LAKE COUNTY, IL

2016 SUMMERHILL ESTATES LAKE SUMMARY REPORT

LAKE COUNTY HEALTH DEPARTMENT

ECOLOGICAL SERVICES

Summerhill Estates Lake, 2016

Summerhill Estates Lake is a glacial lake located in unincorporated Lake County and Fremont Township. The lake has a surface area of 54.0 acres and a mean depth of 2.8 feet. The Lake County Forest Preserve District manages the undeveloped property along the north and east of the lake allowing the public recreational hiking opportunities. The homeowners located on the south side of the lake utilize the lake for aesthetics, boating, and swimming. Summerhill Estates Lake is listed as an ADID (advanced identification) wetland by the U.S. Environmental Protection Agency. This indicates that the lake and surrounding natural environments have potential to have high quality aquatic resources based on water quality and hydrology values.

In 2016, the Lake County Health Department– Ecological Services (LCHD-ES) monitored Summerhill Estates Lake as part of routine water quality sampling. Since Summerhill Estates Lake is a shallow lake system, one sample was collected at the deepest location in the lake. Samples were analyzed for nutrients, solid concentrations and other physical parameters. Additionally, an aquatic plant survey and shoreline assessment survey were conducted in August (2016). This report summarizes the water quality sampling results, aquatic plant survey, and shoreline survey conducted on Summerhill Estates Lake by the LCHD-ES for 2016.

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LAKE FACTS

MAJOR WATERSHED:
FOX RIVER

SUB-WATERSHED:
SQUAW CREEK

SURFACE AREA:
54.0 ACRES

SHORELINE LENGTH:
2.2 MILES

MAXIMUM DEPTH:
6.9 FEET

AVERAGE DEPTH:
2.8 FEET

LAKE VOLUME:
152.6 ACRE-FEET

WATERSHED AREA:
290.8 ACRES

LAKE TYPE:
GLACIAL

CURRENT USES:
FISHING, SWIMMING, BOATING, AND AESTHETICS

ACCESS:
PRIVATE, SUMMERHILL ESTATES LAKE RESIDENTS ONLY

SUMMERHILL ESTATES SUMMARY

Following is a summary of the water quality sampling, shoreline survey and aquatic macrophyte survey from the 2016 monitoring season on Summerhill Estates Lake. Historically, Summerhill Estates Lake had poor water quality. Many parameters did improve since the 2009 sampling. The complete data sets can be found in Appendix A&B of this report, and discussed in further detail in the following sections. There is also an "Understanding Your Lake Data" guide located in the Appendix that can be used to further understand the water chemistry results.

- Average water clarity is measured by Secchi depth. In 2016, Secchi Depth was 3.84 ft., which is a 17% increase since 2009 (3.27 ft.), and is above the Lake County median Secchi depth of 2.98 ft.
- Water clarity is influenced by amount of particles in the water column (both algal cells and sediment) and this is measured by total suspended solids. The average TSS concentrations on Summerhill Estates Lake was 4.7 mg/L in 2016, which is below the Lake County median of 8.2 mg/L. It was a significant decrease of 50% since 2009 (9.4 mg/L).
- Nutrient availability indicated that Summerhill Estates Lake was phosphorus limited with an average TN:TP ratio of 21:1.
- In 2016 the average total phosphorus concentration was 0.051mg/L. This is slightly above the Illinois Environmental Protection Agency (IEPA) water quality standard of 0.050 mg/L and classifies Summerhill Estates Lake as impaired.
- While above the IL EPA water quality standard for phosphorus, there was a significant decrease in total phosphorus concentrations since 2009. In 2009, total phosphorus concentrations averaged 0.199 mg/L and decreased 74% to 0.051 mg/L in 2016.
- Trophic State index (TSIp) value for Summerhill Estates Lake is 60.9 meaning Summerhill Estates Lake is eutrophic.
- A dissolved oxygen (DO) concentration of 5.0 mg/L is considered adequate to support fisheries and fish can suffer oxygen stress when DO drops below these levels. DO concentrations did drop below 5 mg/L for all months of the sampling season.
- Dissolved oxygen concentrations did reach anoxic conditions (<1 mg/L) during the sampling period, except for the August sampling date.
- The aquatic macrophyte survey showed that 100% of the sampling sites had plant coverage.
- A total of 9 plant species and 1 macro-algae (Chara) were present in Summerhill Estates Lake in 2016.
- The most dominant aquatic plants was Coontail followed by White Water Lily.
- Two aquatic invasive plant species were present including Curlyleaf Pondweed and Eurasian Watermilfoil. While Curlyleaf Pondweed was observed during our sampling in August at 3.4% of the sampling sites, Curlyleaf Pondweed had substantial plant coverage earlier in the season.
- 10% of Summerhill Estate's shoreline was experiencing some degree of erosion. The low percentage of erosion is due to the extensive amount of emergent vegetation that borders the lake shoreline.

Summerhill Estates Lake is in the Squaw Creek Watershed.

2016 LAKES SAMPLED

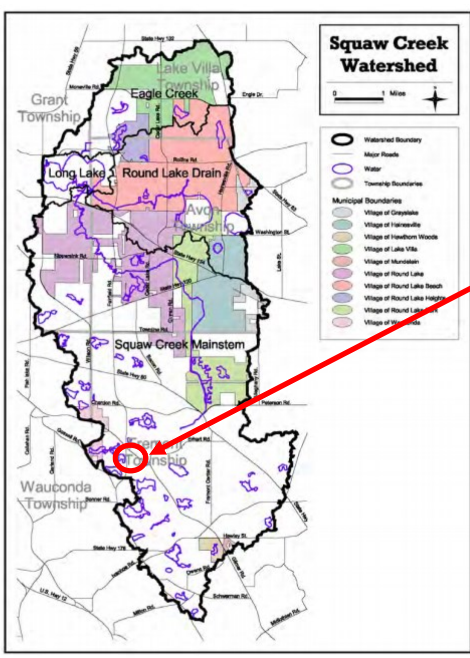
- Ames Pit
- Bresen Lake
- Lake Carina
- Des Plaines Lake
- Duck Lake
- Fischer Lake
- Fish Lake
- Independence Grove
- Lochanora Lake
- Sterling Lake
- Summerhill Lake
- Wooster Lake

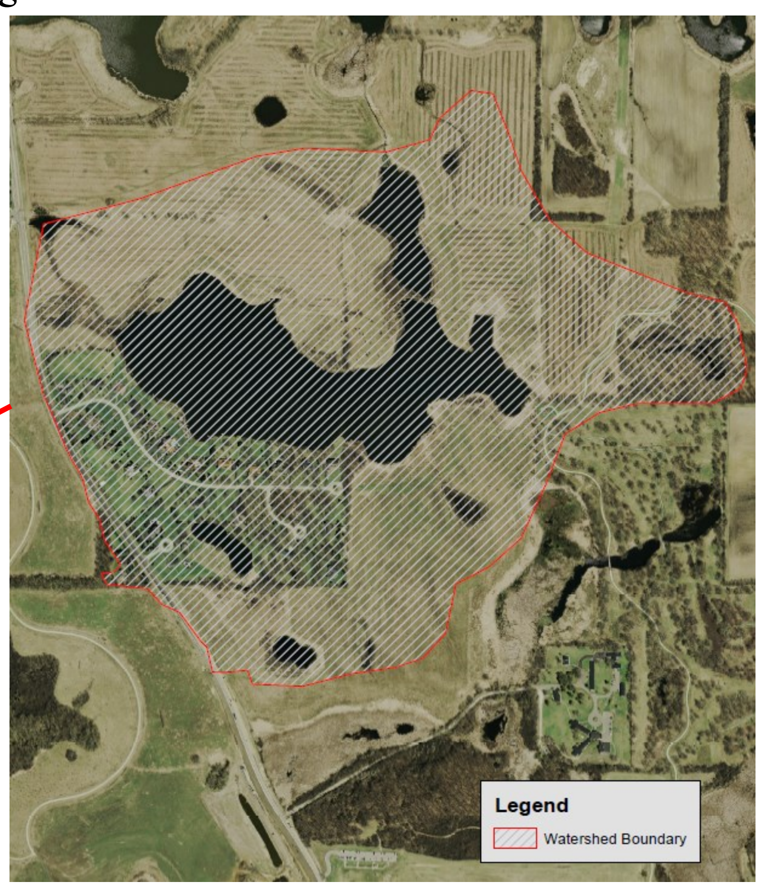
WATERSHED & LANDUSE

A watershed is an area of land where all surface water from rain, melting snow and ice, converge at a lower elevation, usually a lake, river, or other body of water. The source of a lake's water supply is very important in determining its water quality and choosing management practices to protect the lake. Summerhill Estates Lake receives water from its 290.78 acre watershed and drains into Mud Lake through a creek located on the north side which enters Squaw Creek and eventually the Fox River (Fig 1). The watershed to lake ratio is important in understanding how nutrients enter the lake. Summerhill Estates Lake has a small watershed to lake ratio (5:1), however, once pollutants enter the lake they are retained there for up to 1.12 years. Therefore it becomes important to properly manage the lands in a way that minimizes pollutants such as phosphorus, nitrogen, and chlorides from entering the lake.

The Lake County Stormwater Management Commission has created a Squaw Creek Watershed Management Plan adopted in 2004. The plan was developed to provide a "blueprint" for reducing flood damages, improving water quality, and protecting natural resources at a watershed scale. Summerhill Estates Lake is included in this plan as an Advanced Identification Wetland (ADID) number 118. Summerhill Estates Lake has the functional ADID values of: the presence of state threatened or endangered species of bird and also acts at stormwater storage, sediment/toxin retention, and shoreline /bank stabilization. For more information on the Squaw Creek Watershed Plan, visit the Stormwater Management Commission website at: https://www.lakecountyil.gov/2437/Watershed-Management-Plans

Figure 1: Summerhill Estates Lake Watershed





Everyone lives in a watershed! A watershed is an area of land where surface water from rain and melting snow meet at a point, such as a lake or stream.

As a watershed is developed, the amount of impervious surface increases resulting in a greater influx of runoff entering our waters due to reduced infiltration of rainwater into the ground.

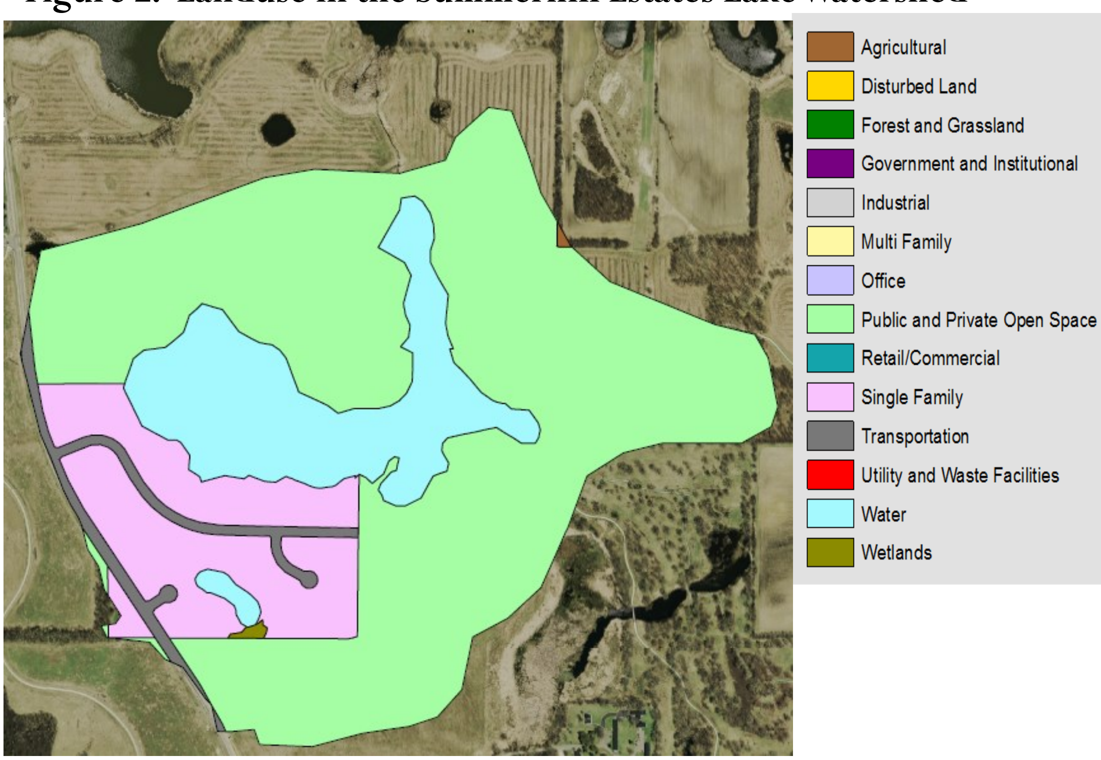
WATERSHED & LANDUSE (CONT.)

