Lake County, IL

2017 White Lake Summary Report

PREPARED BY THE LAKE COUNTY HEALTH DEPARTMENT

ECOLOGICAL SERVICES

Herons flying over White Lake, August 2017

White Lake is a 42 acre impounded wetland situated in the Clublands of Antioch subdivision. White Lake was constructed in 1964 as storage for water from two surrounding streams. The Clublands of Antioch subdivision was developed in 2003. Today the lake is used for non-motorized boating, fishing, and aesthetics. White Lake receives most of its water from storm water runoff and creeks that flow into the northeast and southwest ends of the lake. An earthen dam at the southern tip of the eastern arm is the only outlet of the lake (via a pipe used to provide water control).

The water quality of White Lake is poor. White Lake is currently listed as an impaired lake due to excess phosphorus and high pH by the Illinois Environmental Protection Agency. In 2017, the Lake County Health Department - Ecological Services (LCHD-ES) monitored White Lake as part of routine water quality sampling. A water sample was collected once a month from May through September at the deepest point in the lake; three feet below the surface (Appendix A). Samples were analyzed for nutrients, solid concentrations and other chemical parameters. Additionally, LCHD-ES conducted an aquatic plant and shoreline assessment survey in August 2017.

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LAKE FACTS

MAJOR WATERSHED:
Des Plaines River

SUB-WATERSHED:
North Mill Creek

SURFACE AREA:
41.6 Acres

SHORELINE LENGTH:
1.6 Miles

MAXIMUM DEPTH:
9.9 Feet

AVERAGE DEPTH:
4.48 Feet

LAKE VOLUME:
187.67 Acre- Feet

WATERSHED AREA:
183.63 Acres

LAKE TYPE:
Impoundment

CURRENT USES:
Non motorboat, fishing and aesthetics.

ACCESS:
Private

WHITE LAKE SUMMARY

Following is a summary of the water quality sampling, shoreline survey and aquatic macrophyte survey from the 2017 monitoring season on White 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. Overall the water quality of White Lake is poor and has been decreasing overtime.

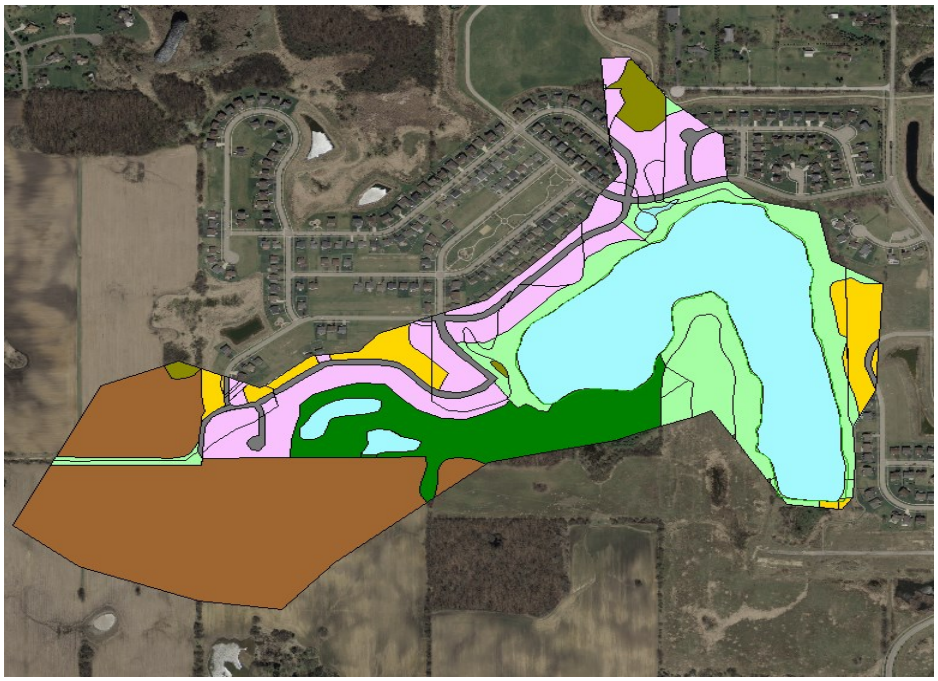
- Average water clarity as measured by Secchi depth in 2017 was 1.53 feet. This is a decrease since 2010 (3.96 ft.) and is below the Lake County median Secchi of 3.00 ft.
- Water clarity is influenced by the amount of particles in the water column; this is measured by total suspended solids (TSS) concentration. The average epilimnion TSS concentrations on White Lake was 18.3 mg/L in 2017, which is more than double the Lake County median of 8.2 mg/L. TSS have increased since the 2010 sampling date.
- Nutrient availability indicated that White Lake is both phosphorus and nitrogen limited with an average TN:TP ratio of 17:1. Monthly TN:TP ratios give better insight into nutrient availability and show that in 2017 June and July were nitrogen limited and August and September were phosphorus limited. For White Lake, both nutrients play an important role in the nutrient dynamics of the lake.
- In 2017, the average total epilimnion phosphorus concentration was 0.087 mg/L. This is above the Illinois Environmental Protection Agency (IEPA) water quality standard of 0.050 mg/L and roughly the same TP as 2010 concentration (0.086 mg/L). However, TP concentrations for 2010 and 2017 are nearly double the 2000 and 2006 sampling concentrations.
- Trophic State Index based on 2017 total phosphorus concentrations (TSIp) for White Lake is 68.3, meaning White Lake is considered a eutrophic lake, with high nutrients.
- White Lake had supersaturated oxygen conditions in July and September indicative of the blue-green algae blooms present in the lake. Dissolved oxygen concentrations did drop below <1.0 mg/L (anoxic) in all months except June.
- The aquatic macrophyte survey showed that 4.1% of lake sites were covered in plants, however, the only plant observed was Chara, a macro-algae.
- In 2017, a total of 1 macro-algae (Chara) was present in White Lake. In 2010, 9 aquatic plants species were found in addition to Chara, with 78.45% of the lake covered in plants. The large reduction in plants is of major concern for White Lake's water quality and overall health.
- Based on the shoreline assessment, only 33% of White Lake had some degree erosion along the shoreline. All erosion was minimal, categorized as "slight" erosion.
- Based on the shoreline assessment, 98% of the shoreline had good shoreline buffer, where >25 feet of the shoreline had minimal impervious surfaces and abundant native vegetation.
- White Lake suffered from frequent blue-green algae blooms in 2017, likely a result of high phosphorus concentrations and lack of rooted aquatic vegetation.
- A catfish die-off occurred on White Lake in August of 2017, likely a result of a virus.
- Based on the 2017 data, White Lake exceeds the criteria for pH and total phosphorus, and would continue to be impaired for these parameters.

WATERSHED & LANDUSE

As a watershed is developed, the amount of impervious surface increases resulting in a greater amounts of runoff entering our waters. Runoff brings increased nutrients, pollutants, and sediment to our rivers, lakes, and wetlands.

White Lake's surface area is 41.6 acres which represents only about one quarter of it's watershed, which is estimated to be 183.63 acres. The main land uses are Agriculture and Water representing 28.8% and 23.9% of the watershed, respectively (Fig 1, Table 1). 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 White Lake were Water (70%), single family homes (12.1%) and Public and Private Open Space (6.3%). Runoff is referring to the amount of water making its way to the lake, however, each land use contributes different amount of pollutant loads associated with the runoff. The water land use doesn't have high pollutants associated with it since it refers to the rainfall falling directly and in terms of pollutants this is mostly atmospheric deposition. Other landuses, such as transportation, contain higher pollutants that are carried to the lake by runoff. Since Single Family land use contributes such a good deal of runoff to a lake, it becomes even more important that homeowner's are paying attention to management activities that they implement on their properties. This is especially important as the Clublands of Antioch expands or increases development.

White Lake is in the North Mill Creek-Dutch Gap Canal subwatershed of the larger Des Plaines River Watershed. The North Mill Creek-Dutch Gap Canal has a watershed plan developed by Lake County Stormwater Management Commission. The watershed plan highlights reducing suspended solids and nutrients entering the waterways, which ultimately impact our lakes.



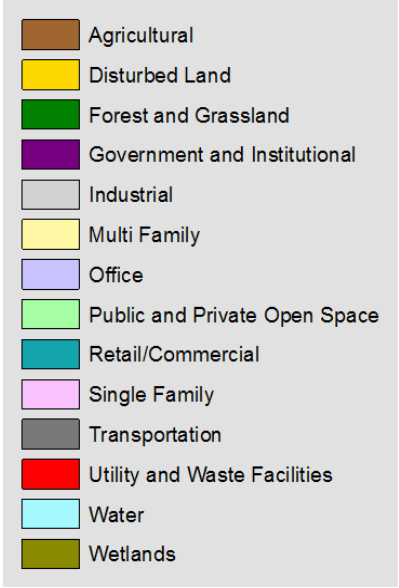


Figure 1 (left): *White Lake Land Use*

Table 1: *White Lake Land Use and Estimated Runoff*

Land Use	Acreage	% of Total Watershed	% Total of Estimated Runoff
Agricultural	52.90	28.8%	4.2%
Disturbed Land	8.50	4.6%	0.7%
Forest and Grassland	17.53	9.5%	1.4%
Public and Private Open Space	26.32	14.3%	6.3%
Single Family	25.25	13.8%	12.1%
Transportation	6.36	3.5%	5.1%
Water	43.88	23.9%	70.0%
Wetlands	2.90	1.6%	0.2%
Total Acres	**183.63**	**100.0%**	100.0%

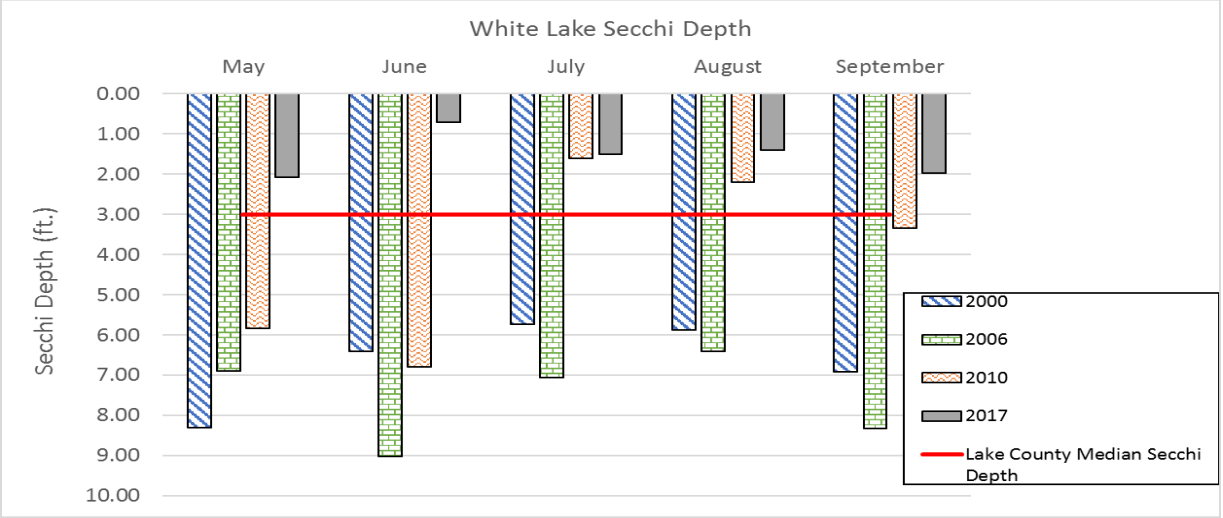
WATER CLARITY

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 Secchi depth for White Lake ranged from 2.08 feet in May to a low of 0.70 feet in June. The average water clarity for White Lake in 2017 was only 1.53 feet, which is roughly half of the Lake County median Secchi Depth (3.00 ft.). The main cause of poor water clarity in White Lake in 2017 were significant blue-green algae blooms and high TSS concentrations. Figure 2 depicts the monthly Secchi depth values over the years that White Lake has been monitored by LCHD-ES. It is evident that the water clarity has changed drastically over time. In 2000 and 2006, White Lake had great water clarity, well above the Lake County median. The change in water clarity is likely a result of increased development around the lake, excessive aquatic plant management that left the lake with minimal aquatic plants, and the abundance of blue-green algae blooms.

White Lake Secchi depth averaged 1.53 ft., in 2017 which is below the Lake County median Secchi depth of 3.00 ft.

Figure 2: *White 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.

White Lake is encouraged to participate in the VLMP program. Participating provides annual data that helps document water quality impacts and support lake management decisions.

FOR MORE INFORMATION ON THE VLMP PROGRAM

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LAKE MONITORING VOLUNTEER PROGRAM ILLINOIS

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.

The 2017 average TSS in White Lake was 18.3 mg/L, more than double the concentration since the 2010 analysis and well above the Lake County median TSS concentration of 8.1 mg/L (Figure 3). TSS is inversely correlated with Secchi depth. Both water clarity and TSS have declined over time and are poorer than measurements in 2000 and 2006. This can be attributed to sediments entering the lake from increased development around the watershed as well as substantial algal blooms that occurred on White Lake for most of the season.

