus. The median TVS value was 123.0 mg/L, ranging from 34.0 mg/L in Pulaski Pond to 298.0 mg/L in Fairfield Marsh.

Total dissolved solids (TDS) are the amount of dissolved substances, such as salts or minerals, remaining in water after evaporation. These dissolved solids are discussed in further detail in the *Alkalinity* and *Conductivity* sections of this document. TDS concentrations were measured in Lake County lakes prior to 2004. This practice was discontinued due to the strong correlation of TDS to conductivity and chloride concentrations. Since 2004, chloride concentrations data are collected..

Water Clarity:

Water clarity (transparency) is not a chemical property of lake water, but is often an indicator of a lake's overall water quality. It is affected by a lake's water color, which is a reflection of the amount of total suspended solids and dissolved organic chemicals. Thus, transparency is a measure of particle concentration and is measured with a Secchi disk. Generally, the lower the clarity or Secchi depth, the poorer the water quality. A decrease in Secchi depth during the summer occurs as the 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 and can, in turn, be negatively affected by low clarity levels. Plants increase clarity by competing with algae for resources and by stabilizing sediments to prevent sediment resuspension. A lake with a healthy plant community will almost always have higher water clarity than a lake without plants. Additionally, if the plants in a lake are removed (through herbicide treatment or the stocking of grass carp), the lake will probably become dominated by algae and Secchi depth will decrease. This makes it very difficult for plants to become re-established due to the lack of available sunlight and the lake will, most likely, remain turbid. Turbidity will be accelerated if the lake is very shallow and/or common carp are present. Shallow lakes are more susceptible to sediment resuspension through wind/wave action and are more likely to experience clarity problems if plants are not present to stabilize bottom sediment.

Common Carp are prolific fish that feed on invertebrates in the sediment. Their feeding activities stir up bottom sediment and can dramatically decrease water clarity in shallow lakes. As mentioned above, lakes with low water clarity are, generally, considered to have poor water quality. This is because the causes and effects of low clarity negatively impact both plant and fish communities. Fish populations will suffer as water clarity decreases due to a lack of food and decreased ability to successfully hunt for prey. Bluegills are planktivorous fish and feed on invertebrates that inhabit aquatic plants. If low clarity results in the disappearance of plants, this food source will disappear too. Largemouth Bass and Northern Pike are piscivorous fish that feed on other fish and hunt by sight. As the water clarity decreases, these fish species find it more difficult to see and ambush prey and may decline in size as a result. This could eventually lead to an imbalance in the fish community. Phosphorus release from resuspended sediment could increase as water clarity and plant density decrease. This would then result in increased algae blooms, further reducing Secchi depth and aggravating all problems just discussed. The median Secchi depth for Lake County lakes is 2.95 feet. From 2000-2010, both Ozaukee Lake and McDonald Lake #2 had the lowest Secchi depths (0.25 feet) and West Loon Lake had the highest (23.50 feet). As an example of the difference in Secchi depth based on plant coverage, South Churchill Lake, which had no plant coverage and large numbers of Common Carp in 2003 had an average Secchi depth of 0.73 feet (over four times lower than the county average), while Deep Lake, which had a diverse plant community and few carp had an average 2003 Secchi depth of 12.48 feet (almost four times higher than the county average).

Another measure of clarity is the use of a light meter. The light meter measures the amount of light at the surface of the lake and the amount of light at each depth in the water column. The amount of attenuation and absorption (decreases) of light by the water column are major factors controlling temperature and potential photosynthesis. Light intensity at the lake surface varies seasonally and with cloud cover, and decreases with depth. The deeper into the water column light penetrates, the deeper potential plant growth. The maximum depth at which algae and plants can grow underwater is usually at the depth where the amount of light available is reduced to 0.5%-1% of the amount of light available at the lake surface. This is called the euphotic (sunlit) zone. A general rule of thumb in Lake County is that the 1% light level is about 1 to 3 times the Secchi disk depth.

Alkalinity, Conductivity, Chloride, pH:

Alkalinity:
Alkalinity is the measurement of the amount of acid necessary to neutralize carbonate ($CO_3^{=}$) and bicarbonate (HCO_3^{-}) ions in the water, and represents the buffering capacity of a body of water. The alkalinity of lake water depends on the types of minerals in the surrounding soils and in the bedrock. It also depends on how often the lake water comes in contact with these minerals. If a lake gets groundwater from aquifers containing limestone minerals such as calcium carbonate ($CaCO_3$) or dolomite ($CaMgCO_3$), alkalinity will be high. The median alkalinity in Lake County lakes (162 mg/L) is considered moderately hard according to the hardness classification scale of Brown, Skougstad and Fishman (1970). Because hard water (alkaline) lakes often have watersheds with fertile soils that add nutrients to the water, they usually produce more fish and aquatic plants than soft water lakes. Since the majority of Lake County lakes have a high alkalinity they are able to buffer the adverse effects of acid rain.
Conductivity and Chloride:
Conductivity is the inverse measure of the resistance of lake water to an electric flow. This means that the higher the conductivity, the more easily an electric current is able to flow through water. Since electric currents travel along ions in water, the more chemical ions or dissolved salts a body of water contains, the higher the conductivity will be. Accordingly, conductivity has been correlated to total dissolved solids and chloride ions. The amount of dissolved solids or conductivity of a lake is dependent on the lake and watershed geology, the size of the watershed flowing into the lake, the land uses within that watershed, and evaporation and bacterial activity. Many Lake County lakes have elevated conductivity levels in May, but not during any other month. This was because chloride, in the form of road salt, was washing into the lakes with spring rains, increasing conductivity. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts. Beginning in 2004, chloride concentrations are one of the parameters measured during the lake studies. Increased chloride concentrations may have a negative impact on aquatic organisms. Conductivity changes occur seasonally and with depth. For example, in stratified lakes the conductivity normally increases in the hypolimnion as bacterial decomposition converts organic materials to bicarbonate and carbonate ions depending on the pH of the water. These newly created ions increase the conductivity and total dissolved solids. Over the long term, conductivity is a good indicator of potential watershed or lake problems if an increasing trend is noted over a period of years. It is also important to know the conductivity of the water when fishery assessments are conducted, as electroshocking requires a high enough conductivity to properly stun the fish, but not too high as to cause injury or death.