Land use plays a significant role on water quality of a lake. The primary land use within the Summerhill Estates Lake watershed is public and private open space (65%), which is a unique characteristic as Lake County as whole only has 13% of land preserved as public and private open space. The next largest land use category by area was Single Family Residential at 15% of the watershed. As areas become more developed, that typically means an increase in impervious surfaces, reducing the amount of open space for infiltrating and storing precipitation. Based on the amount of impervious surfaces each land use contributes varied amounts of runoff. Impervious surfaces (parking lots, roads, buildings, compacted soil) impact water quality in lakes by increasing pollutant loads and water temperature. During storm events, pollutants such as excess nutrients (nitrogen and phosphorus), metals, oil and grease, and bacteria are easily transferred from impervious surfaces to rivers, wetlands, and lakes.

Summerhill Estates Lake receives the majority of it's runoff from the Public & Private Open Space category at 58% of the runoff. The second largest runoff contributor is the Transportation landuse category at 15%. It's important to note that land-uses with high impervious surfaces, such as Transportation can contribute high amounts of runoff even if they are a small fraction of the overall landuse. For instance, in the Summerhill Estates Lake watershed, the "transportation" landuse only accounts for 3% of the total watershed but contributes 15% of the runoff. Lakes that receive a significant amount of stormwater runoff can have variable water quality that is heavily influenced by human activity. It's also important to note that while other landuses may contribute a smaller percentage of runoff, they can still deliver high concentrations of total suspended solids and total phosphorus (Appendix B).

The Lake County Forest Preserve district acquired the southern portion of land near Summerhill Lake in 1968 and the Northeast portion in 2001. At the time, this land were former farmfields. The former farm fields surrounding Summerhill Estates Lake were retired in 2007 (Southern fields) and 2008 (Northern fields) (LCFPD 2016). The retirement of the farm fields and increase of the buffer zone around the lake has improved water quality in Summerhill Estates Lake.

Figure 2: Landuse in the Summerhill Estates Lake Watershed

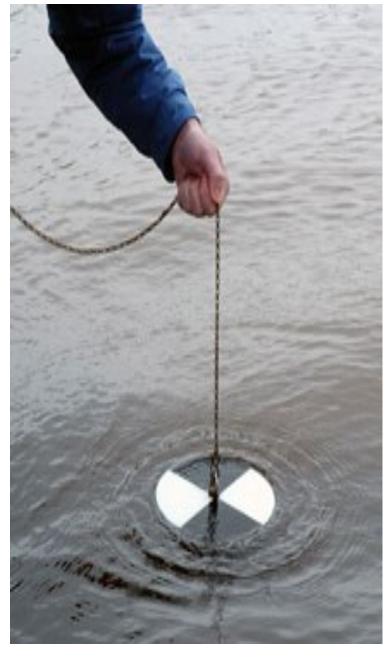


WATER CLARITY

Water clarity, or water transparency, is an indicator of water quality related to chemical and physical properties. Water clarity is typically measured with a Secchi disk and indicates the amount of light penetration into a body of water. It can also provide an indirect measurement of the amount of suspended material in 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. Boat propellers can also impact water clarity by redistributing loose bottom sediment and creating more turbid waters.

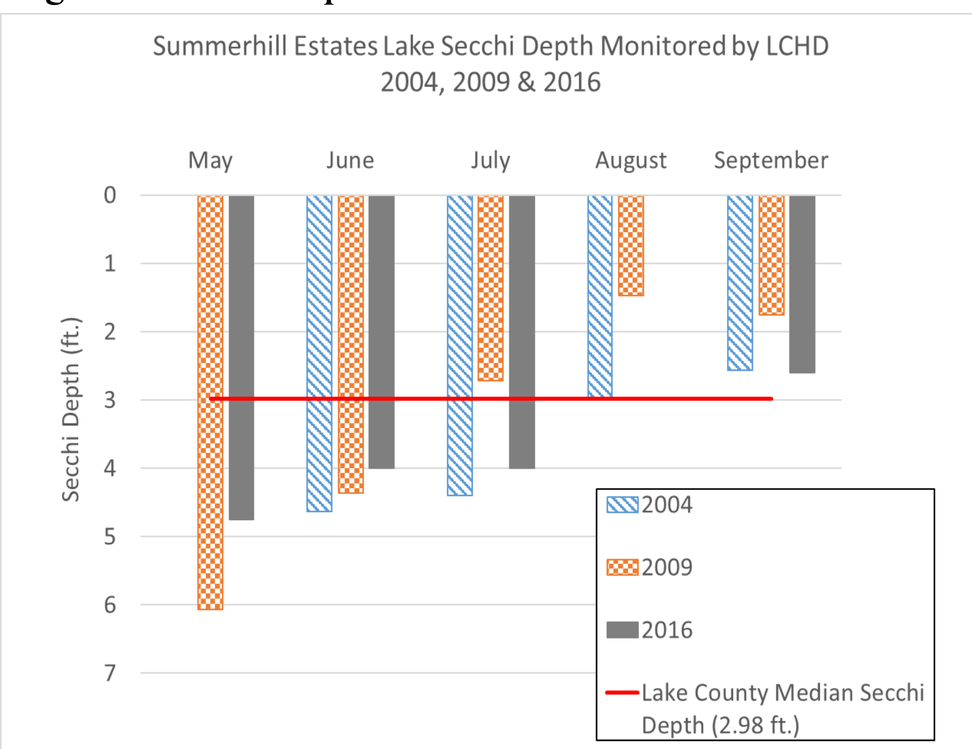
Secchi disk depth is primarily used as an indicator of algal abundance and general lake productivity. Although it is only an indicator, Secchi disk depth is the simplest and one of the most effective tools for estimating a lake's productivity.

The 2016 average water clarity in Summerhill Estates Lake was 3.84 ft. This is a 17% increase since the 2009 water quality sampling which had a Secchi depth of 3.27 ft. Compared to other lakes in Lake County, Summerhill Estates Lake is above the median Lake County Secchi depth of 2.98 ft. (Figure 3). Summerhill Estates Lake is considered a glacial lake, and an Advanced Identification Wetland. It's shallow nature allows light to penetrate all the way to the bottom, allowing plants to be established. The high plant density on Summerhill Estate Lakes aids in the water clarity. No secchi value was recorded for the month of August in 2016 as Secchi was hidden in a bed of plants and could not represent a true secchi value, although it was most likely clear all the way to the bottom.



Summerhill Estates Lake Secchi depth was 3.84 ft., which is above the Lake County median Secchi depth of 2.98 ft.

Figure 3: Secchi Depth in Summerhill Estates Lake



WHAT YOU CAN DO TO IMPROVE WATER QUALITY ON SUMMERHILL ESTATES LAKE?

- Do not throw leaves, grass clippings, pet waste, and other organic debris into the street or driveway. Runoff carries these through storm sewers, directly into Summerhill Estates Lake.
- Install buffer strips around the lake to stabilize shorelines and filter out nutrients before entering the lake.
- Build a rain garden to filter run-off from roofs, driveways, and streets. This allows the phosphorus to be bound to the soil so it does not reach surface waters.

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). Water clarity can provide an indication of the general water quality of the lake. Other observations such as water color, suspended algae and sediment, aquatic plants and odor are also recorded. The sampling season is May through October with measurements taken twice a month.

Summerhill Estates Lake has not participated in the VLMP program. Participating provides annual data that helps document water quality impacts and support lake management decisions. **LCHD recommends the Summerhill Estates Homeowners participate in VLMP Program.** This will provide valuable data for the lake as it provides annual data and can help look at long term trends.

For more information visit:

www.epa.state.il.us/water/vlmp/index.html

FOR MORE INFORMATION ON THE VLMP PROGRAM

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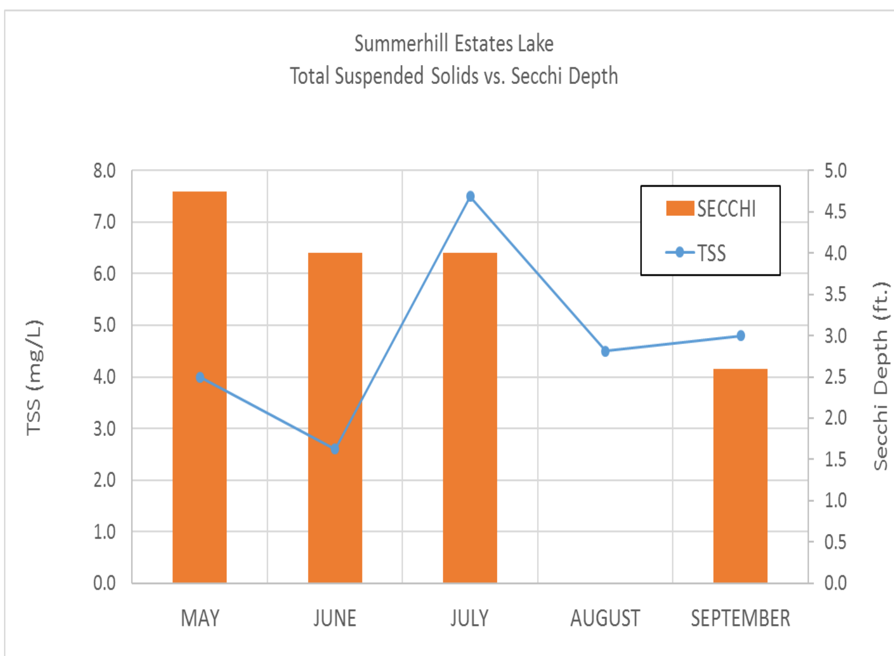
TOTAL SUSPENDED SOLIDS

Another measure of water clarity is turbidity and total suspended solids. Suspended particles dissipate light, which affects the depth at which plants can grow. The total suspended solid (TSS) parameter represents the concentration of all organic and inorganic materials suspended in the lake's water column. Typical inorganic components of TSS are referred to as non-volatile suspended solids (NVSS). NVSS originate from weathering and erosion of rocks and soils in the lake's watershed and re-suspension of lake sediments. The organic portion of TSS are called volatile suspended solids (TVS). TVS is mostly composed of algae and other organic matter such as decaying plant and animal matter. Secchi depth and TSS are inversely related as shown in Figure 4.