Figure 3:
Total Suspended Solid Concentrations on White Lake

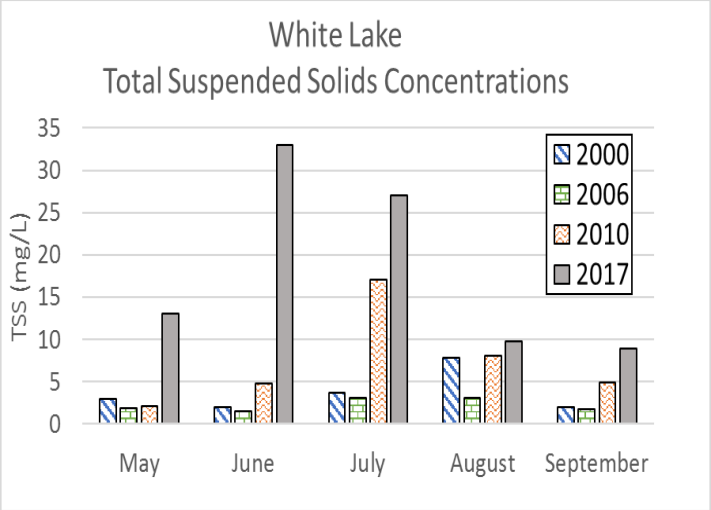


Table 2: *2017 Suspended solid concentrations on White Lake*

DATE	TSS (mg/L)	TS (mg/L)	TVS (mg/L)
May	13.0	NA	100
June	33.0	361	109
July	27.0	260	114
August	9.8	257	153
Sept.	8.9	254	105
Average	18.3	246	116

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: 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. Nitrogen concentrations in the epilimnion of White Lake were below detectable concentrations for the entire monitoring season. Total Kjeldahl Nitrogen (TKN), an organically associated form of nitrogen averaged 1.45 mg/L, greater than the Lake County Median. While there are no impairments on White 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. White Lake had an average TN:TP of 17:1, however, June and July had ratios <10:1, indicating a nitrogen limited lake earlier in the season (June– July) and ratios were >20:1 for Aug-September indicating phosphorus limitation. Blue-green algal blooms can thrive in both conditions, as TP and TN fuel algal blooms, but in addition, some cyanobacteria can atmospherically fix nitrogen giving them a competitive advantage in nitrogen limiting lakes.

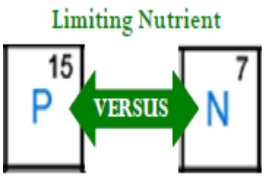
TN:TP Ratio

<10:1=Nitrogen limited

>20:1=Phosphorus limited

TN:TP Ratio: 17:1

White Lake is both phosphorus and nitrogen limited.



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.

White Lake is listed as an 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 White Lake was 0.087 mg/L for 2017, which is above the Lake County median of 0.068 mg/L and exceeded the IEPA water quality standard every month (Figure 4). The highest TP concentration occurred in June at 0.134 mg/L and the lowest concentration occurred in August with 0.066 mg/L. Both 2010 and 2017 TP concentrations are significant increase since the 2006 and 2000. TP has nearly doubled in concentration since then, likely a result of a decreased aquatic plant population. 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 since it is typically used first, however in White Lake SRP was present in every month except August. The higher concentrations of SRP observed are likely a result of anoxic conditions and the polymictic nature of White Lake, in addition to the lake being nitrogen limited.

TP 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 hypereutrophic. These range from nutrient poor and least productive (oligotrophic) to most nutrient rich and most productive (eutrophic). In 2017, White Lake had a TSIp value of 68.6, which categorizes it as eutrophic. Based on the TSIp, White Lake is ranked 100 out of 175 lakes studied by the LCHD-ES from 2000 –2017 (Appendix B).

WHAT HAS BEEN DONE TO REDUCE PHOSPHORUS LEVELS IN ILLINOIS?

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 White Lake monitored by LCHD*

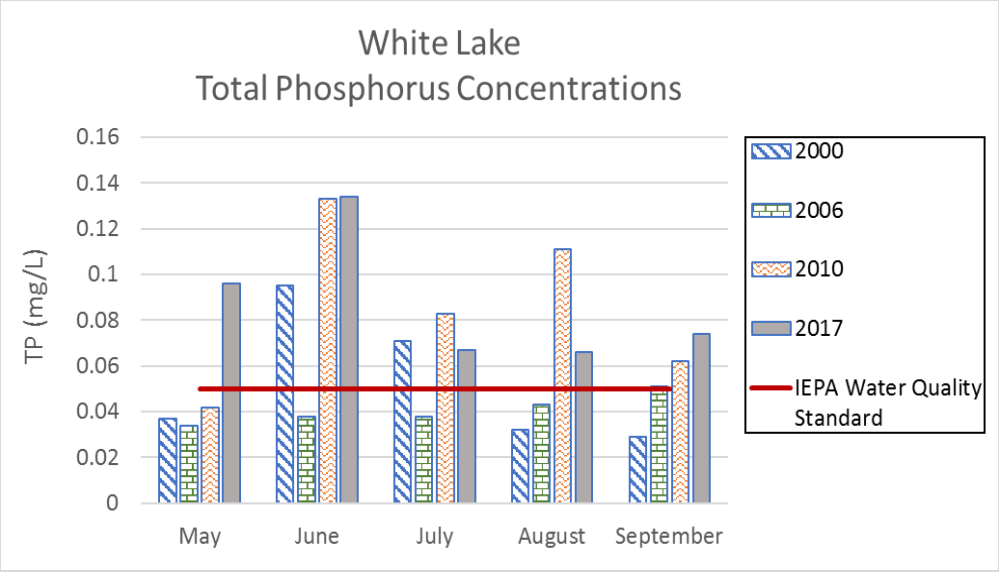


Table 3: *TP and SRP Values on White Lake for 2017*

DATE	TP (mg/L)	SRP (mg/L)
May	0.096	0.0053
June	0.134	0.0071
July	0.067	0.019
August	0.066	ND
September	0.074	0.0058
Average	*0.087*	*0.0093*

STRATIFICATION

Lake stratification is a result of variations in density caused by temperature (or salinity) and can prevent warm and cold water from mixing, called stratification. 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). Stratification traps nutrients released from bottom sediments in the hypolimnion and prevents mixing.

Monthly depth profiles of water temperature, dissolved oxygen, conductivity, and pH were conducted at 1 foot intervals from the lake surface to the lake bottom. 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. Values greater than 20 RTRM indicate stratification. From the calculated RTRM values based on the 2017 multiparameter data on White Lake, White Lake s a polymictic lake, meaning it generally has weaker stratification and mixes multiple times throughout the year. In 2017, White Lake was stratified in May, July, and August. However, was able to mix in June and September. Since it was polymictic, nutrients were able to be available throughout the water column more fueling summer algal blooms.

DISSOLVED OXYGEN

Anoxic conditions, where dissolved oxygen (DO) concentrations are <1 mg/L occurred at the bottom of White Lake in every month except June. The combination of anoxic conditions and the polymictic nature of White Lake allow phosphorus to be released from the bottom sediments (during anoxia) and then available throughout the entire water column when the lake mixes (Figure 6). This pulse of nutrients helped fuel summer blue-green algae blooms during the 2017 season. Most fish prefer dissolved oxygen concentrations greater than 5 mg/L. There were some months during 2017 where D.O. dropped below 5 mg/L near the surface, for example in July, DO dropped below 5 mg/L at just below 4 ft. (Figure 5) While two aerators were observed on White lake, they are mostly used for aesthetic purposes. However, properly sized aerators that prevent stratification can reduce TP release from the sediment by preventing anoxic conditions.

Additionally, LCHD observed super-saturated dissolved oxygen conditions in the epilimnion in July and September with DO concentrations >18 mg/L and >14 mg/L in the upper 3 feet of the water column. This is correlates with the blue-green algae bloom occurring at this time. Blue-Green algae blooms produce large amounts of oxygen which may result in supersaturated levels of DO.

Figure 5: *Dissolved Oxygen Concentrations on White Lake*

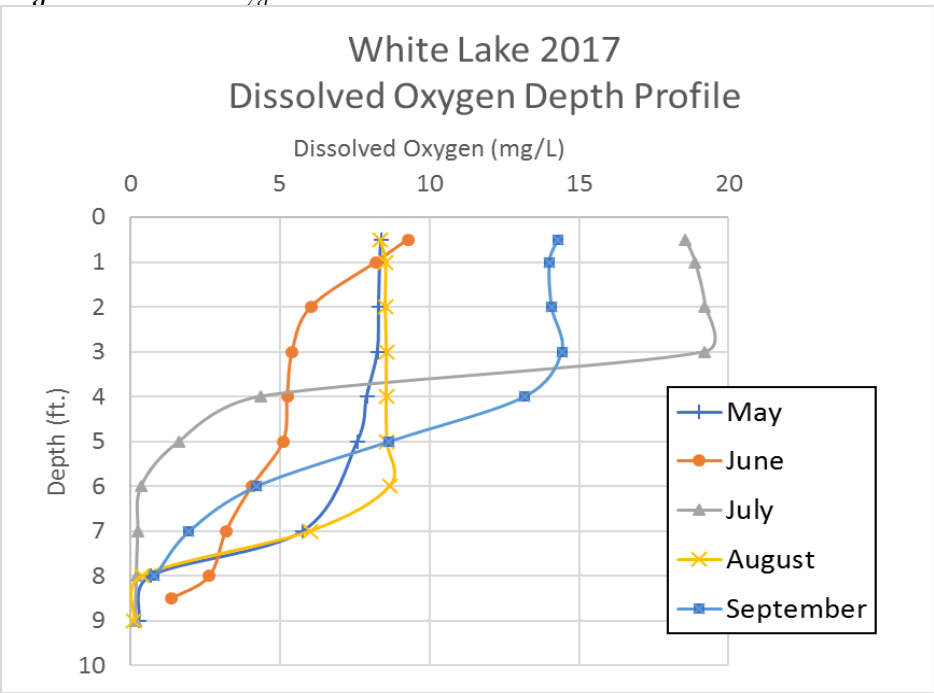
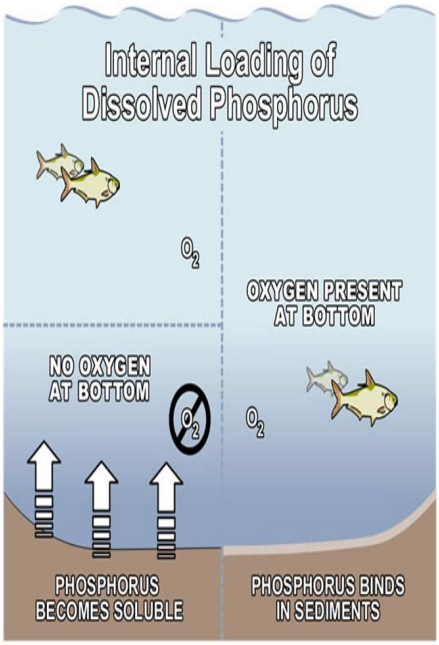


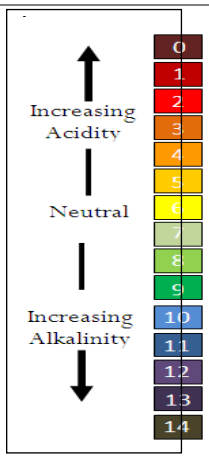
Figure 6: *Schematic of Internal Loading of TP*



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.

White Lake had an average pH in 2017 was 9.10, which is above the Lake County median of 8.32 and outside the range of pH values for most aquatic organisms. White Lake remains impaired for pH. The high pH values are likely result of the blue-green algal blooms. 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.



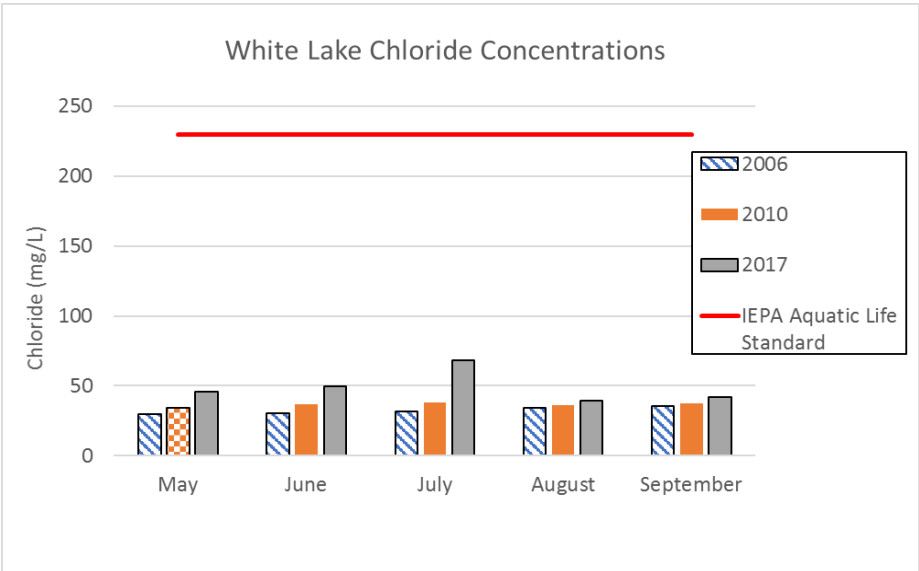
The pH scale ranges from 0 to 14. A pH of 7 is considered neutral. Substances with a pH of less than 7 are acidic, and greater than 7 are basic.