Since 2004 measurements taken in Lake County lakes have exhibited a trend of increasing salinity measured by chloride concentrations. The median near surface chloride concentration of Lake County Lakes was 142 mg/L. In 2009, Schreiber Lake had the lowest chloride concentration recorded at 2.7 mg/L. The maximum average chloride measurement was at 2760 mg/L at IMC. It is important to note that salt water is denser than fresh water and so it accumulates in the hypolimnion or near the bottom of the lake, this can impact mixing of bottom waters into surface waters in lakes that experience turnover. This phenomenon could have far reaching impacts to an entire ecosystem within a lake. Further, in studies conducted in

Minnesota, chloride concentrations as low as 12 mg/L have been found to impact some species of algae.

pH:

pH is the measurement of hydrogen ion (H^+) activity in water. The pH of pure water is neutral at 7 and is considered acidic at levels below 7 and basic at levels above 7. Low pH levels of 4-5 are toxic to most aquatic life, while high pH levels (9-10) are not only toxic to aquatic life they may also result in the release of phosphorus from lake sediment. The presence of high plant densities can increase pH levels through photosynthesis, and lakes dominated by a large amount of plants or algae can experience large fluctuations in pH levels from day to night, depending on the rates of photosynthesis and respiration. Few, if any pH problems exist in Lake County lakes. Typically, the flooded gravel mines in the county are more acidic than the glacial lakes as they have less biological activity, but do not usually drop below pH levels of 7. The median near surface pH value of Lake County lakes was 8.37, with a minimum average of 7.07 in Bittersweet #13 Lake and a maximum of 10.40 in Summerhill Estates Lake.

Eutrophication and Trophic State Index:

The word *eutrophication* comes from a Greek word meaning "well nourished." This also describes the process in which a lake becomes enriched with nutrients. Over time, this is a lake's natural aging process, as it slowly fills in with eroded materials from the surrounding watershed and with decaying plants. If no human impacts disturb the watershed or the lake, natural eutrophication can take thousands of years. However, human activities on a lake or in the watershed accelerate this process by resulting in rapid soil erosion and heavy phosphorus inputs. This accelerated aging process on a lake is referred to as cultural eutrophication. The term trophic state refers to the amount of nutrient enrichment within a lake system. *Oligotrophic* lakes are usually deep and clear with low nutrient levels, little plant growth and a limited fishery. *Mesotrophic* lakes are more biologically productive than oligotrophic lakes and have moderate nutrient levels and more plant growth. A lake labeled as *eutrophic* is high in nutrients and can support high plant densities and large fish populations. Water clarity is typically poorer than oligotrophic or mesotrophic lakes and dissolved oxygen problems may be present. A *hypereutrophic* lake has excessive nutrients, resulting in nuisance plant or algae growth. These lakes are often pea-soup green, with poor water clarity. Low dissolved oxygen may also be a problem, with fish kills occurring in shallow, hypereutrophic lakes more often than less enriched lakes. As a result, rough fish (tolerant of low dissolved oxygen levels) dominate the fish community of many hypereutrophic lakes. The categorization of a lake into a certain trophic state should not be viewed as a "good to bad" categorization, as most lake residents rate their lake based on desired usage. For example, a fisherman would consider a plant-dominated, clear lake to be desirable, while a water-skier might prefer a turbid lake devoid of plants. Most lakes in Lake County are eutrophic or hypereutrophic. This is primarily as a result of cultural eutrophication. However, due to the fertile soil in this area, many lakes (especially man-made) may have started out under eutrophic conditions and will never attain even mesotrophic conditions, regardless of any amount of money put into the management options. This is not an excuse to allow a lake to continue to deteriorate, but may serve as a reality check for lake owners attempting to create unrealistic conditions in their lakes.

The Trophic State Index (TSI) is an index which attaches a score to a lake based on its average total phosphorus concentration, its average Secchi depth (water transparency) and/or its average chlorophyll *a* concentration (which represent algae biomass). It is based on the principle that as phosphorus levels increase, chlorophyll *a* concentrations increase and Secchi depth decreases. The higher the TSI score, the more nutrient-rich a lake is, and once a score is obtained, the lake can then be designated as oligotrophic, mesotrophic or eutrophic. Table 1 (below) illustrates the Trophic State Index using phosphorus concentration and Secchi depth.

Table 1. Trophic State Index (TSI).

Trophic State	TSI score	Total Phosphorus (mg/L)	Secchi Depth (feet)
Oligotrophic	<40	≤ 0.012	>13.12
Mesotrophic	≥40<50	>0.012 ≤ 0.024	≥6.56<13.12
Eutrophic	≥50<70	>0.024 ≤ 0.096	≥1.64<6.56
Hypereutrophic	≥70	>0.096	< 1.64