Figure 4: Total Suspended Solids vs. Secchi Depth



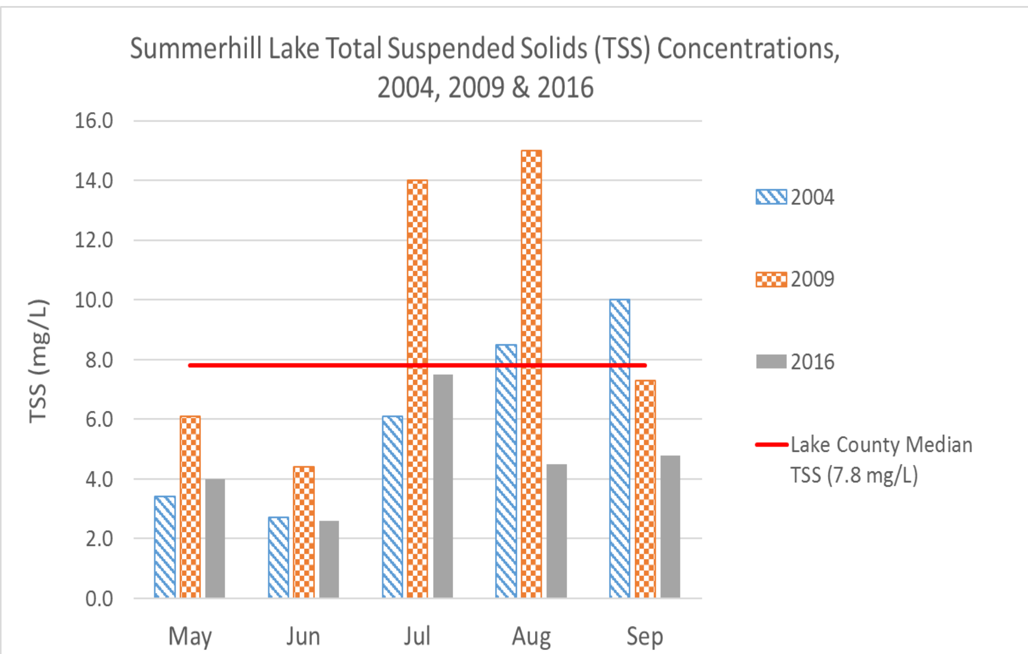
TOTAL SUSPENDED SOLIDS

2016 TSS concentrations in the epilimnion of Summerhill Estates Lake averaged 4.7 mg/L. The 2016 concentration is a 50% decrease in TSS since the 2009 sampling and is below the Lake County median of 7.8 mg/L (Figure 5). TSS ranged from non detectable to it's highest TSS concentration of 2.8 mg/L which occurred in August. High TSS values correlated with decrease in water clarity (Secchi disk depth) and can be detrimental to many aspects of lake ecosystem including the plant and fish communities (Figure 4, pg. 6).

A lake can have a TSS impairment which is based on if the median surface NVSS is greater or equal to 12 mg/L for the monitoring season. Based on the 2016 sampling data, median surface NVSS was 1.2 mg/L, thus there is no TSS impairment.

Decrease in total suspended solids since the 2009 and 2004 sampling dates may be a result of increased buffers around the shoreline of Summerhill Estates Lake implemented by the Lake County Forest Preserve district and the high density of aquatic plants which keeps sediment rooted.

Figure 5: Total Suspended Solid Concentrations in Lake Carina



2016	**Epilimnion**				
DATE	DEPTH	TDS	TSS	TS	TVS
19-May	3	333	4.0	351	89
15-Jun	3	352	2.6	379	108
13-Jul	3	362	7.5	406	124
16-Aug	3	321	4.5	331	70
14-Sep	3	318	4.8	346	99
	Average	*337*	*4.7*	*363*	*98*

TSS

Total Suspended Solids

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

TVS

Total Volatile Solids

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

NVSS

Non-Volatile Suspended Solids

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

TDS

Total Dissolved Solids

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

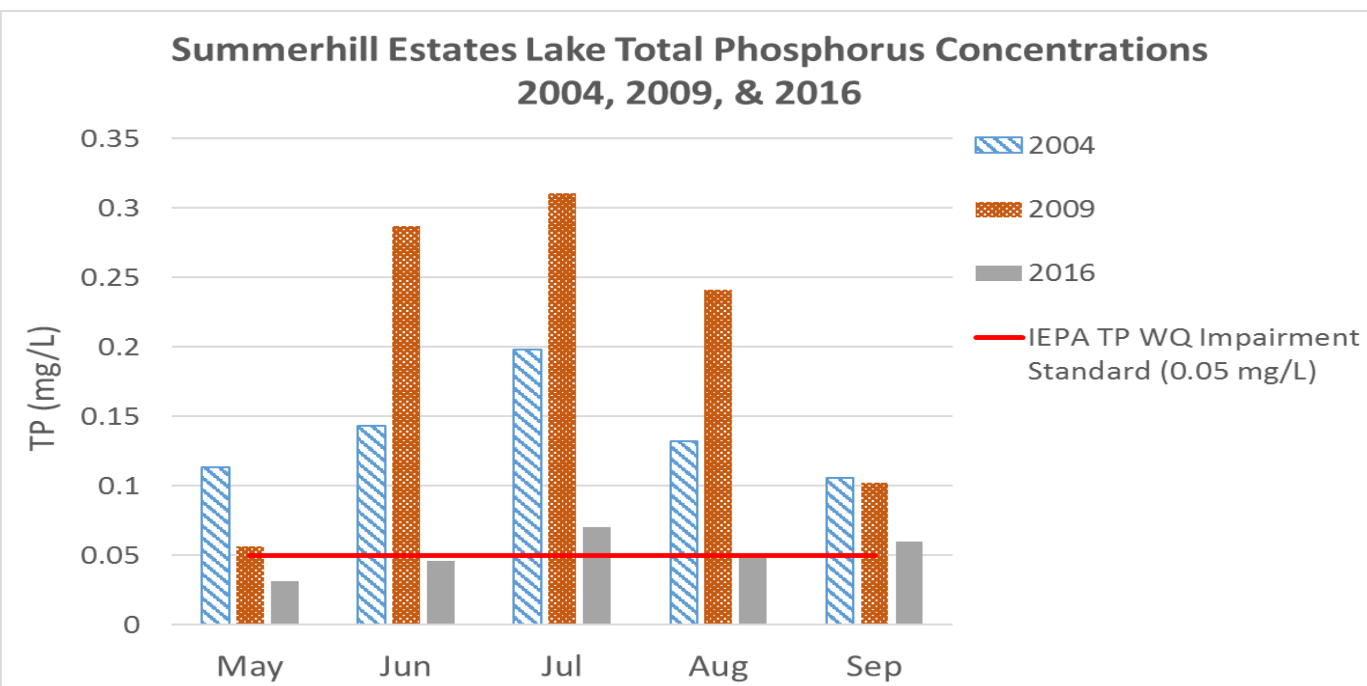
NUTRIENTS: PHOSPHORUS

Organisms take nutrients in from their environment. In a lake, the primary nutrients needed for aquatic plant and algal growth are phosphorus (P) and nitrogen (N). Phosphorus occurs in dissolved organic and inorganic forms or attached to sediment particles. Phosphates, the inorganic form, are preferred for plant growth but other forms can be used. Phosphorus builds up in the sediments of a lake.

The source of phosphorus to a lake can be external, internal, or both. Phosphorus originates from a variety of external sources, many of which are related to human activities including: human and animal waste, soil erosion, detergents, sewage treatment plants, septic systems, and runoff from lawns. Internal sources of phosphorus originate within 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 and be available in the water column. Carp spawning and feeding activity can release phosphorus by stirring up the bottom sediment and can add phosphorus through their fecal matter. Sediment resuspension and subsequent phosphorus release can occur through wind/ wave action or heavy boat traffic. Lakes that experience anoxic conditions also contribute to the release of P from the bottom sediments. Summerhill Estates Lake did experience anoxic conditions.

The average total phosphorus concentrations in the epilimnion of Summerhill Estates Lake averaged 0.051 mg/L, which is a 74% decrease since the 2009 sampling where TP concentrations averaged 0.199 mg/L (Figure 6). The average TP concentration is above the IL EPA water quality impairment standard of 0.050 mg/L. May had the lowest TP concentration at 0.031 mg/L and July had the highest at 0.070 mg/L. In 2009, May also had the lowest concentration during the peak growing cycle of Curlyleaf Pondweed. After the Curlyleaf Pondweed died back in June, TP concentrations increased significantly—which was observed in both 2004 and 2009. In 2016, there is not as severe of an increase in TP concentrations after May. The overall decrease in TP could be a result of reduced CPL abundance. CLP was noted throughout the lake in the early season but an early season CLP survey was not conducted. It could also be a result of the farm fields surrounding Summerhill Estates being retired in 2007 and 2008.

Figure 6: Phosphorus Concentrations in Summerhill Estates Lake monitored by LCHD

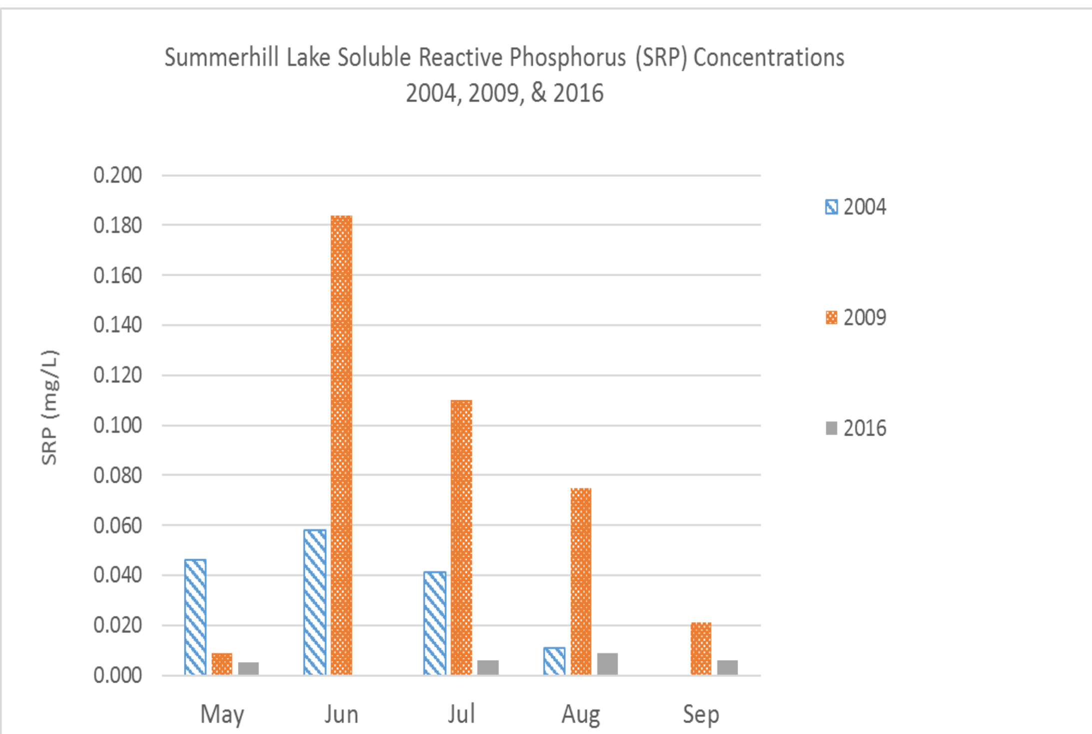


NUTRIENTS: PHOSPHORUS (CONTINUED)

Filamentous algae blooms were prevalent in the beginning of the monitoring season and covered much of the lake. Internal sources of phosphorus within Summerhill Estates Lake likely included these large densities of algae that continue to recycle phosphorus and sediments that are stirred up by carp and wind. Also important to note is that historically, Summerhill Lake had been drained and farmed meaning the sediments within the lake likely contain higher nutrient concentrations.

Total phosphorus concentrations is a better overall indicator of a lake's nutrient status because its concentrations remain more stable then other forms of phosphorus. Soluble Reactive Phosphorus (SRP) was included in 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 depending on how plants and algae absorb and release it and it can give an indication of how much phosphorus is available for uptake. It does not indicate how much phosphorus is present in the water column. SRP concentrations for 2016 were significantly lower than in the past as seen in Figure 7. This is in part because Summerhill Estates lake went from being nitrogen limited in 2009 to phosphorus limited in 2016. When a lake is nitrogen limited, SRP would be higher since there is an excess of phosphorus for algae and plants. When the lake shifts to phosphorus limited, SRP—the readily available phosphorus for plant and algae growth, will be lower since plants and algae will be using it up. This is depicted in Figure 7.