CHLORIDES

Chlorides are not currently a main concern on White Lake as it has one of the lowest chloride concentrations in the county. 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. White Lake's average chloride concentration was 49 mg/L which is well below the Lake County median of 127 mg/L (Figure 7). The United States Environmental Protection agency has determined that chloride concentrations higher than 230 mg/L can disrupt aquatic systems. 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. While Chloride concentrations are not a main concern, concentrations have been increasing since 2006. Proper and efficient deicing practices should be used in the watershed do reduce increases in chloride.

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 10F 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.

Figure 7: *Chloride Concentrations in Lake Carina*



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.

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.

In 2017, blue-green algae blooms were noted on White Lake starting in June. A sample was brought back to the lab and looked at under the microscope where it was noted to be mostly the microcystis species. The quick test in the lab showed values greater than 10 ug/L of microcystin toxin so further analysis was done by sending a sample to IEPA. Results showed microcystin concentration of 42.4 ug/L, which is above the threshold recommended by the World Health Organization (Table 4).

While White Lake does not have a public swimming beach, homeowners should educate themselves on blue-green algae blooms. It is recommended to report any potential blue-green algae blooms by calling the Lake County Health Department. 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 homeowner association to disseminate information regarding the presence of blue-green algae.

Table 4: *World Health Organization Microcystin Toxin Guidelines*

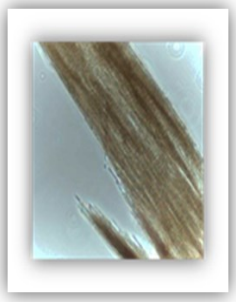
Relative Probability of Acute Health Effects	Cyanobacteria (cells/mL)	Microcystin-LR (µg/L)	Chlorophyll-a (µg/L)
Low	< 20,000	<10	<10
Moderate	20,000-100,000	10-20	10-50
High	100,000-10,000,000	20-2,000	50-5,000
Very High	> 10,000,000	>2,000	>5,000

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.

BATHYMETRIC MAPS

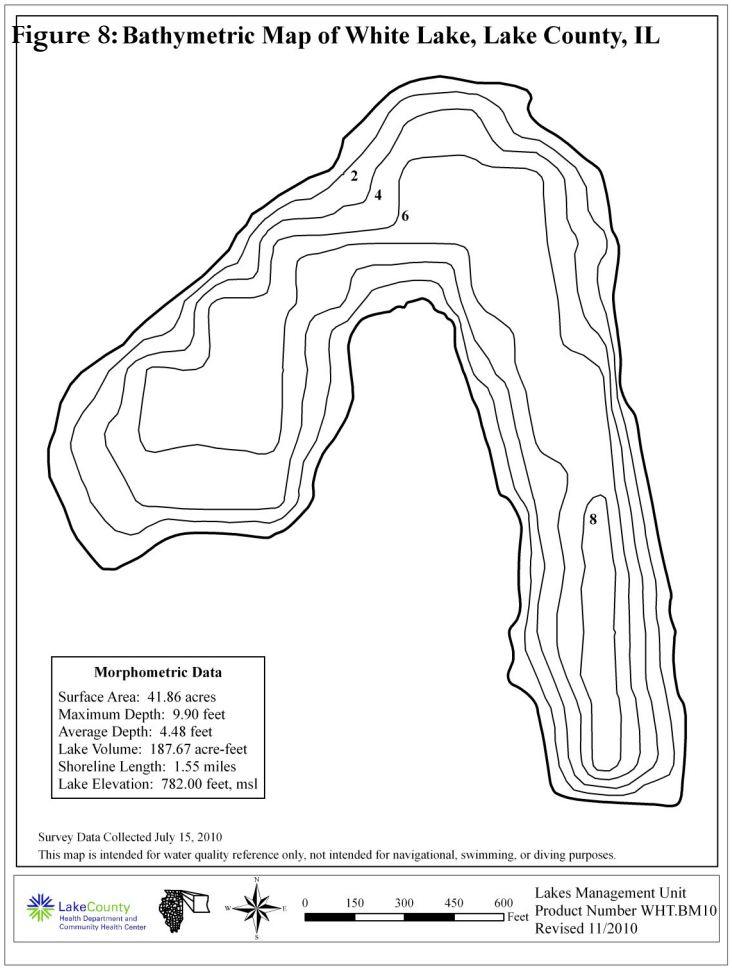


Figure 8: Bathymetric Map of White Lake, Lake County, IL

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).

White Lake had a bathymetric survey conducted in 2010 by LCHD (Figure 8). The maximum depth was 9.90 ft. and average depth was 4.48 ft. Lake volume was 187.67 acre-feet. LCHD recommends updating bathymetric map every 10 years. For a complete list of the morphometric table for White 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 stormwater infrastructure. River flooding began in the Fox, Des Plaines, and Skokie rivers and established record crest levels (Figure 9). Many lakes experienced high lake levels and increased nutrient levels. White Lake did not appear to have a strong response to the flooding events.

Figure 9: *River crests as a result of the July Flooding in Lake County, Lake County Stormwater Management Commission*

2017 Lake Levels on White Lake

2017	ft	Level	Seasonal Change	Monthly Change
June	5.09	61.08	0.00	0.00
July	5.09	61.08	0.00	0.00
August	5.71	68.52	-7.44	-7.44
September	5.34	64.08	-3.00	-4.44

Shoreline erosion

A shoreline erosion assessment was conducted on White Lake by dividing the lake into reaches and evaluating the shoreline 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, 33% of White Lake shoreline had slight degree of erosion and 67% had no erosion (Figure 9). Erosion was never significant on any of the reaches. This is an increase in erosion since the 2010 sampling, where only 6% exhibited erosion.

In addition to shoreline erosion, a shoreline buffer assessment 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. Overall, White Lake has decent buffer coverage around the lake shoreline. From the assessment, 98% of the shoreline had good buffer, 1% with fair, and 1% with poor buffer (Figure 10). Buffers help 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. Most of the buffer on White Lake consisted of reed canary grass and cattails, and while these are not invasive species they can become nuisance species. For a complete list of buffer and erosion conditions by reach, refer to Appendix B.

Figure 9: Shoreline Erosion on White Lake

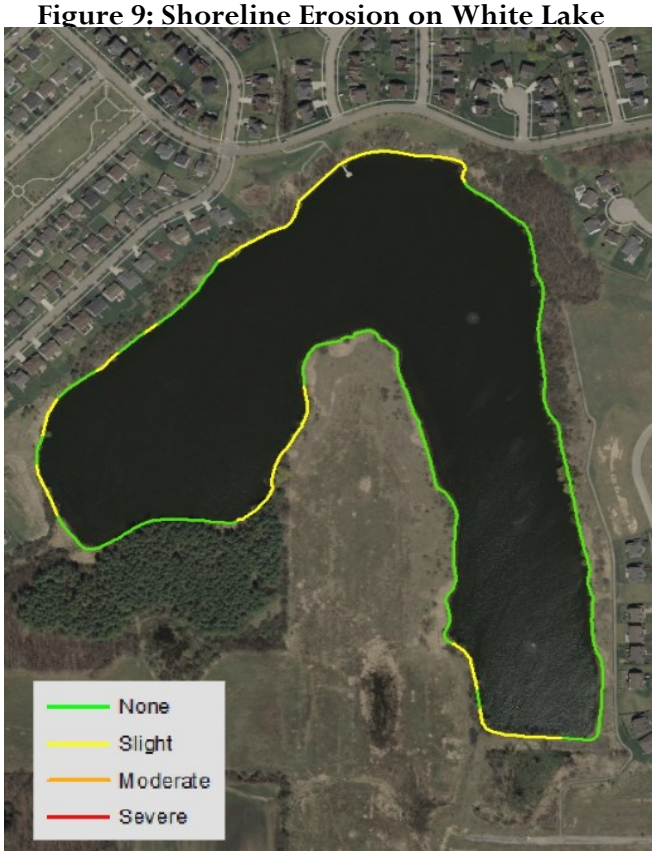
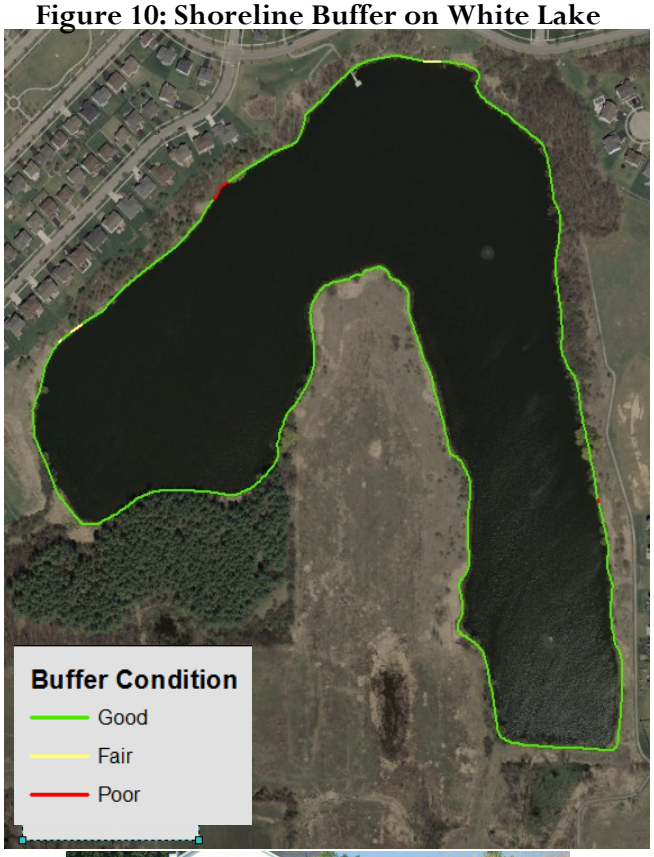


Figure 10: Shoreline Buffer on White Lake



AQUATIC PLANTS & FLORISITC QUALITY INDIEX

Aquatic plants are a critical component in 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 White Lake in early August of 2017. Sampling sites were based on a grid system created by mapping software, with each site located 60 meters apart for a total of 48 sites. At each site, overall plant abundance was ranked and plant species were identified and ranked. Based on the aquatic plant rake survey, plants occurred at 2 of the 48 sites (Figure 12). However, the only species observed was Chara, a macro-algae. This is a significant decrease since previous sampling on White Lake. In 2010, nine aquatic plant species were found, plus Chara, covering an estimated 78.4% of the lake (Figure 11). Coontail was the dominant species and other plants observed included: Flatstem Pondweed, Elodea, Slender Naiad, and Sago Pondweed. The only invasive species observed was Curlyleaf Pondweed. While aquatic vegetation in the past may have been excessive for a shallow lake, the current situation of zero aquatic plants is shifting the lake from a plant dominanted to algae dominated system. Aquatic plants are crucial to lake ecosystems as they compete with algae for nutrients, provide suitable fish habitat, and stabilize bottom sediments.

It is recommended to create a lake management plan that is focused on aquatic plant management. It is necessary to try and allow plants to grow back in the lake so White Lake. In 2017, multiple chemical treatments were conducted in White Lake to treat algae. A total of 10 treatments from April - September were conducted mostly with Cutrine Plus, a copper-based algaecide treatment.

Floristic quality index (FQI) is an assessment tool designed to evaluate how close the flora of an area is compared to one of undisturbed conditions. It can be used to identify natural areas, compare the quality of different sites, monitor long term floristic trends, and monitor habitat restoration efforts. A high FQI number indicates that a large number of sensitive, high quality plant species are present in the lake. Non-native species were also included in the FQI calculates for Lake county lakes. The FQI for White Lake was 0.0 This is significant decrease since the 2010 sampling when the FQI was 14.3.