Figure 7: Phosphorus Concentrations in Summerhill Estates Lake monitored by LCHD



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*

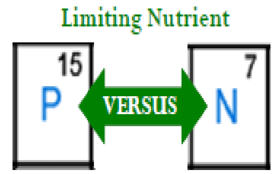
July 2010: *The state of Illinois passed another law restricting the use of lawn fertilizers containing phosphorus by commercial applicators.*

NUTRIENTS: NITROGEN

Nitrogen, in the forms of nitrate (NO_3^-), nitrite (NO_2^-), or ammonium (NH_4^+) is a nutrient needed for plant and algal growth. Nitrogen enters the ecosystem in a several chemical forms and a lake's nitrogen source can vary widely. Sources of nitrogen include septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, and sanitary landfills, and atmospheric deposition. All inorganic forms of nitrogen (NO3-, NO2-, and NH4+) can be used by aquatic plants and algae. If these inorganic forms exceed 0.3 mg/L, there is sufficient nitrogen to support summer algae blooms. If the surface median total nitrogen as N (TKN + NO2/NO3-N) exceeds 3.6 mg/L for the monitoring season, there is a nitrogen impairment for the water body.

Nitrogen concentrations (NO3-N and NH3-N) in the epilimnion of Summerhill Estates Lake were below detectable concentrations for the entire monitoring season, except for September where ammonia was at 0.148 mg/L. There were no nitrogen impairments for Summerhill Estates Lakes. Total Kjeldahl nitrogen (TKN), an organically (algae) associated form of nitrogen, averaged 1.01 mg/L, which is below the Lake County median of 1.170 mg/L. Total Kjeldahl nitrogen is a measure of organic nitrogen, and is typically bound up in algal and plant cells.

Typically lakes are either phosphorus or nitrogen limited. This means that one of the nutrients is in short supply and any addition of that nutrient to the lake will result in an increase of plant and/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. Ratios less than 10:1 suggest the lake is limited by nitrogen, while ratios greater than 20:1 are limited by phosphorus. Summerhil Estates Lake has a TN:TP ratio of 21:1, meaning the lake is phosphorus limited and additions of phosphorus into the lake system can contribute to algae issues. In 2009 the TN:TP ratio was 6:1 meaning it was nitrogen limited but has since changed to phosphorus limited.



TN:TP Ratio

<10:1 = nitrogen limited

>20:1= phosphorus limited

TN:TP Ratio on Summerhill Estates Lake:

21:1

Summerhill Lake is Phosphorus Limited

WAYS TO REDUCE NUTRIENTS IN YOUR LAKE

Waterfowl management (ducks and geese)

- Do not feed or encourage others to feed waterfowl
- Use good landscaping practices to discourage waterfowl. Landscapes with taller plants and shrubbery can discourage geese.

Fertilizer use:

- If you apply fertilizers to lawns and gardens, have your soil tested to determine how much fertilizer to apply.
- Check the weather before applying fertilizer—avoid applying before heavy rainfalls.
- Sweep up any fertilizer which is spilled on impervious surfaces such as walks and driveways.
- Do not spread fertilizer within 75 feet of surface waters or wetlands

Pet Waste Disposal

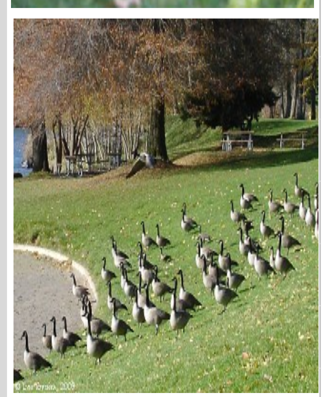
- Regularly scoop up and dispose of pest waste.

Landscaping Practices

- Consider native vegetation as a quality alternative to lawns. Native vegetation provides a more diverse plant community, and can filter out nutrients and also provides habitat for important pollinators.
- Plant a buffer strip of native plants (at least 20 feet) between the lake's edge and your property.

Keep fall leaves out of the storm drains

- Never rake leaves into or near storm drains, ditches, creeks, or on lakeshore.



TROPHIC STATE INDEX

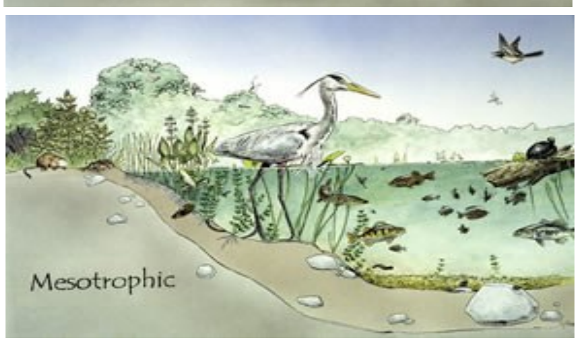
Trophic state describes the overall productivity of a lake and refers to the amount of nutrient enrichment within a lake system. This has implications for the biological, chemical and physical conditions of the lake. Lakes are classified into four main categories of trophic states that reflect nutrient levels and productivity. The four categories are: oligotrophic, mesotrophic, eutrophic, and hypereutrophic. These range from nutrient poor and least productive (oligotrophic) to most nutrient rich and most productive (eutrophic). Eutrophication is a natural process where lakes become increasingly enriched with nutrients. Lakes start out with clear water and few aquatic plants and over time become more enriched with nutrients and vegetation until the lake becomes a wetland. This process takes thousands of years. However, human activities that supply lakes with additional phosphorus and nitrogen (such as fertilizer, household products, waste by-products, etc.) are accelerating the eutrophication process.

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 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) value is based on phosphorus (TSIp) and Secchi (TSIsd) and are calculated from the monitoring data. A lake's response to additional phosphorus is an accelerated rate of eutrophication. In 2016, Summerhill Estates Lake had a TSIp value of 60.9 which categorizes it as eutrophic. In 2009, Summerhill Estates Lake had a TSIp of 80.5 and was considered hypereutrophic. The decrease in TSIPp is related the decrease in average TP concentration. Based on the TSIp, Summerhill Estates Lake is ranked 58 of 175 lakes studied by the LCHD-ES from 2000 –2016 (Appendix B).

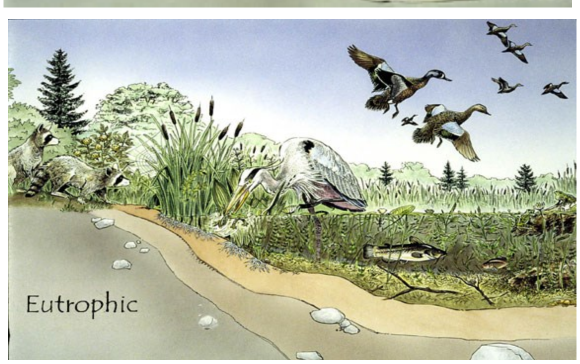
OLIGOTROPHIC

Lakes have low nutrients and are generally deep and free of weeds or large algae blooms. They do not support large fish populations.



MESOTROPHIC

Lakes have medium nutrients and intermediate level of productivity. Mesotrophic lakes typically have clear water with beds of submerged aquatic plants. Mesotrophic lakes can have a diverse fish population.



EUTROPHIC

Lakes are high in nutrients, and are usually weedy or subject to frequent algae blooms. Eutrophic lakes often support large fish populations but are also susceptible to oxygen depletion. Increased sedimentation also is typical of eutrophic lakes

LAKE COUNTY AVERAGE TSIP = 66.1

SUMMERHILL ESTATES LAKE TSIP = 60.9

TROPHIC STATE: EUTROPHIC

RANK= 58/175

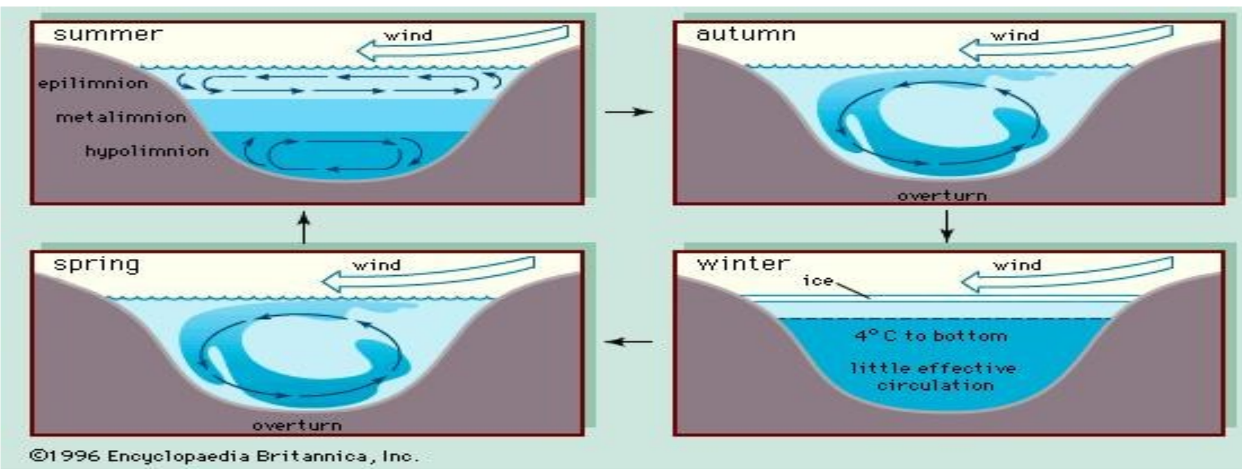
STRATIFICATION

A lake's water quality and ability to support fish are affected by the extent to which the water mixes. The depth, size, and shape of a lake are the most important factors influencing mixing, but climate, lakeshore topography, inflow from streams and vegetation also play a role. Variations in density caused by different temperatures can prevent warm and cold water from mixing, called stratification.

For example: when lake ice melts in early spring, the temperature and density of lake water will be similar from top to bottom. Since it is uniform throughout the water column, the lake can mix completely recharging the bottom water with oxygen and bringing nutrients up to the surface. Some lakes in summer experience stratification where the lake is dividing into three zones: epilimnion (warm surface layer), thermocline (transition zone between warm and cold water) and hypoliminion (cold bottom water). Stratification traps nutrients released from bottom sediments in the hypoliminion and prevents mixing (Figure 8).

Monthly depth profiles of water temperature, dissolved oxygen, conductivity, and pH every foot from the lake surface to the lake bottom on Summerhill Estates Lake. The relative thermal resistance to mixing (RTRM) value can be calculated from this data and indicates if a lake stratifies, how great the stratification is, and at what depth the thermocline occurs. Values greater than 20 RTRM indicate stratification. Even though Summerhill Estates Lake is shallow, it was thermally stratified in June, July, and August (Figure 9). Wind forces are usually strong enough to mix shallow lakes to prevent stratification.

Figure 8: Schematic representing seasonal lake mixing and stratification



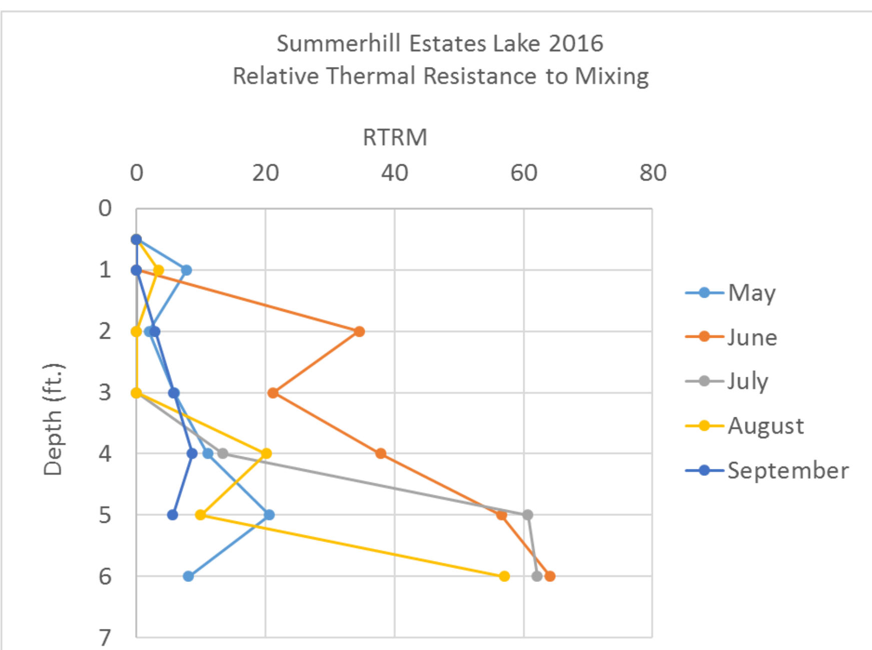


Figure 9: RTRM based on depth profile data in Summerhill Estates Lake for 2016. Values greater than 20 RTRM indicate stratification.