LAKE COUNTY AVERAGE FQI = 13.7

WHITE LAKE FQI = 0

RANK = 166/171

AQUATIC PLANTS SPECIES OBSERVED = 1

NATIVE PLANT SPECIES: 1

Fig 11: *2010 White Lake Plant Rake*

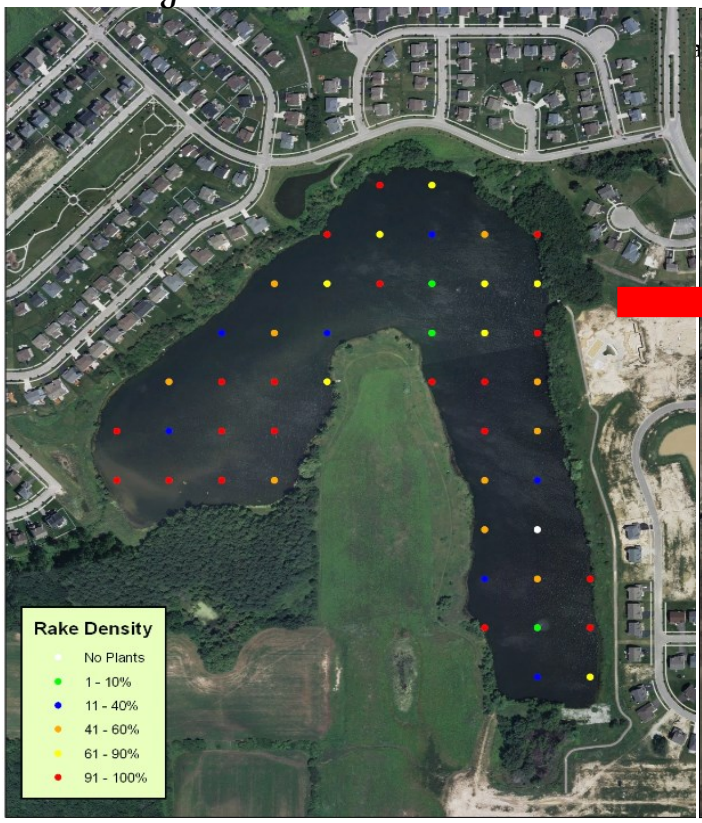
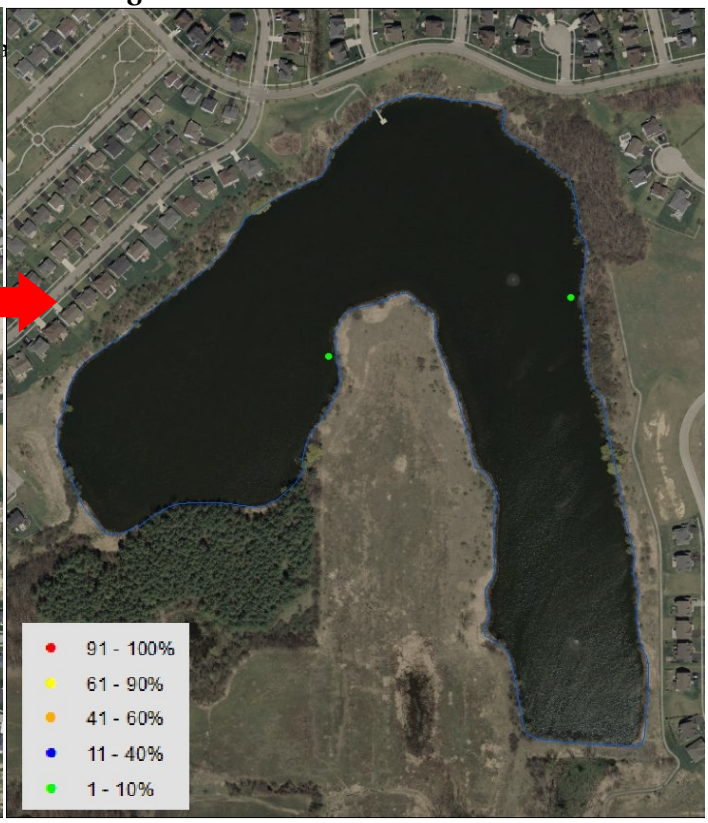


Figure 12: *2017 White Lake Plant Rake*



Fish

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 (Table 6). While many fish require some aquatic vegetation for growth, excessive amounts of aquatic vegetation can negatively impact growth by reducing foraging success. The Illinois Department of Natural Resources (IDNR) recommends 20-40% plant coverage for appropriate fish habitat. IDNR conducted a fish survey in 2009 on White Lake where a total of 5 species were observed (Table 5). No predators were collected or observed during this survey which suggests a catastrophic event occurred. Recommendations from IDNR include: stocking if funds are available specifically largemouth bass, channel catfish and northern pike. They also recommend removing and dispose of carp or yellow bass caught by fisherman. The Clublands of Antioch hired a consultant to preform an additional survey in 2013 due to another winter fish kill. The lake was stocked with largemouth bass, black crappie and channel catfish in the spring of 2014. An additional survey is anticipated for 2018. It is recommended to improve fish habitat to provide shelter and food for the fish species in the lake.

Table 5: *IDNR Fisheries Survey 2009*
Bluegill
Pumpkinseed Sunfish
Green Sunfish
Sunfish Hybrid
Black Crappie

Wildlife

Despite poor water quality, numerous great blue herons, painted turtles, mallards, and geese were frequently spotted during sampling. A significant portion of the shoreline has a large area of buffer, providing a good habitat for many waterfowl and other wildlife. Improving water quality will also benefit these wildlife.

Coarse Woody Habitat

An example of in-lake fish habitat that would be beneficial in White Lake is coarse woody habitat or large woody debris. CWT 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).

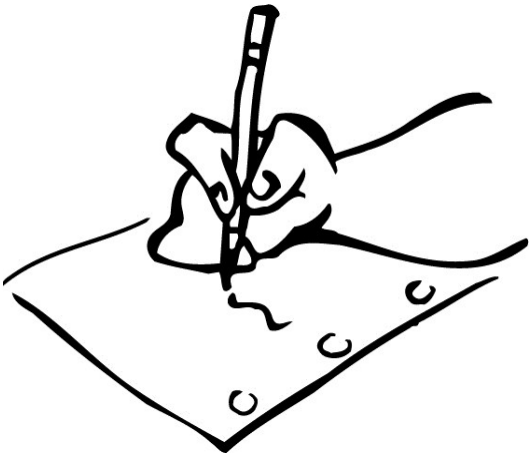
Lake management plans

It is recommended that a long term Lake Management Plan be developed to effectively manage lake issues. White Lake would benefit from a Lake Management Plan that includes appropriate algae control and aquatic plant restoration. 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

In general, White Lake has poor water quality and has been declining in overall water quality since it started being monitored in 2000. To improve the overall quality of White Lake and prevent any decline the ES (Ecological Services) has the following recommendations:

- Join the Volunteer Lake Monitoring Program to monitor yearly status of White Lake.
- Initiate a native aquatic plant restoration plan. This can be a combination of reduced herbicide treatments and physical plantings.
- Evaluate the effectiveness of aerating system. Since White Lake was weakly stratified, the aeration/fountain system may be doing more harm that what is benefited. Making sure the system is sized appropriately
- Re-assess fisheries. Many lakes have a fish-stocking program in which fish are stocked every year or two to supplement fish species already occurring in the lake or to introduce additional fish species into the system. However, few lakes that participate in stocking check the progress or success of these programs with regular fish surveys. Lake managers should have information about whether or not funds delegated to fish stocking are being well spent, and it is difficult to determine how stocked fish species are surviving and reproducing or how they are affecting the rest of the fish community without a comprehensive fish assessment. This can be done by surveying anglers (cheap and easy method), hiring a consultant, or waiting until the Department of Natural Resources updates their fisheries survey for your lake.
- Establish fish habitat structures in the lake. This includes increased aquatic vegetation but can also include artificial structures, coarse woody debris, and other alternatives.
- Develop a Lake Management Plan focusing on aquatic plant management and herbicide/algacide use.

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: 847-377-8020
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.

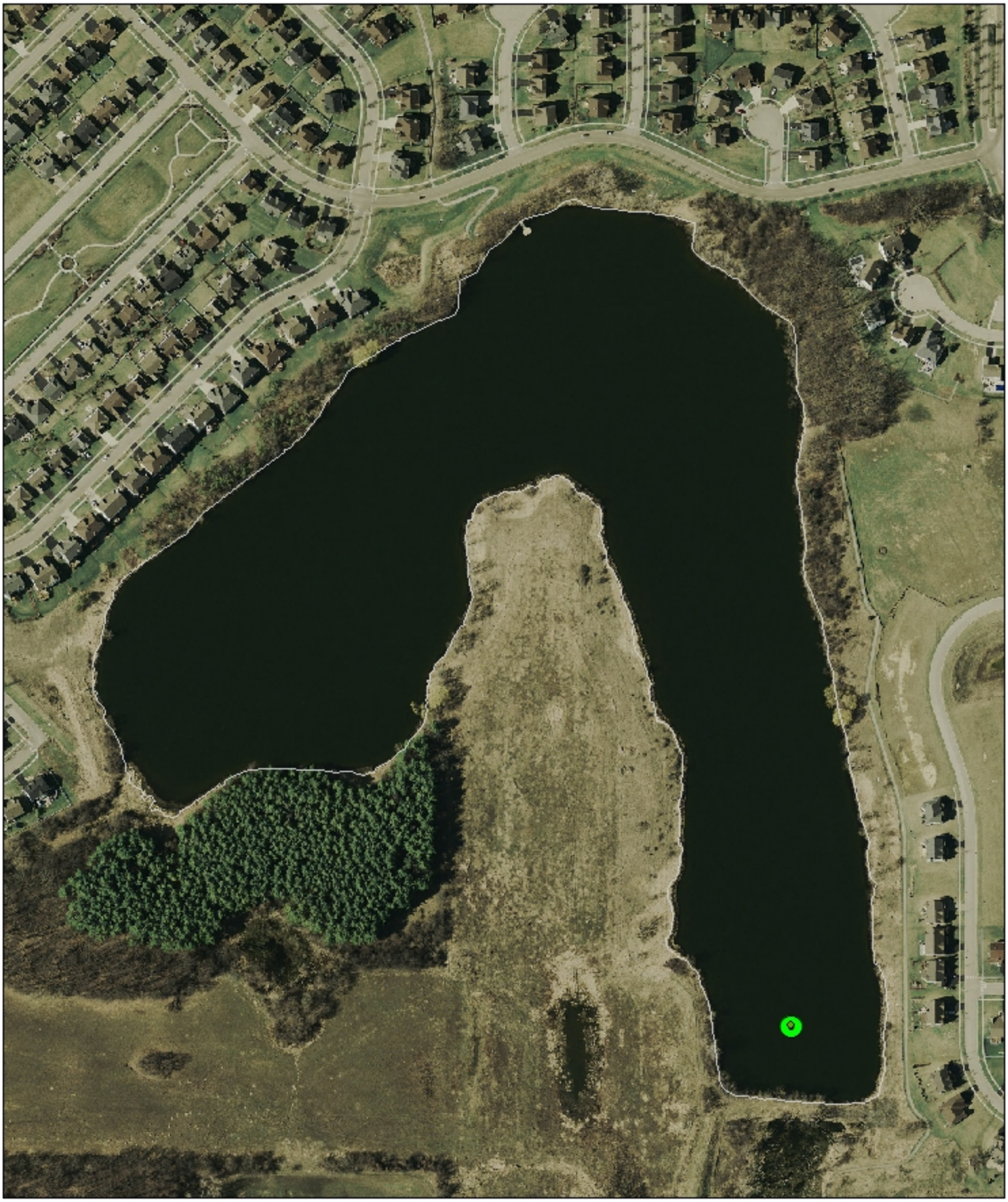
Environmental Service's goal is to monitor the quality of the county's surface water in order to:

- 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

White Lake Sampling Location

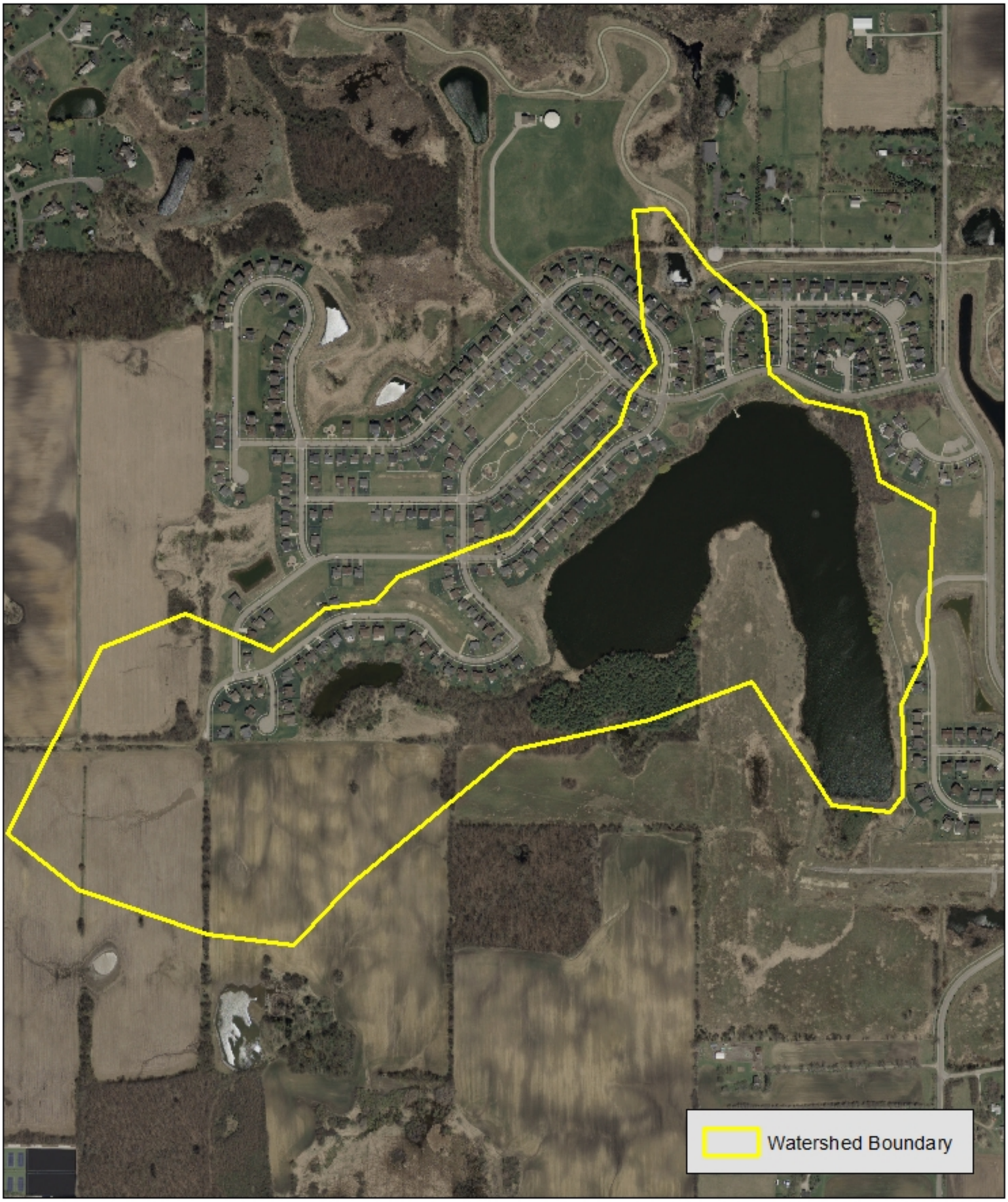


LakeCounty
Health Department and
Community Health Center

0 150 300 450 600 Feet

Ecological Services
Product Number WHT.17
Revised 05/2017

White Lake Watershed Boundary



LakeCounty
Health Department and Community Health Center

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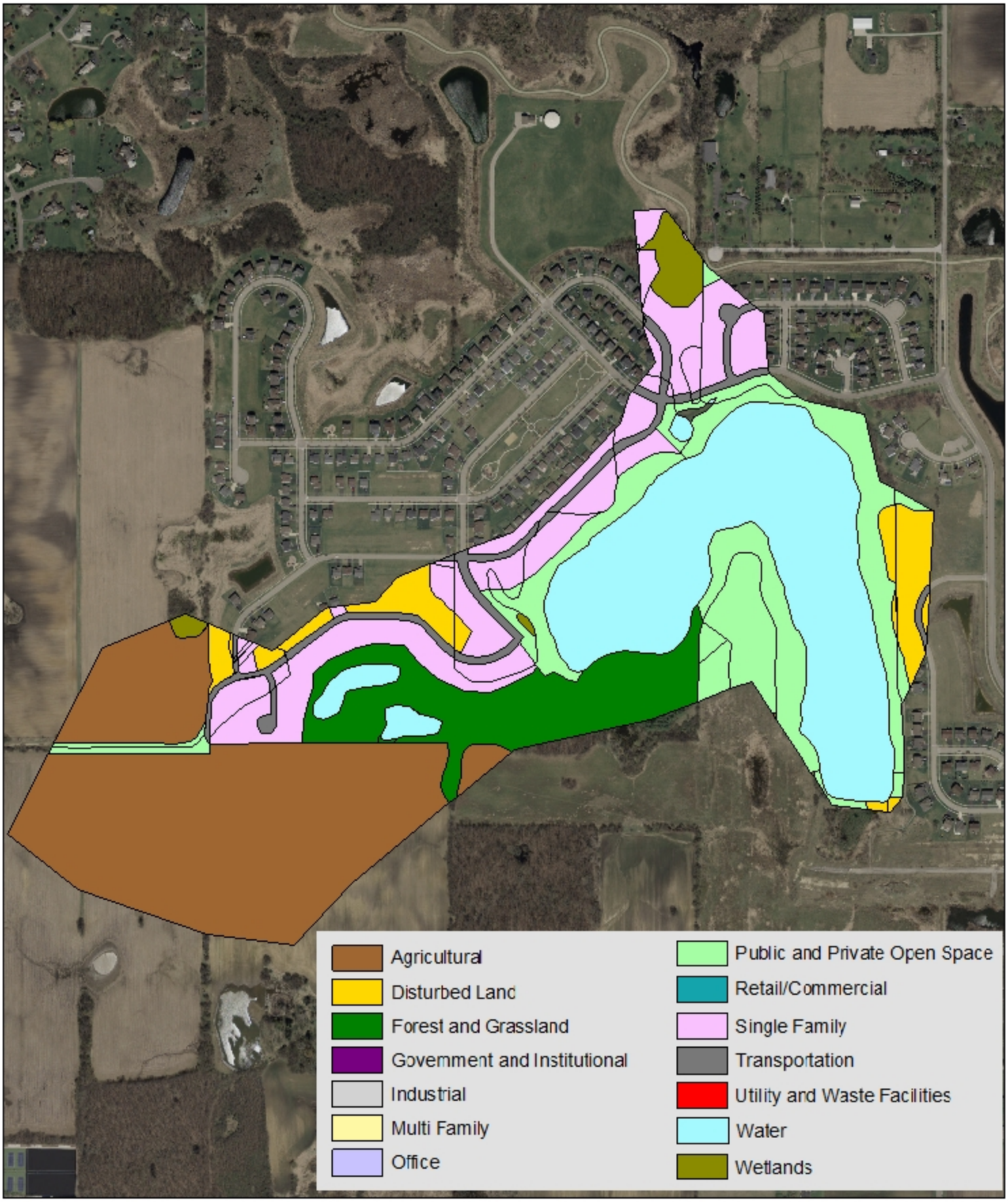
Ecological Services
Product Number WHT17
Revised 12/2017

White Lake Land Use



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Health Department and Community Health Center

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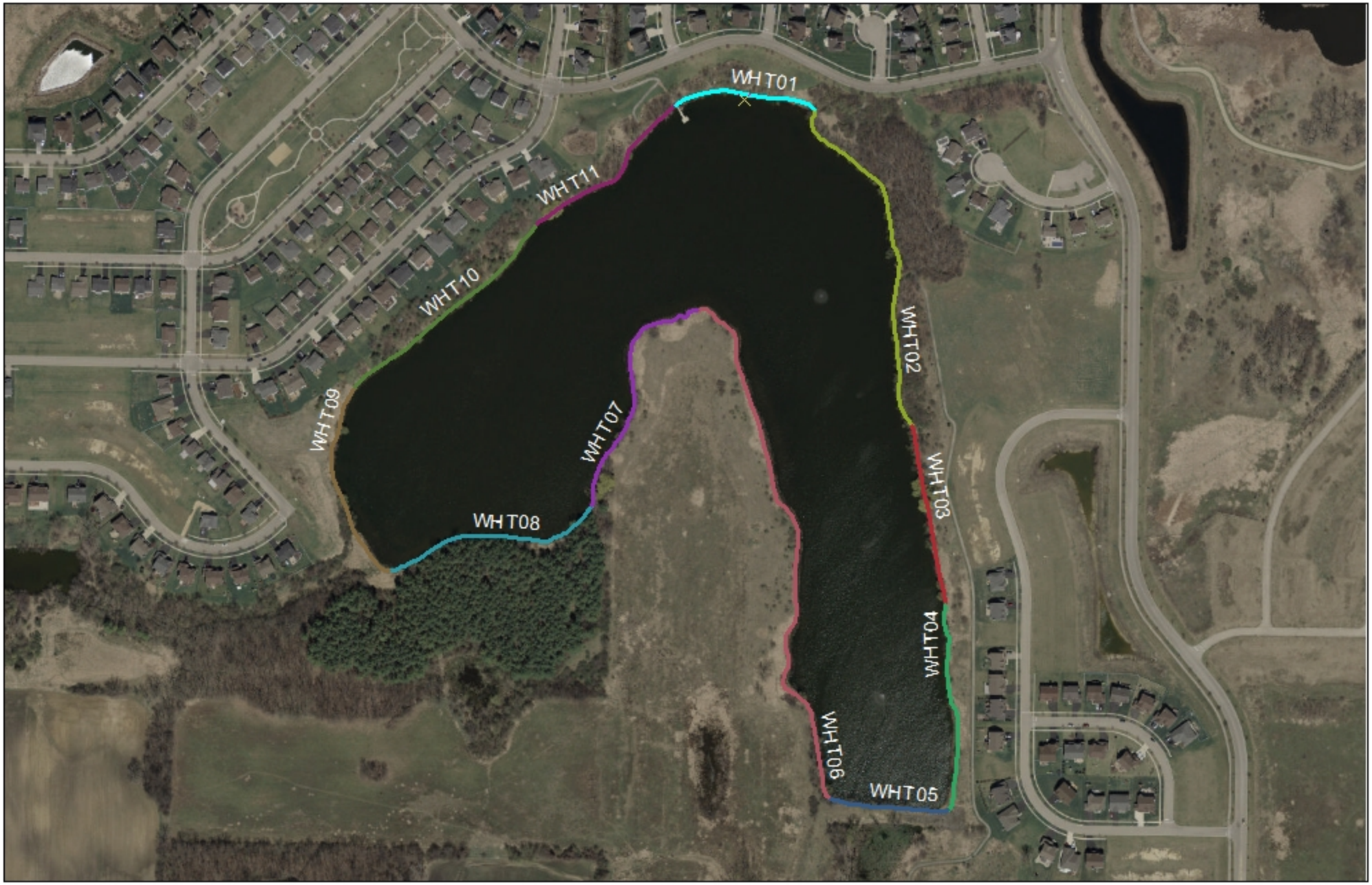
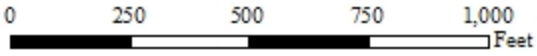
Ecological Services
Product Number WHT17
Revised 12/2017