DISSOLVED OXYGEN

A dissolved oxygen (DO) concentration of 5.0 mg/L is considered adequate to support fisheries since fish can suffer oxygen stress below this concentration level. Dissolved oxygen (DO) concentrations in the water column of Summerhill Estates Lake did drop below 5 mg/L in all months, typically at depths of 4 ft. or greater (Figure 10). The volume of water in Summerhill Estates Lake above this 5 mg/L standard for most of the season is 62.6%. In June, Dissolved oxygen dropped below 5 mg/L at depths greater than 2 ft. During this sampling period in June, only 38.9% of the volume of water in Summerhill Estates Lake was above the standard. Anoxic conditions, where DO concentrations are <1 mg/L, occurred in all months except August. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters (Figure 11). Anoxic conditions occurred at depths greater than 5 ft., meaning 85.3% of the volume of water is above anoxic conditions. Low oxygen conditions in the upper water of a lake can also be problematic since all aquatic organisms need oxygen to live.

Figure 10: The dissolved oxygen depth profile on Summerhill Estates Lake shows that DO dropped below 5 mg/L in all months during the sampling season.

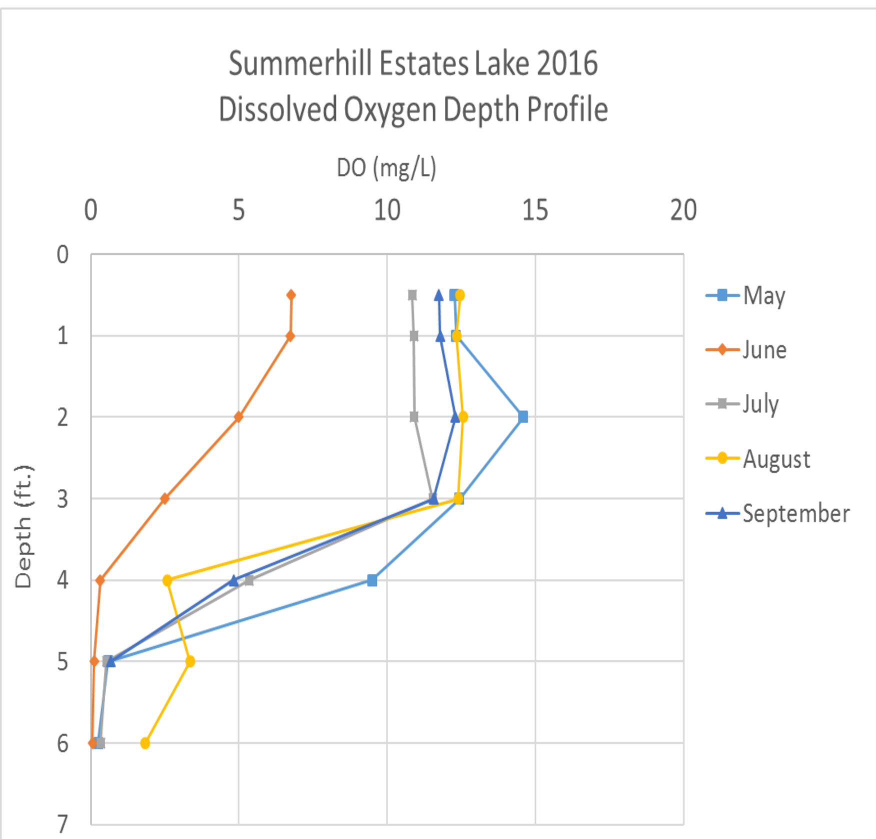
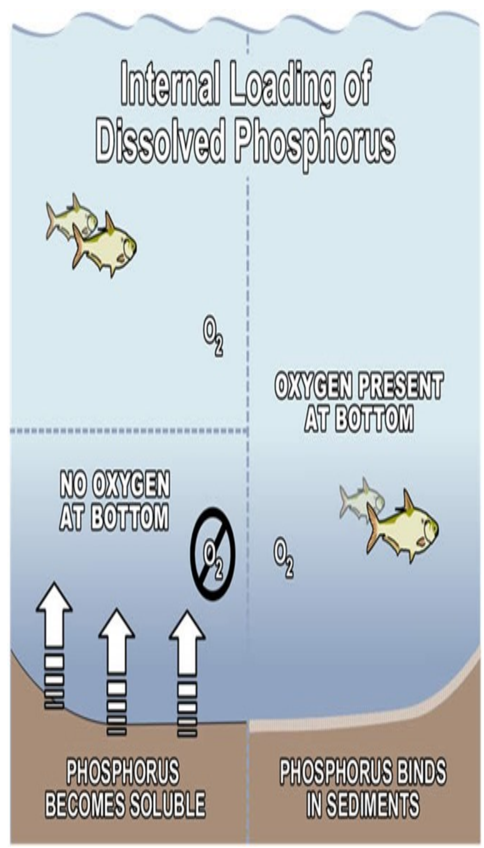


Figure 11: Schematic of how oxygen near the bottom of the lake and can impact phosphorus release from bottom sediments.



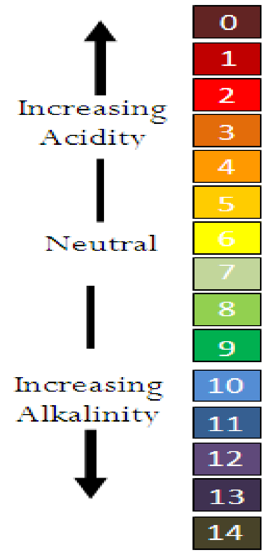
ALKALINITY AND PH

Alkalinity is the buffering capacity of a water body. It measures the ability of water bodies to neutralize acids and bases to maintain a stable pH. In a lake, alkalinity acts to buffer lakes from the effects of acid rain. Alkalinity comes from rocks, soils, salts, and certain plant activities. If a lakes watershed contains large quantities of calcium carbonate (CaCO3, limestone), the surface waters tend to be more alkaline; while granite bedrock does not have high amounts of CaCO3 and therefore lacks alkaline materials to buffer acidic inputs.

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.

In 2016, the average alkalinity (CaCO3) concentration in Summerhill Estates Lake was 137 mg/L which is below the Lake County median alkalinity concentration of 162 mg/L. The USEPA considers lakes with CaCO3 concentrations greater than 20 mg/L to not be sensitive to acidification.

Summerhill Estates Lake average pH in 2016 was 8.91, which is above the Lake County median of 8.32. During the August and September sampling period, pH was greater than 9.0, which means Summerhill Estates Lake has a pH impairment.

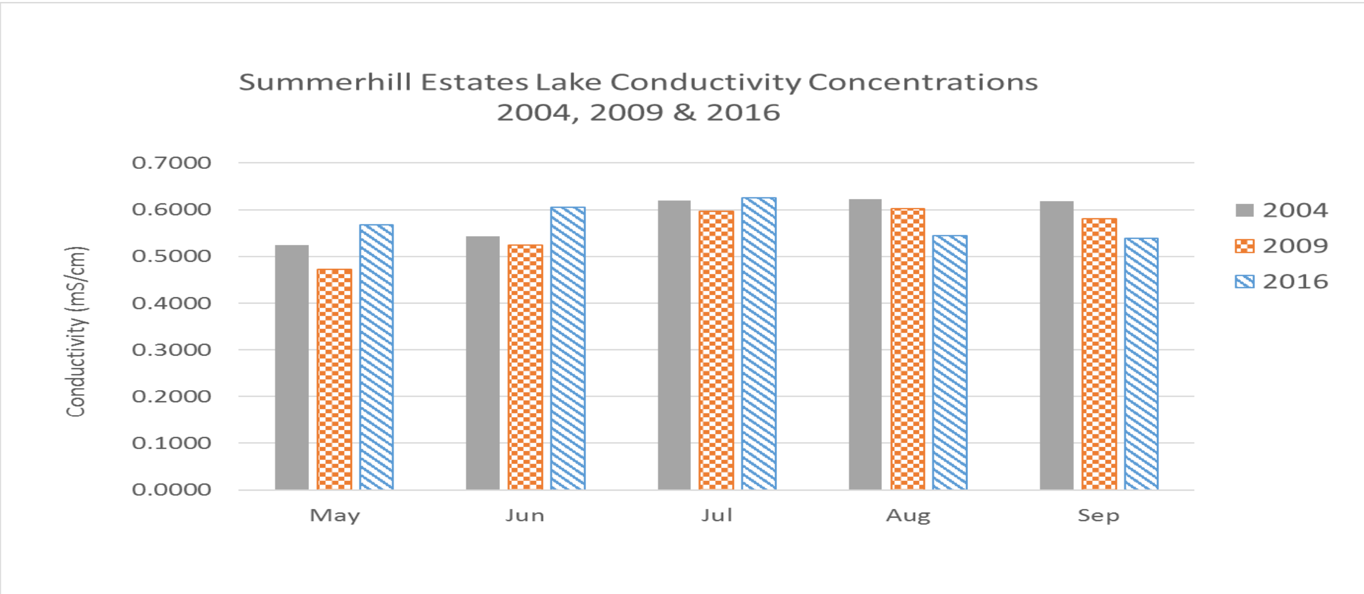


The pH scale ranges from 0 to 14. A pH of 7 is considered neutral. Substances with a pH of less than 7 are acidic, and greater than 7 are basic.

CONDUCTIVITY

Another parameter measured during the 2016 monitoring season is conductivity. Conductivity is the measure of different chemical ions in solution. As the concentration of these ions increases, conductivity increases. The conductivity of a lake is dependent on the lake and watershed geology, size of the watershed flowing into the lake, land use, evaporation, and bacterial activity. Conductivity in urban areas has been shown to be highly correlated with chloride ions found in road salt mixes (Figure 12). In 2016, Summerhill Estates lake average conductivity reading was 0.5761 mS/cm. This is below the Lake County median conductivity concentration of 0.7889 mS/cm. This value is a a slight increase since the 2009 sampling but a decrease since the 2004 sampling. Overall, there hasn't been significant changes in conductivity.