White Lake Shoreline Reaches 2017

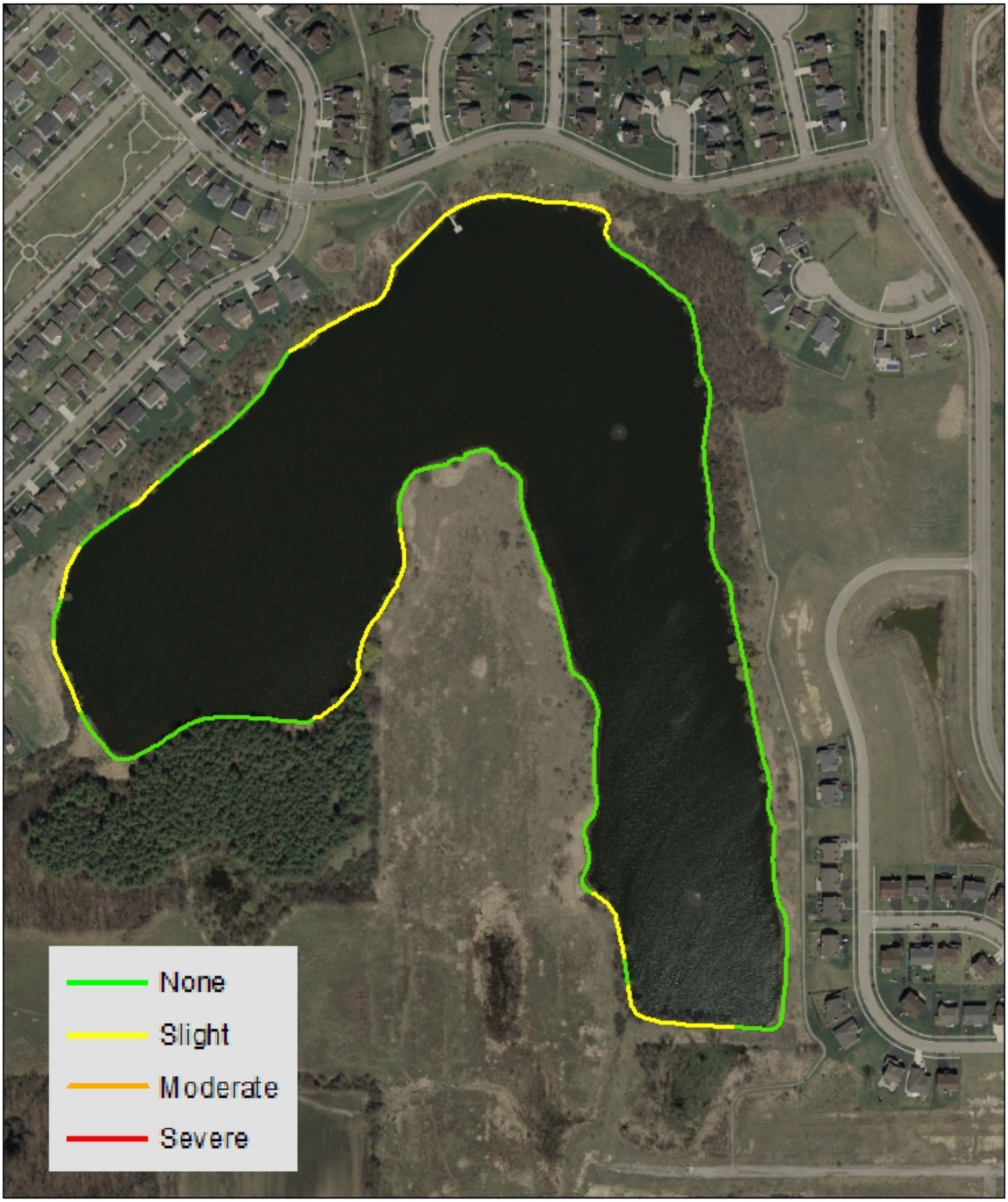


LakeCounty
Health Department and
Community Health Center



Ecological Services
Product Number WHT17
Revised 6/2016

White Lake Shoreline Erosion Condition, 2017

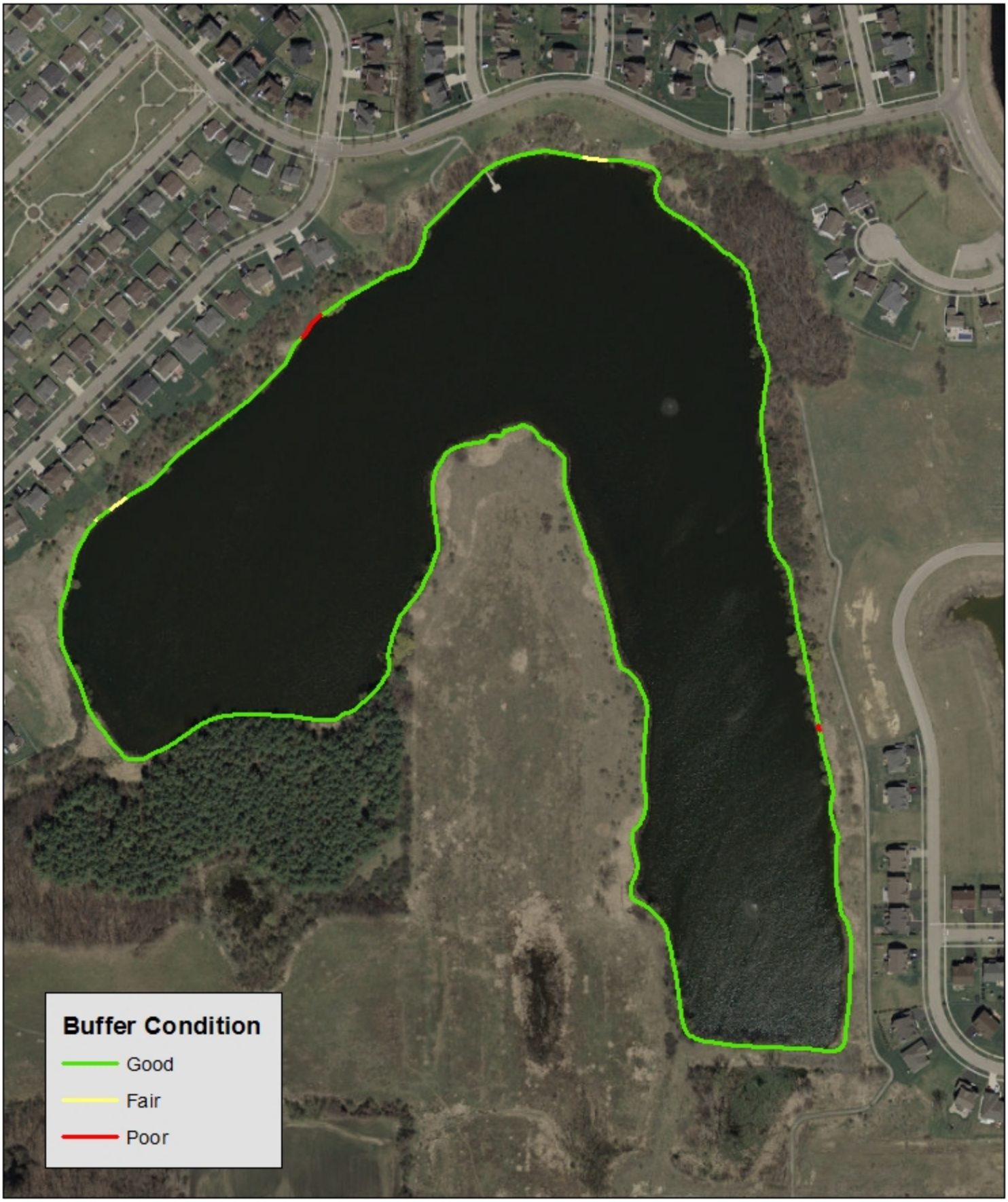


LakeCounty
Health Department and Community Health Center

0 150 300 450 600 Feet

Ecological Services
Product Number WHT17
Revised 12/2017

White Lake Shoreline Buffer Condition, 2017



LakeCounty
Health Department and Community Health Center

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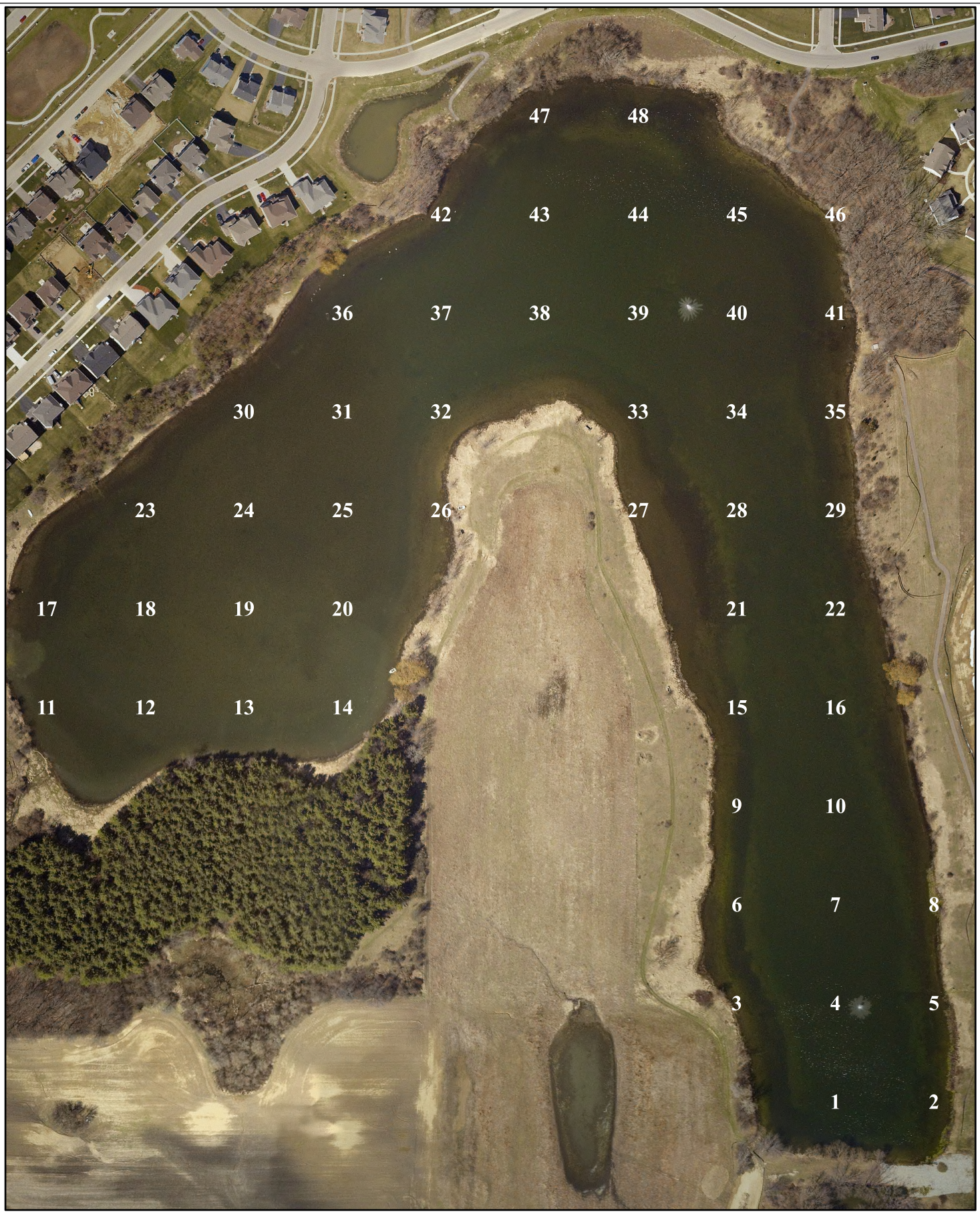
Ecological Services
Product Number WHT17
Revised 12/2017

White Lake Plant Grid 2017



LakeCounty
Health Department and
Community Health Center

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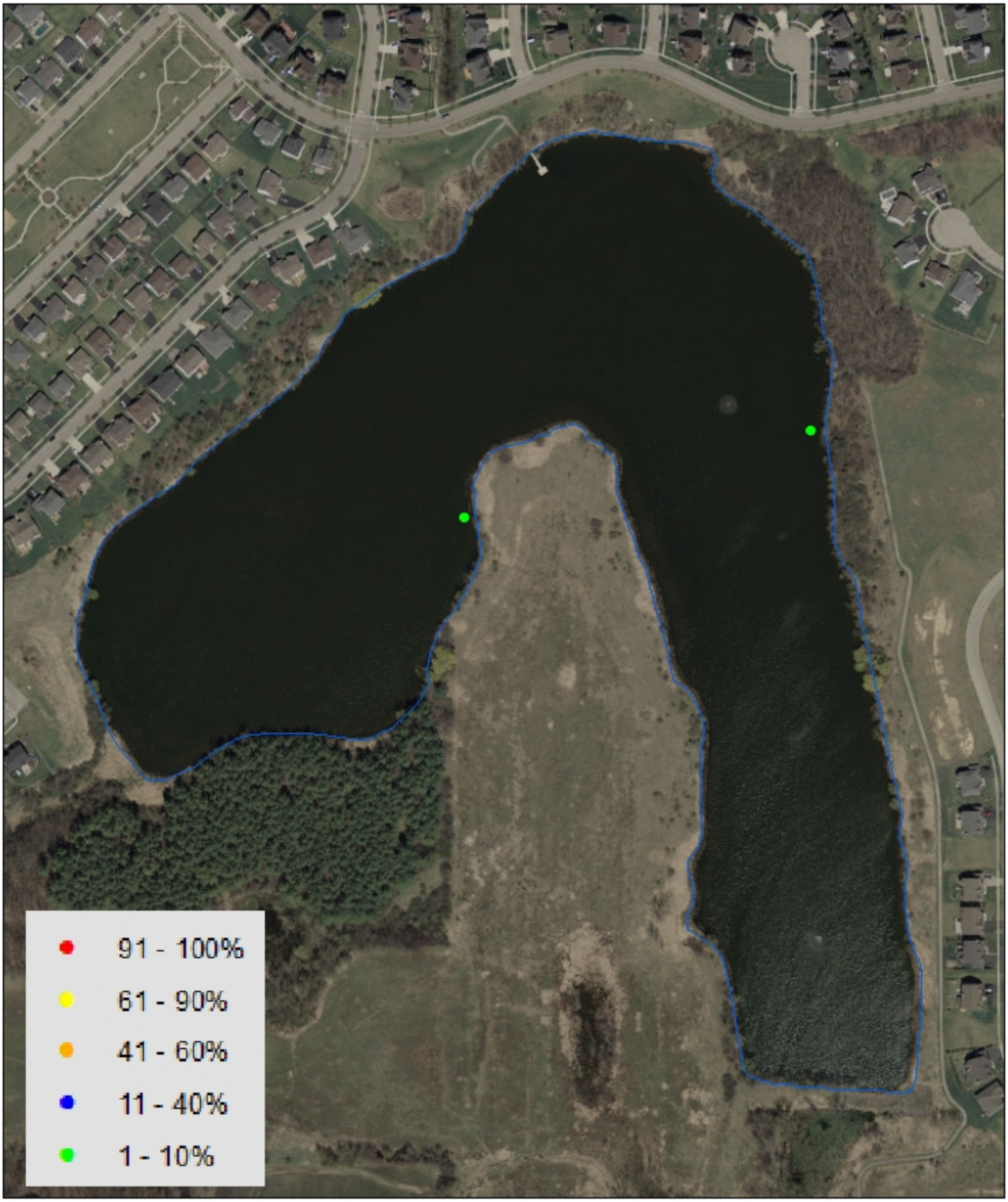
Enviornmental Services
Product Number WHT.PG10
Revised 07/2017

White Lake Plant Rake Density, August 2017



LakeCounty
Health Department and Community Health Center

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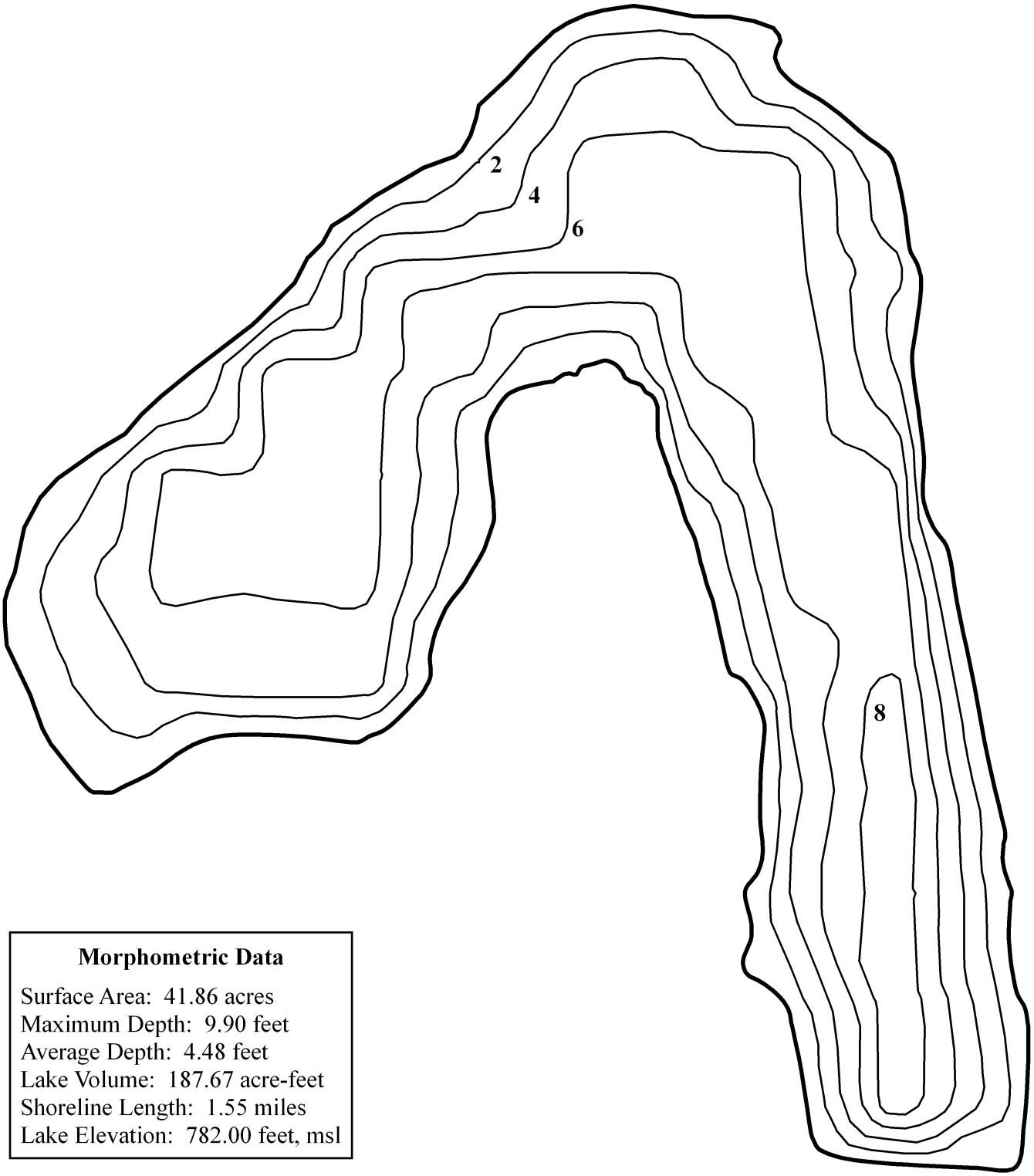
Ecological Services
Product Number WHT17
Revised 12/2017

Bathymetric Map of White Lake, Lake County, IL



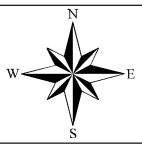
Morphometric Data

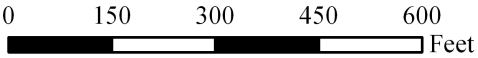
Surface Area: 41.86 acres
Maximum Depth: 9.90 feet
Average Depth: 4.48 feet
Lake Volume: 187.67 acre-feet
Shoreline Length: 1.55 miles
Lake Elevation: 782.00 feet, msl

Survey Data Collected July 15, 2010

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

LakeCounty
Health Department and
Community Health Center





Lakes Management Unit
Product Number WHT.BM10
Revised 11/2010

Appendix B:
Tables

White Lake Water Quality Summary Table
2000, 2006, 2010, and 2017

2017	Epilimnion															
DATE	DEPTH	ALK	TKN	NO_2+NO_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
18-May	3	135	1.36	<0.100	<0.05	0.096	0.0053	257	46	13.0	NA	100	2.08	0.4170	8.67	8.27
20-Jun	3	142	1.07	<0.100	<0.05	0.134	0.0071	262	50	33.0	361	109	0.70	0.4260	8.5	5.42
19-Jul	3	101	NA	NA	0.1	0.067	0.0190	230	68	27.0	260	114	1.51	0.3622	9.52	19.19
22-Aug	3	106	1.76	<0.100	<0.05	0.066	<0.005	214	39	9.8	257	153	1.40	0.3318	9.37	8.57
14-Sep	3	110	1.6	<0.100	<0.05	0.074	0.0058	217	42	8.9	254	105	1.98	0.3374	9.46	14.43
	Average	119	1.45	<0.100	.06[k]	0.087	.0084[k]	236	49	18.3	283	116	1.53	0.3749	9.10	11.18

2010	Epilimnion															
DATE	DEPTH	ALK	TKN	NO_2+NO_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
19-May	3	140	0.775	<0.100	<0.05	0.042	<0.005	NA	34	2.1	265	75	5.84	0.4080	8.78	12.29
16-Jun	3	141	0.96	<0.100	0.059	0.133	0.046	NA	37	4.7	251	106	6.80	0.4030	8.02	6.14
21-Jul	3	108	1.85	<0.100	<0.05	0.083	<0.005	NA	38	17.0	224	95	1.60	0.3390	9.50	8.62
18-Aug	3	110	2.05	<0.100	<0.05	0.111	<0.005	NA	36	8.0	221	94	2.20	0.3430	8.85	3.89
21-Sep	3	124	1.4	0.108	<0.05	0.062	<0.005	NA	38	4.9	232	86	3.34	0.3740	8.17	5.98
	Average	125	1.41	0.108	0.059	0.086	0.046	NA	37	7.3	239	91	3.96	0.3734	8.664	7.38

2006	Epilimnion	ALK	TKN	NO_2+NO_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	3	158	0.90	<0.100	<0.05	0.034	<0.005	261	29.8	1.8	259	101	6.89	0.4250	8.53	11.11
21-Jun	3	138	0.93	<0.100	<0.05	0.038	<0.005	242	30.4	1.5	241	94	9.02	0.3870	8.44	6.57
19-Jul	3	148	1.13	<0.100	<0.05	0.038	<0.005	249	31.6	3.0	256	107	7.05	0.4010	8.53	4.75
16-Aug	3	165	1.18	<0.100	<0.05	0.043	<0.005	280	34.4	3.0	277	108	6.40	0.4620	7.83	4.28
20-Sep	3	166	1.36	0.208	<0.05	0.051	0.013	275	35.7	1.7	268	99	8.33	0.4520	7.75	4.27
	Average	155	1.10	0.208[k]	<0.05	0.041	.013[k]	261	32.4	2.2	260	102	7.54	0.4254	8.51	6.20

2000	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
9-May	3	101	0.73	<0.100	<0.05	0.037	0.007	150	NA	2.9	150	69	8.30	0.2305	9.69	6.66
13-Jun	3	105	<0.5	<0.100	0.052	0.095	0.032	170	NA	1.9	172	78	6.40	0.2461	8.68	5.52
12-Jul	3	114	1.05	<0.100	<0.05	0.071	0.016	170	NA	3.6	188	96	5.74	0.2545	8.75	1.97
15-Aug	3	115	1.70	<0.100	<0.05	0.032	<0.005	180	NA	7.8	199	91	5.87	0.2584	8.78	2.36
12-Sep	3	150	0.96	<0.100	<0.05	0.029	<0.005	200	NA	2.0	220	82	6.92	0.3329	7.37	0.84
	Average	121	0.93[k]	0.100[k]	0.05[k]	0.057	0.02[k]	180	NA	3.8	195	87	6.23	0.2730	8.40	3.47

2006	Hypolimnion															
DATE	DEPTH	ALK	TKN	NO_2+NO_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	6	157	1.02	<0.1	<0.05	0.037	<0.005	NA	29.6	2.0	259	93	NA	0.4310	8.35	9.37
21-Jun	6	138	0.95	<0.1	<0.05	0.031	<0.005	NA	30.4	1.3	241	95	NA	0.3870	8.44	6.61
19-Jul	6	150	1.17	<0.1	<0.05	0.049	<0.005	NA	31.5	3.5	266	114	NA	0.4020	8.37	3.07
16-Aug	6	209	1.83	<0.1	<0.05	0.101	<0.005	NA	33.8	8.0	309	106	NA	0.5090	6.9	1.04
	Average	164	1.24	<0.1	<0.05	0.055	<0.005	NA	31.3	3.7	269	102	NA	0.6447	8.51	5.02

2000	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
9-May	7	145	1.00	<0.1	<0.05	0.038	0.009	190	NA	4.4	181	66	NA	0.2988	8.43	4.45
13-Jun	8	126	1.23	<0.1	0.078	0.221	0.071	160	NA	13.0	189	94	NA	0.3031	8.22	0.09
12-Jul	8	196	1.85	<0.1	<0.05	0.271	0.034	236	NA	20.0	258	100	NA	0.3923	6.82	0.17
15-Aug	7	205	1.60	<0.1	<0.05	0.160	<0.005	264	NA	31.0	303	121	NA	0.4362	6.83	0.05
12-Sep	7.5	153	1.18	<0.1	<0.05	0.035	<0.005	190	NA	1.9	212	86	NA	0.3375	7.33	0.19
	Average	165	1.37	<0.1	0.078[k]	0.15	0.04[k]	208	NA	14.1	229	93	NA	0.3536	7.53	0.99

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

White Lake 2017 Multiparameter Data

Date MMDDYY	Depth feet	Depth Text feet	Temp °C	spCond mS/cm	DO mg/L	DO Sat Saturation	pH Unit	BGA RFU
5/18/2017	0.768	0.5	20.940	0.4175	8.39	94.1	8.66	0.37
5/18/2017	1.355	1.0	20.947	0.4177	8.35	93.7	8.68	0.40
5/18/2017	2.165	2.0	20.914	0.4177	8.31	93.1	8.68	0.48
5/18/2017	3.251	3.0	20.883	0.4179	8.27	92.6	8.67	0.51
5/18/2017	4.311	4.0	20.565	0.4200	7.91	88.1	8.66	0.46
5/18/2017	5.039	5.0	20.313	0.4218	7.60	84.2	8.62	0.47
5/18/2017	7.149	7.0	18.522	0.4355	5.78	61.8	8.43	0.51
5/18/2017	8.163	8.0	15.937	0.4524	0.69	7.0	8.30	1.16
5/18/2017	8.839	9.0	14.722	0.4665	0.28	2.7	8.02	3.23

Date MMDDYY	Depth feet	Depth Text feet	Temp °C	spCond mS/cm	DO mg/L	DO Sat Saturation	pH Unit	BGA RFU
6/20/2017	0.492	0.5	25.347	0.4211	9.29	113.2	8.72	5.98
6/20/2017	1.086	1.0	24.916	0.4218	8.22	99.4	8.71	5.09
6/20/2017	2.083	2.0	24.333	0.4257	6.05	72.4	8.59	4.30
6/20/2017	3.068	3.0	24.245	0.4265	5.42	64.8	8.50	3.84
6/20/2017	4.091	4.0	24.235	0.4268	5.26	62.8	8.43	3.65
6/20/2017	5.095	5.0	24.217	0.4268	5.12	61.2	8.40	3.36
6/20/2017	6.037	6.0	24.077	0.4291	4.07	48.5	8.29	3.00
6/20/2017	7.044	7.0	23.994	0.4308	3.21	38.2	8.17	3.02
6/20/2017	8.045	8.0	23.793	0.4344	2.65	31.4	8.07	2.90
6/20/2017	8.501	8.5	23.504	0.4423	1.37	16.2	7.88	2.86