Figure 12: Conductivity Concentrations in Summerhill Lake Estates

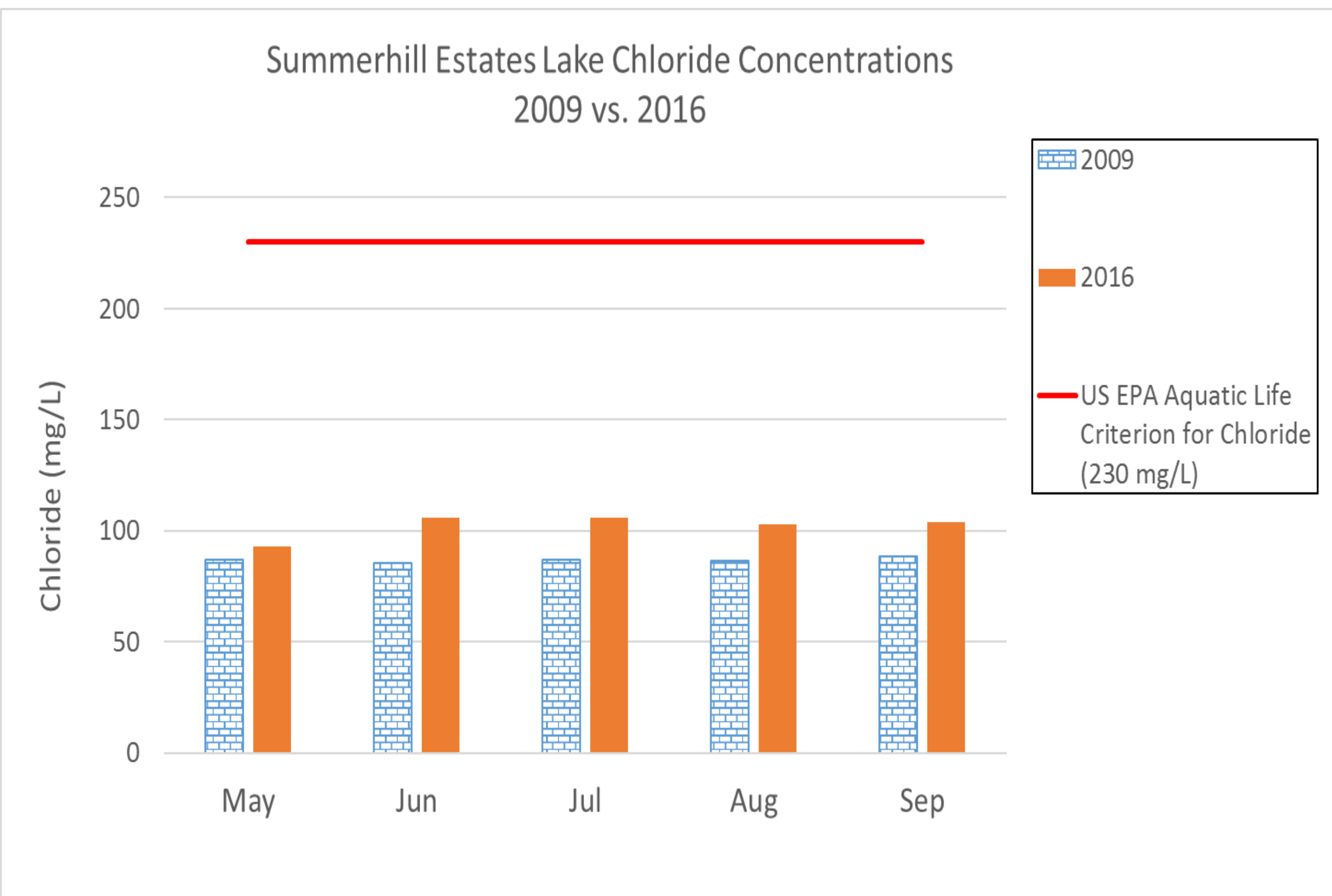


CHLORIDES

One of the most common dissolved solids is road salt used in winter road deicing. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocynaide salts. Summerhill Estates Lake chloride concentration was 102 mg/L which is below the Lake County median of 127 mg/L (Figure 13). 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 in Summerhill Estates Lake are below the USEPA aquatic life criteria, concentrations have increased since the 2009 sampling.

The LCHD-ES and Lake County Stormwater Management Commission (LCSMC) have been holding annual trainings targeting deicing maintenance personnel for both public and private entities to hopefully reduce the amount of chloride being introduced into our environment while maintaining safe passageways. Almost all deicing products contain chloride so it is important to read an follow product labels for proper application. For instance, at 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. Unfortunately, Lake Carina is located directly off a major road which can contribute to the high chloride levels.

Figure 13: Summerhill Estates Lake Chloride Concentrations



CHLORIDES & DE-ICING FACTS

ICE FACTS

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

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.

LAKE LEVELS AND PRECIPITATION

Lakes with stable water levels potentially have less shoreline erosion problems. The lake level in Summerhill Estates was measured off of the inside post of the homeowners dock from the access site. The lake level decreased from May through September by 7.8 inches. The most significant water level fluctuation occurred between June and July where the lake level decreased by 7 inches.

In order to accurately monitor water levels it is recommended that a staff gauge be installed and levels measured and recorded frequently (daily or weekly). The data provides lake managers a much better idea of lake level fluctuations relative to rainfall events and can aid in future decisions regarding lake level. A staff gauge is a great tool for measuring water level in lakes, rivers, reservoirs. The data collected can be compiled to help understand the natural fluctuations of the lake. Lakes with fluctuating water levels potentially have poorer water quality and have more shoreline erosion problems.

Rainfall information is also important for understanding lake water quality, as large rainstorm events can carry in pollutants, sediments, and affect water quality. Lake County Stormwater Management Commission has a number of rain gauges throughout the County. Based on the

EXAMPLE OF A PERMANENT STAFF GAUGE

Month	Level (in)	Seasonal Change (in)	Monthly Change	Precipitation (in)
May	21.0			4.6
June	19.9	-1.08	-1.08	3.13
July	28.1	7.08	8.16	4.26
August	27.5	6.48	-0.6	2.89
September	28.8	7.8	1.32	1.94

HARMFUL ALGAL BLOOMS

Algae are important to freshwater ecosystems and most species of algae are not harmful. Algae can grow quickly in water and is often associated with increased concentrations of nutrients such as nitrogen and phosphorus. 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 2016, the US EPA has issued a draft of *Human Health Recreational Ambient Water Quality Criteria (AWQC) and/or Swimming Advisories for Microcystins and Cylindrospermospin.* This will be the first time the EPA is issuing recommendation concentrations of microcystins and cylindrospermopsin, two types of toxins associated with harmful algal blooms. Different cyanotoxins have different health effects associated with exposure. For example, microcystins are primarily associated with liver toxicity, while kidney toxicity is a key health effect for cylindrospermopsin. Other toxins have been shown to affect the skin, gastrointestinal, or nervous systems.

In 2016, there were no major concerns of blue-green algae while out sampling, although there were significant filamentous algae blooms. While Summerhill Estates Lake does not have a swimming beach, many users fish and boat in the water. 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.

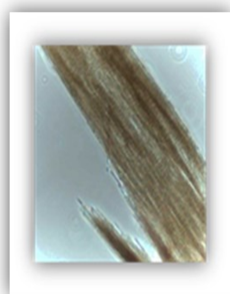
FOR MORE INFORMATION ON BLUE-GREEN ALGAE:
www.epa.state.il.us/water/surface-water/blue-green-algae.html

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

For more information or to report a blue-green algae bloom, contact the Lake County Health Department Environmental Services (847) 377-8030.

Anabaena Sp.

Microcystis Sp.



Aphanizomenon Sp.

ALGAL BLOOMS

In 2016, Summerhill Estates had substantial filamentous algae bloom in the early season covering most of the lake. While it cleared up a bit throughout the season it remained for the monitoring period. Below is a picture of Summerhill Lake Estates taken in August showing the coverage of the filamentous algae bloom. Algae are important to lake ecology because they serve as food sources for protozoans, insects, and fish and are a vital component of the food web. However, sometimes can algae blooms can reach nuisance levels. An overabundant plant growth is a symptom of excessive nutrients (phosphorus and nitrogen) in the water. Long-term control of overabundant plants and algae concerns are best accomplished by reducing or redirecting nutrient sources to the lake. These filamentous algae blooms, while not aesthetically pleasing, are not harmful to human health and are not considered a harmful algal bloom. They are also commonly mistaken for blue-green algae. Below are two pictures taken from Summerhill Lake in August where abundant filamentous algae can be seen.

For More Information On Blue-green algae:
www.epa.state.il.us/water/surface-water/blue-green-algae.html

BATHYMETRIC MAPS PROVIDE LAKE MANAGERS WITH AN ACCURATE LAKE VOLUME THAT CAN BE USED FOR HERBICIDE APPLICATION AND HELP ANGLERS FIND POTENTIAL FISHING SPOTS.

BATHYMETRIC MAPS

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 acrruacy 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).

Summerhill Estates Lake had a bathymetric survey conducted by LCHD in 2009 (Figure 14). LCHD recommends updating bathymetric map every 10 years.

Figure 14: Summerhill Estates Lake Bathymetric Map

Morphometric Features of Summerhill Estates Lake ~
Data From the April 29, 2009 Bathymetric Survey, LCHD Environmental Service

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	53.95	100.0%	46.18	0 - 1	15.13	28.0%	30.3%
1	38.82	72.0%	35.85	1 - 2	5.86	10.9%	23.5%
2	32.96	61.1%	30.24	2 - 3	5.37	9.9%	19.8%
3	27.59	51.1%	23.78	3 - 4	7.43	13.8%	15.6%
4	20.16	37.4%	13.59	4 - 5	12.22	22.6%	8.9%
5	7.95	14.7%	2.93	5 - 6	7.87	14.6%	1.9%
6	0.07	0.1%	0.12	6+	0.07	0.1%	0.1%
			152.56		53.95	100%	100%

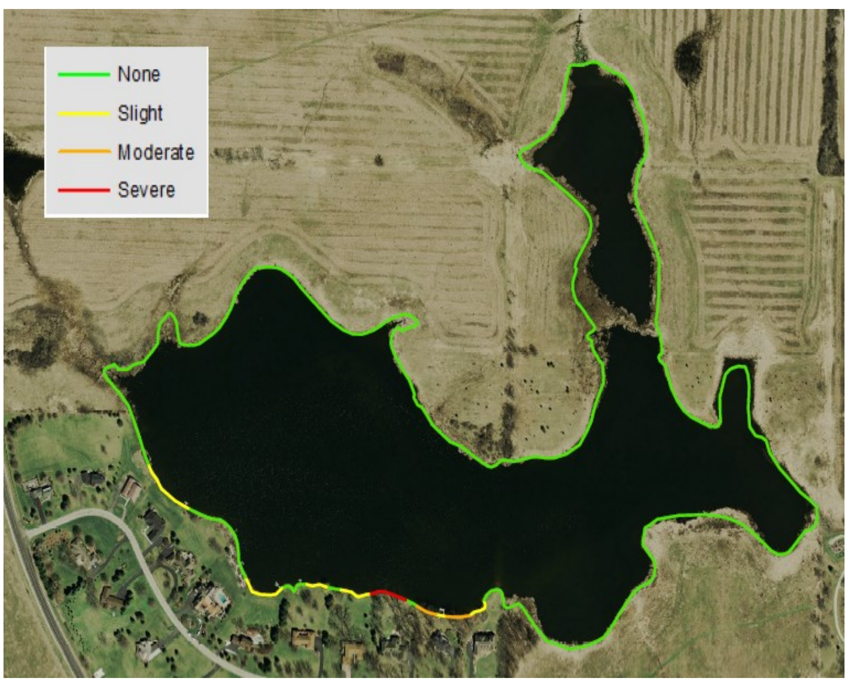
SHORELINE EROSION

Erosion is a natural process along lake shorelines primarily caused by wind and wave action resulting in the loss of material from the shoreline. Disturbed shorelines caused by human activity such as clearing of vegetation and beach rocks and increasing runoff will accelerate erosion. Eroded materials cause turbidity, sedimentation, nutrients, and pollutants to enter a lake. Excess nutrients are the primary cause of algal blooms and increased aquatic plant growth. Once in the lake, sediments, nutrients and pollutants are harder and more expensive to remove.

A shoreline erosion study was assessed for Summerhill Estates Lake in 2016 (Figure 15). Summerhill Esates was divided into reaches, and the shoreline evaluated for none, slight, moderate and severe erosion based on exposed soil and tree/plant roots, failing infrastructure, undercut banks, and other signs of erosion. Based on the 2016 data, only 10% of Summerhill Estates Lake shoreline has some degree of erosion; with 7% being slight erosion, 2% being moderate erosion, and 1% being severe. It is much easier and less costly to mitigate slightly eroding shorelines than those with more severe erosion. If these shorelines are repaired by the installation of a buffer strip with native plants, there are multiple benefits. First, the erosion is repaired and the new native plants can stabilize the shoreline to prevent future erosion. The addition of native plants adds habitat for wildlife and can also help filter pollutants and nutrients from the near shore areas. Natives shorelines also help lakes that have problems with geese and gulls, as it is not desirable habitat for them.

Shoreline erosion appears to have decreased in 2007, most likely a result of an increase in emergent plants that line most of the shoreline. To see data of shoreline erosion broken down by reach, refer to the shoreline condition assessment tables in Appendix B.

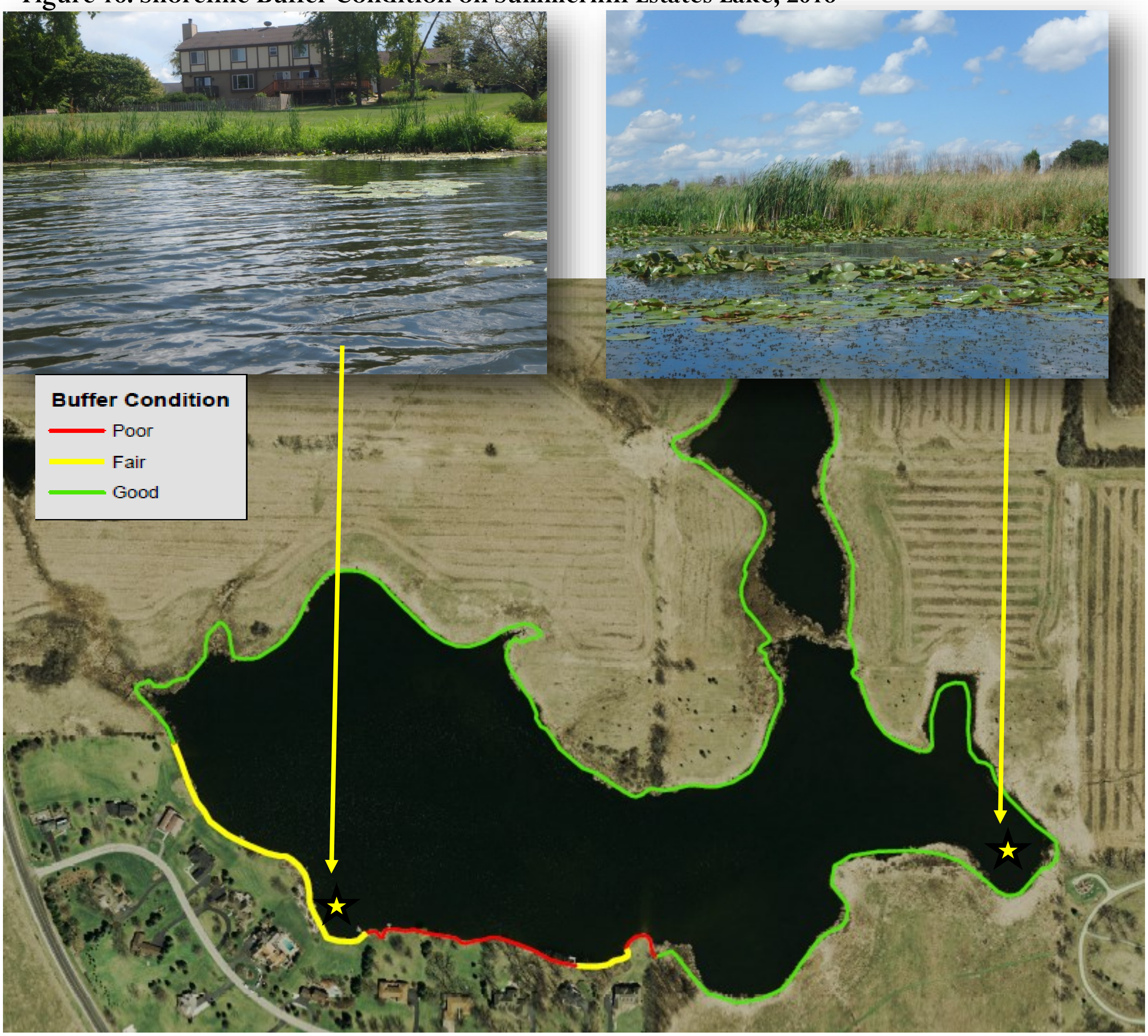
Figure 15: Shoreline Erosion Condition on Summerhill Estates Lake, 2016



SHORELAND BUFFERS

A shoreland buffer helps stabilize the sediment near the lakes edge which prevents soil erosion. The buffer will also filter out pollutants and unwanted nutrients from entering the lake. Buffer strips should be at least 25 feet wide and can include native wildflowers, native grasses, and native wetland plants. Wider buffers may be needed for areas with a greater slope or additional runoff issues. Areas that are already severely or moderately eroding, a buffer strip of native plants may need to be bolstered for additional stability. Many LCFPD lakes have re-established buffers or do not mow to lakes edge to allow native grasses to grow. A shoreland buffer condition of Summerhill Estates Lake was assessed by looking at the land within 25 feet of the lake's edge on aerial images in ArcGIS. Shoreland buffer's were classified into three categories; poor, fair or good based on the amount of unmowed grasses, forbs, tree trunks and shrubs, and impervious surfaces within that 25 foot range. In 2016, Summerhill Estates Lake had 8% of the shoreline with poor buffer, 10% with fair, and 82% with good buffer (Figure 16). For complete list of shoreline buffer conditions by reach, refer to Appendix B. Areas that could be improved with buffer conditions are the Summerhill Estate Lakes subdivision homeowners. While some houses do have buffer zones between their house and the lake, the area of the buffer could be expanded. Some houses that do not have buffers, have enough lawn space that buffer zones could be easily and feasibly implemented.

Figure 16: Shoreline Buffer Condition on Summerhill Estates Lake, 2016

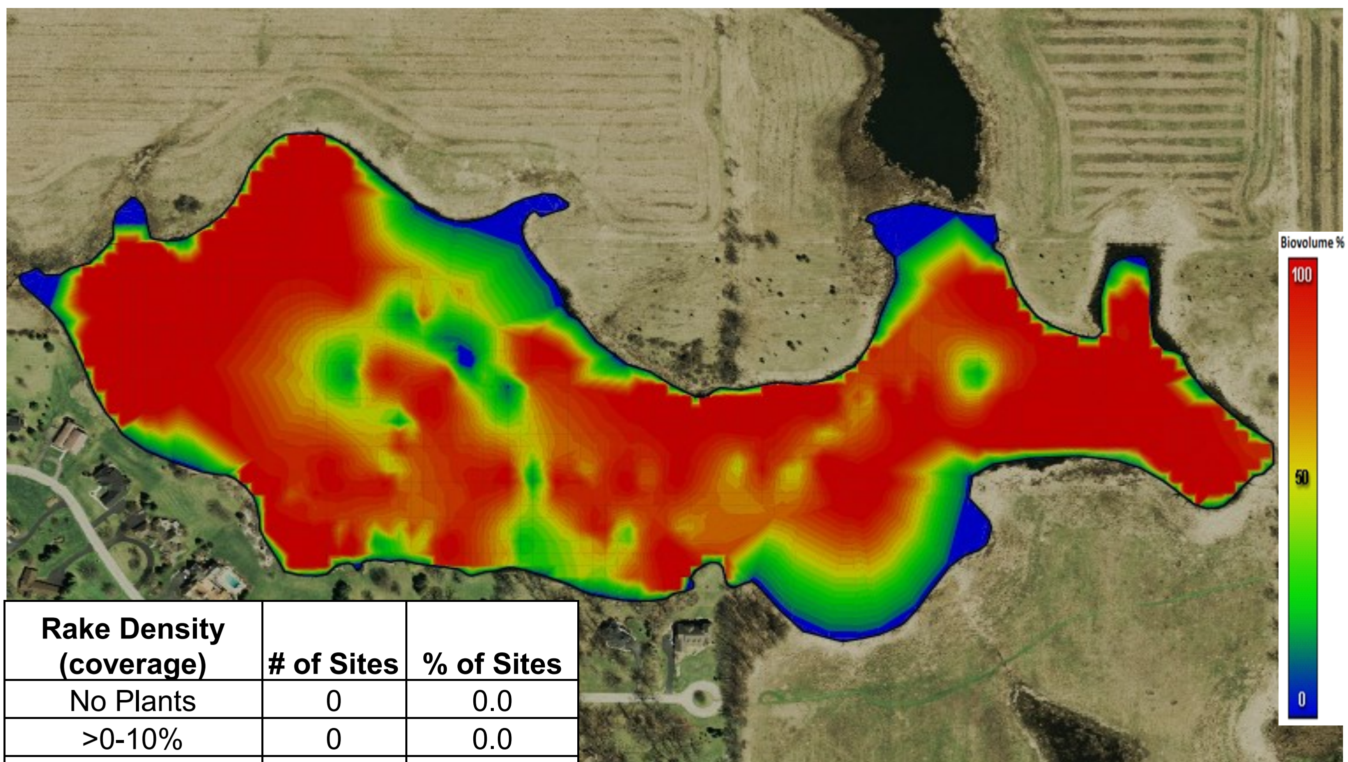


AQUATIC PLANTS

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 Summerhill Estates Lake in August 2016. Sampling sites were based on a grid system created by mapping software, with each site located 30 meters apart for a total of 58 sites. At each site, overall plant abundance was ranked and plant species were identified and ranked. In addition to the plant rake survey, the lake was mapped using Sonar and CIBiobase as more accurate measure for overall aquatic plant biovolume. Based on the aquatic plant rake survey, plants occurred at all 58 sites with 100% plant coverage. Plants found at depths up to 5.5 feet (Figure 17). Out of the sample points that did have plants the majority had >90% plant density.

There were a total of 9 aquatic plant species and one macro-algae were found in Summerhill Estates Lake. Coontail was by far the most dominant plant species occurring at nearly every site, 98.3% of the sampling sites. The next most abundant plant was White Water Lily at 36.2% of the sampling sites. The number of plant species is an increase since the 2009 sampling where 6 plant species were found. In 2016, the plant community had a seasonal variation in dominant species. In May, a majority of the lake was observed to have toped out Curlyleaf Pondweed. By August, only 3% of the sampling sites had Curlyleaf Pondweed and Coontail became the most dominant. Curlyleaf Pondweed is an exotic plant and has a tolerance for low light and low water temperatures that allow it to get a head start and outcompete native plants in the spring. Figure 9 shows overall plant rake density on Summerhill Estates Lake.

Figure 17: Overall plant biovolume for Summerhill Estates Lake, July 2016



Rake Density (coverage)	# of Sites	% of Sites
No Plants	0	0.0
>0-10%	0	0.0
10-40%	1	1.7
40-60%	4	6.9
60-90%	14	24.1
>90%	39	67.2
Total Sites with Plants	58	100%
Total # Sites	58	100%

Aquatic plants (continued)

Two exotic aquatic plants species were observed in Summerhill Estates Lake in the 2016 aquatic vegetation survey; Eurasian Watermilfoil (EWM) and Curlyleaf Pondweed (CLP). EWM was found at 24.1% of the sampling and Curlyleaf Pondweed was found at 3.4% of the sampling sites in August. While CLP was only found at a few spots in August, it was notably higher earlier in the season.

CLP is a non-native invasive pondweed. Like our native pondweeds it is a perennial monocot. This has management consequences as our native pondweeds and other of our native plant species are equally sensitive to herbicides that are effective on this plant. CLP however, does have a life history that differs from our native pondweeds. The vegetative part of the plant dies back completely in early summer and only seeds and turions oversummer. The turions (which are the main source of reproduction in CLP) sprout in fall, and are rapidly able to elongate in spring after ice melts as temperatures reach 5°C. Vigorous growth of CLP occurs as most of our native plants are just beginning to emerge, senescing by late June and early July after turion production giving it a competitive advantage. Algal blooms have been associated with larges stands of senescing or dying plants of CLP, as nutrients are released into the water.

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

The diversity and extent of plant populations can be influenced by a variety of factors. Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow. When the light level in the water column falls below 1% of surface light level, plants can no longer grow. 1% surface light level is roughly at 2 times the average Secchi depth or can be measured with a photosynthetically active radiation (PAR) sensor. For Summerhill Esates Lake, the 1% light level based on average Secchi would reach the bottom of the lake and plants were found at the deepest portions in the lake. For a complete list of aquatic plants in Summerhill Estates Lake, refer to the aquatic plant table in Appendix B.