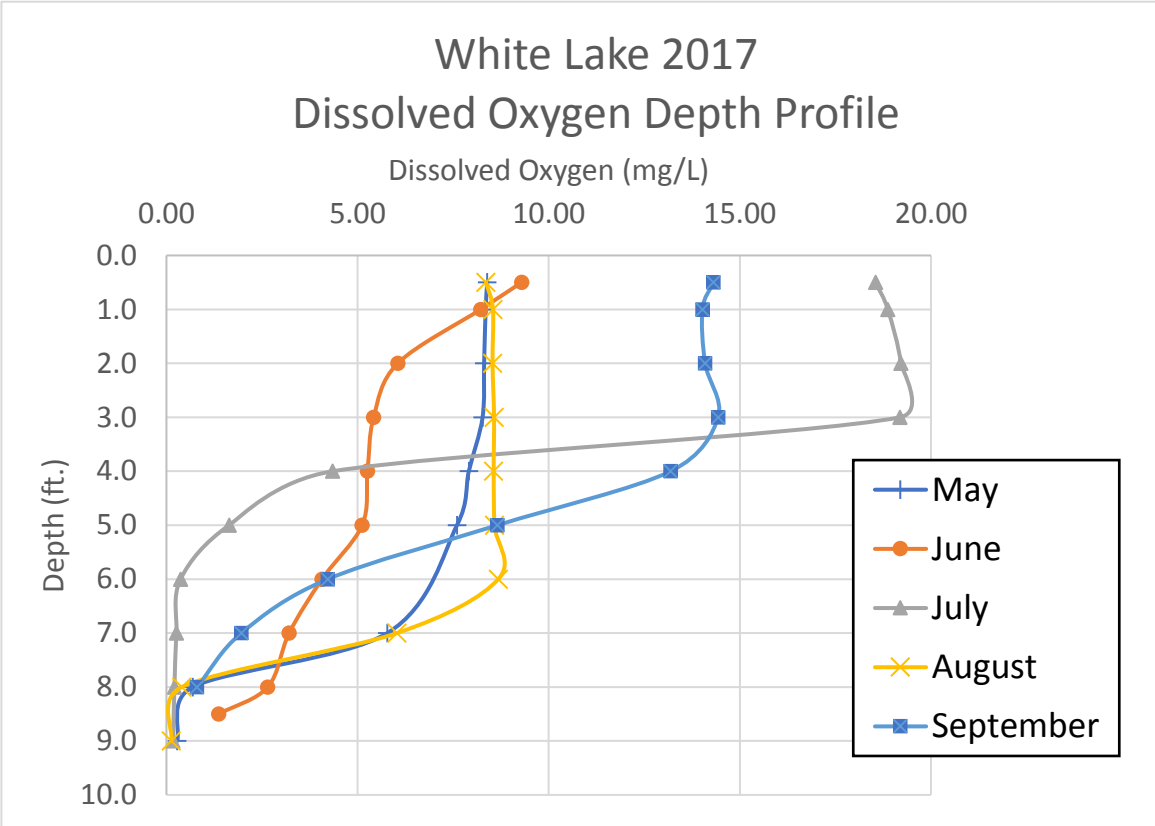
Date MMDDYY	Depth feet	Depth Text feet	Temp °C	spCond mS/cm	DO mg/L	DO Sat Saturation	pH Unit	BGA RFU
7/19/2017	0.541	0.5	27.259	0.3623	18.55	234.0	9.53	2.42
7/19/2017	1.122	1.0	27.257	0.3623	18.87	238.1	9.53	2.60
7/19/2017	2.054	2.0	27.275	0.3624	19.21	242.5	9.54	2.48
7/19/2017	3.064	3.0	27.190	0.3622	19.19	241.8	9.52	2.85
7/19/2017	4.364	4.0	23.772	0.3771	4.35	51.5	8.29	2.11
7/19/2017	5.039	5.0	23.532	0.3816	1.64	19.3	7.93	2.34
7/19/2017	6.076	6.0	23.420	0.3844	0.37	4.3	7.80	3.63
7/19/2017	7.136	7.0	23.273	0.3849	0.26	3.1	7.71	4.30
7/19/2017	8.153	8.0	23.060	0.3911	0.21	2.5	7.55	4.10
7/19/2017	8.871	9.0	22.831	0.3998	0.17	1.9	7.41	3.93

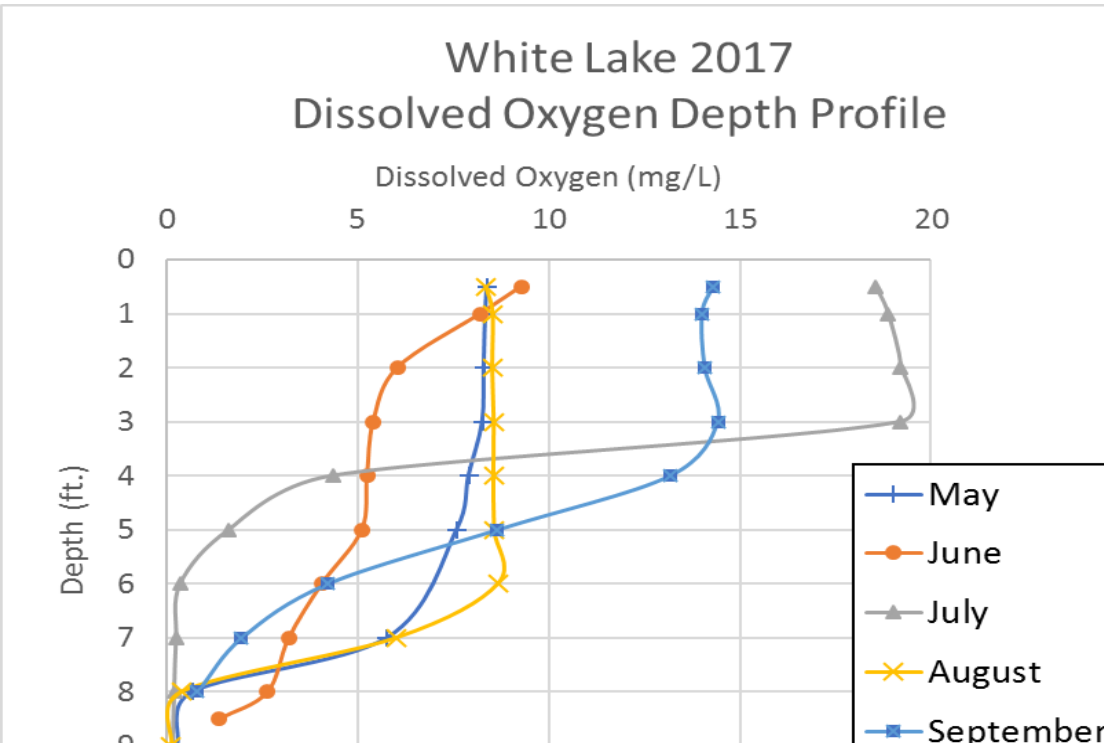
White Lake 2017 Multiparameter Data

Date MMDDYY	Depth feet	Depth Text feet	Temp °C	spCond mS/cm	DO mg/L	DO Sat Saturation	pH Unit	BGA RFU
8/22/2017	0.3445	0.5	24.817	0.3318	8.36	100.9	9.35	1.97
8/22/2017	1.0039	1.0	24.833	0.3318	8.54	103.2	9.37	1.66
8/22/2017	2.0210	2.0	24.830	0.3319	8.53	103.0	9.37	1.62
8/22/2017	3.0709	3.0	24.833	0.3318	8.57	103.5	9.37	1.56
8/22/2017	4.0617	4.0	24.826	0.3318	8.56	103.4	9.36	2.16
8/22/2017	5.0164	5.0	24.827	0.3318	8.58	103.6	9.36	1.79
8/22/2017	6.0105	6.0	24.792	0.3317	8.68	104.7	9.36	2.07
8/22/2017	7.0899	7.0	24.543	0.3344	6.03	72.4	9.19	2.29
8/22/2017	8.0479	8.0	23.739	0.3527	0.40	4.7	8.32	4.41
8/22/2017	8.9075	9.0	23.388	0.3935	0.13	1.5	7.14	1.76

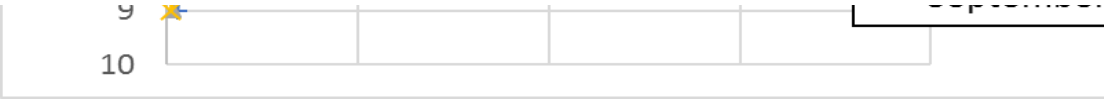
Date MMDDYY	Depth feet	Depth Text feet	Temp °C	spCond mS/cm	DO mg/L	DO Sat Saturation	pH Unit	BGA RFU
9/14/2017	0.5577	0.5	22.201	0.3372	14.31	164.4	9.46	0.71
9/14/2017	0.9875	1.0	21.349	0.3383	14.02	158.6	9.45	1.07
9/14/2017	2.3753	2.0	20.726	0.3381	14.09	157.4	9.44	1.18
9/14/2017	3.0315	3.0	20.535	0.3374	14.43	160.5	9.46	1.24
9/14/2017	4.0453	4.0	20.313	0.3378	13.19	146.1	9.40	1.33
9/14/2017	5.2001	5.0	19.530	0.3431	8.66	94.5	9.22	2.00
9/14/2017	6.1155	6.0	19.219	0.3479	4.22	45.7	8.85	1.98
9/14/2017	7.1883	7.0	18.959	0.3518	1.96	21.1	8.66	2.42
9/14/2017	8.0118	8.0	18.880	0.3550	0.80	8.6	8.38	0.62

White Lake 2017 Multiparameter Data





White Lake 2017 Multiparameter Data



White Lake 2017 Multiparameter Data

White Lake 2017 Multiparameter Data

White Lake 2017 Land Use

Land Use	Acreage	% of Total
Agricultural	52.90	28.8%
Disturbed Land	8.50	4.6%
Forest and Grassland	17.53	9.5%
Government and Institutional	0.00	0.0%
Industrial	0.00	0.0%
Multi Family	0.00	0.0%
Office	0.00	0.0%
Public and Private Open Space	26.32	14.3%
Retail/Commercial	0.00	0.0%
Single Family	25.25	13.8%
Transportation	6.36	3.5%
Utility and Waste Facilities	0.00	0.0%
Water	43.88	23.9%
Wetlands	2.90	1.6%
Total Acres	**183.63**	**100.0%**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Agricultural	52.90	0.05	7.3	4.2%
Disturbed Land	8.50	0.05	1.2	0.7%
Forest and Grassland	17.53	0.05	2.4	1.4%
Government and Institutional	0.00	0.50	0.0	0.0%
Industrial	0.00	0.50	0.0	0.0%
Multi Family	0.00	0.50	0.0	0.0%
Office	0.00	0.85	0.0	0.0%
Public and Private Open Space	26.32	0.15	10.9	6.3%
Retail/Commercial	0.00	0.85	0.0	0.0%
Single Family	25.25	0.30	20.8	12.1%
Transportation	6.36	0.50	8.7	5.1%
Utility and Waste Facilities	0.00	0.30	0.0	0.0%
Water	43.88	1.00	120.7	70.0%
Wetlands	2.90	0.05	0.4	0.2%
TOTAL	**183.63**		**172.3**	100.0%

Lake volume	**187.67**	**acre-feet**
Retention Time (years)= lake volume/runoff	**1.09**	**years**
	397.46	**days**

White 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
WHT01	0.0	0%	444.9	100%	0.0	0%	0.0	0%	444.9	0.03
WHT02	1023.4	94%	65.1	6%	0.0	0%	0.0	0%	1088.5	0.01
WHT03	555.4	100%	0.0	0%	0.0	0%	0.0	0%	555.4	0.01
WHT04	639.3	100%	0.0	0%	0.0	0%	0.0	0%	639.3	0.01
WHT05	107.3	29%	262.7	71%	0.0	0%	0.0	0%	369.9	0.02
WHT06	1384.1	83%	276.8	17%	0.0	0%	0.0	0%	1660.9	0.01
WHT07	334.5	44%	431.7	56%	0.0	0%	0.0	0%	766.1	0.02
WHT08	531.6	77%	154.8	23%	0.0	0%	0.0	0%	686.3	0.01
WHT09	271.6	43%	361.0	57%	0.0	0%	0.0	0%	632.7	0.02
WHT10	610.2	81%	146.9	19%	0.0	0%	0.0	0%	757.1	0.01
WHT11	0.0	0%	572.3	100%	0.0	0%	0.0	0%	572.3	0.03
Total	5457.4	67%	2716.1	33%	0.0	0%	0.0	0%	8173.5	0.01

White Lake Shoreline Buffer Condition, 2017

Reach	Good		Fair		Poor		Total
	ft.	%	ft.	%	ft.	%	ft
WHT01	388.1	87%	56.8	13%	0.0	0%	444.9
WHT02	1088.5	100%	0.0	0%	0.0	0%	1088.5
WHT03	540.6	97%	0.0	0%	14.8	3%	555.4
WHT04	639.3	100%	0.0	0%	0.0	0%	639.3
WHT05	369.9	100%	0.0	0%	0.0	0%	369.9
WHT06	1660.9	100%	0.0	0%	0.0	0%	1660.9
WHT07	766.1	100%	0.0	0%	0.0	0%	766.1
WHT08	686.3	100%	0.0	0%	0.0	0%	686.3
WHT09	632.7	100%	0.0	0%	0.0	0%	632.7
WHT10	651.7	86%	58.7	8%	46.8	6%	757.1
WHT11	546.2	95%	0.0	0%	26.1	5%	572.3
Total	7970.5	98%	115.5	1%	87.6	1%	8173.6

Morphometric Features of White Lake ~
Data From the July 2010 Aquatic Plant Survey, LCHD Environmental Services

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	41.86	100%	39.88	0 - 1	3.92	9.4%	21.3%
1	37.94	91%	35.88	1 - 2	4.08	9.8%	19.1%
2	33.86	81%	31.71	2 - 3	4.24	10.1%	16.9%
3	29.62	71%	27.36	3 - 4	4.45	10.6%	14.6%
4	25.16	60%	22.69	4 - 5	4.87	11.6%	12.1%
5	20.30	48%	16.91	5 - 6	6.56	15.7%	9.0%
6	13.73	33%	8.70	6 - 7	9.23	22.0%	4.6%
7	4.51	11%	2.97	7 - 8	2.85	6.8%	1.6%
8	1.66	4%	1.10	8 - 9	1.04	2.5%	0.6%
9	0.62	1.5%	0.47	9+	0.62	1.5%	0.3%
			187.67		41.86	100%	100%

Maximum Depth of Lake: 9.90 feet
Average Depth of Lake: 4.48 feet
Volume of Lake: 187.67 acre-feet

Area of Lake: 41.86 acres
Shoreline Length: 1.55 miles
Water Elevation at 782.00 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

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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

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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