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

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

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

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

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

Invasive plant species found in Summerhill Estates

Curyleaf Pondweed

Curyleaf Pondweed

Eurasian Watermilfoil

Aquatic plants –dominant plants

Aquatic plants provide many water quality benefits and play an important role in the lakes ecosystem by providing habitat for fish and shelter for aquatic organism. Plants provide oxygen, reduce nutrients such as phosphorus to prevent algae blooms, and help stabilize sediment. A native plant community tends to be diverse and usually does not impede lake activities such as boating, swimming and fishing. The Illinois Department of Natural Resources recommends lakes with 20-40% plant coverage for fish habitat. Lakes with higher percentages of plant populations can be a nuisance for water recreation. The most dominant plants found in Summerhill Estates Lake were Coontail and White Water Lily. Coontail was overly abundant found at 98.3% of the sampling sites and in high abundance (Figure 18). Coontail is a native plant that often forms dense colonies. Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates. Also the fruits of Coontail are consumed by ducks and it is considered good wildlife food. While native, it can cause an issue for recreation in such high densities. White Water Lily was the next dominant plant found at 36.2% of the sampling sites (Figure 19). White Water Lily form large thick rhizomes and the leaves are more round than heart –shaped and typically 6-12 inches in diameter. It also has a white flower that may float or stick above the water and opens in the morning and closes in the afternoon. White Water Lily typically found on perimeter of the lake.

Figure 18: Coontail (*Ceratophyllum demersum* abundance in Summerhill Estates Lake, 2016

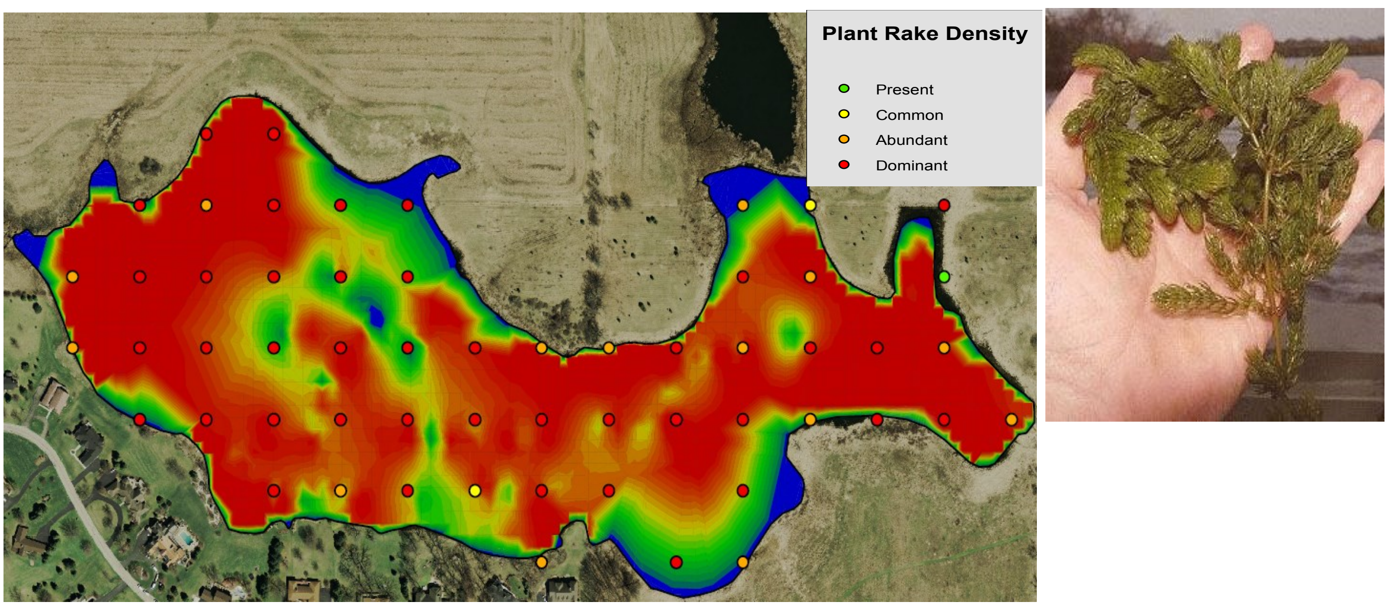
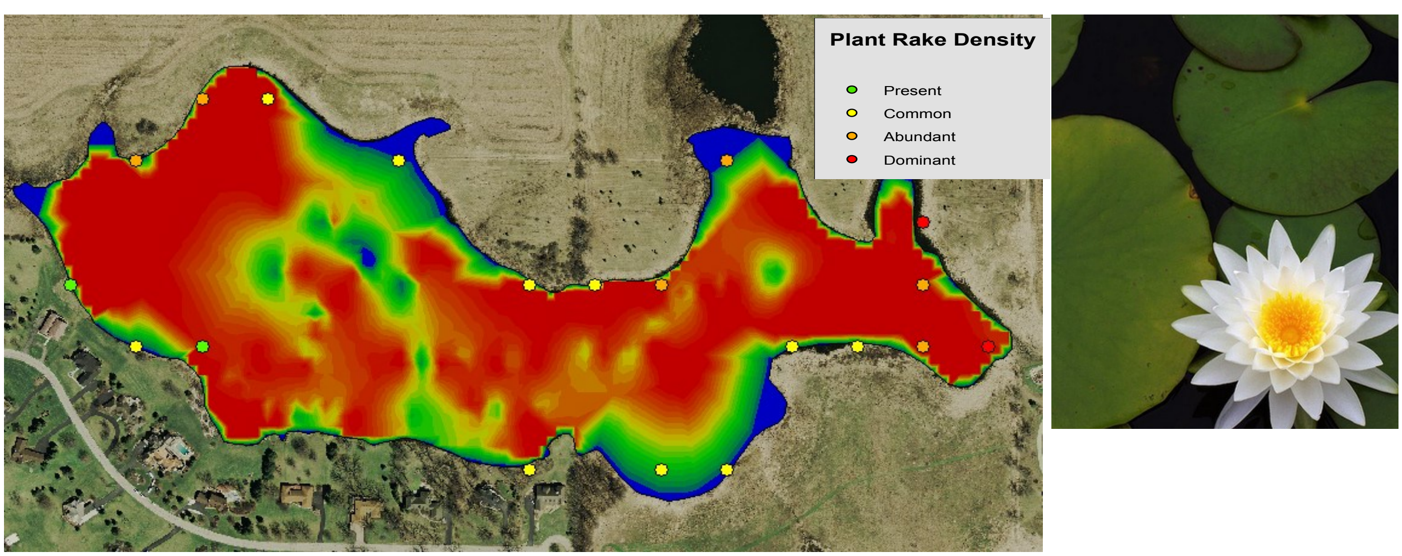


Figure 19: White Water Lily (*Nymphaea tuberosa*) abundance in Summerhill Estates Lake, 2016



FLORISTIC QUALITY INDEX

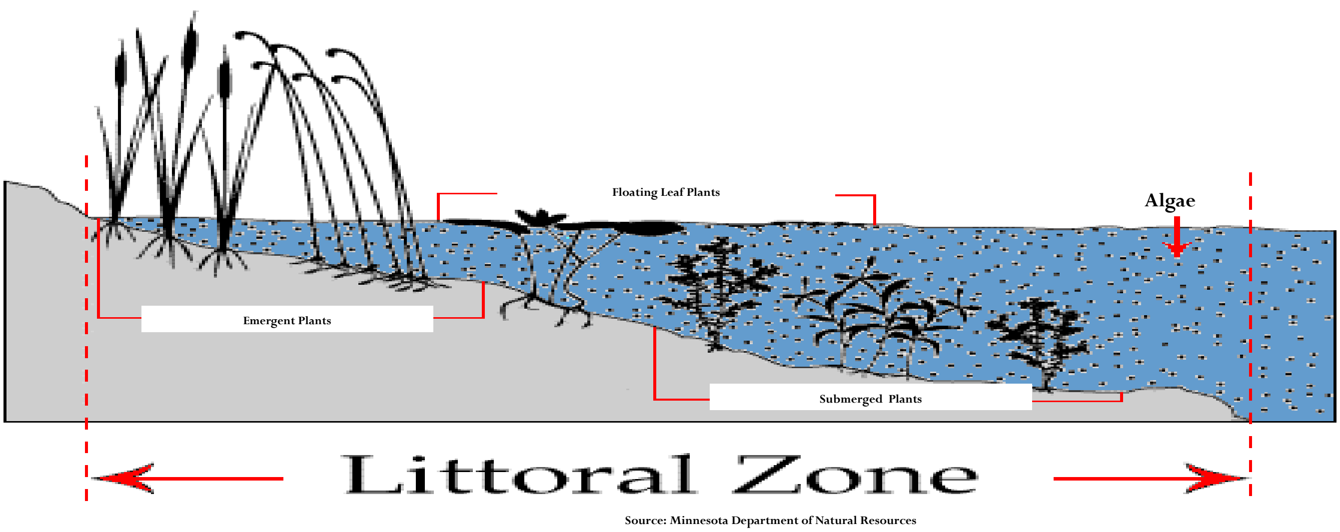
Floristic quality index (FQI) is an assessment tool designed to evaluate how close the flora of an area is compared to one of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site 3) monitor long-term floristic trends and 4) monitor habitat restoration efforts. Each aquatic plant in a lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). This is done for every floating and submerged plant species found in the lake. The FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. 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 calculations for Lake County lakes. The median FQI for Lake County lakes from 2000-2016 was 13.4. Summerhill Estates Lake had an FQI value of 14.5 ranking 73 out of 171 lakes in Lake County (Appendix B). The 2016 FQI for Summerhill Estates Lake is an improvement since the 2009 sampling when the FQI was 12.7. This is due to the increase in aquatic native plant species. Nine plant species, with two of those species being aquatic invasive, and one macro-algae were observed in the lake in 2016.

Lake county Average FQI = 13.4

Summerhill Estates Lake FQI = 14.50

Rank = 73/171

Aquatic Plants Species Observed = 9

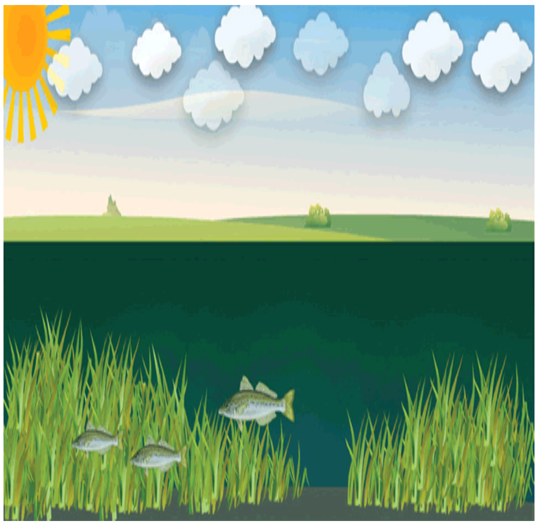


In many lakes, macrophytes contribute to the aesthetically pleasing appearance of the setting and are enjoyable in their own right. But even more important, they are an essential element in the life systems of most lakes.

- Macrophyte leaves and stems provide a habitat or home for small attached plants and animals. Some are microscopic in size and some are larger. These attached organisms are valuable as food for animals higher in the food chain, such as fish and birds.
- Many types of small organisms live in the sediment. There are insects that spend the immature stages of life in the sediments, leaving when they become adults. Decomposing plant life provides part of the food supply for these sediment-dwelling organisms and the emerging insects, in turn, are food for fish.
- The submerged portions of macrophytes provide shelter and cover for small or young fish from larger fish that would feed on them.
- Types of plants that extend above the water can provide cover for waterfowl and their young, and many plants can serve directly as food for certain types of waterfowl.
- Aquatic plants provide many water quality benefits such as sediment stabilization and competition with algae for available nutrients.

Aquatic plants and 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 parameters of an ideal fish habitat change base on the size and species of fish, the type of lake, structures present in the lake and many other factors. There is no recent or historical survey on file for Summerhill Lake. It is recommended that an updated survey be conducted. The report generated by the IDNR would provide status of the fish populations and also recommendations to keep a healthy fishery.



How do plants impact fish?

- *Plants provide critical structure to aquatic habitats.*
- *Plants influence growth of fish by enhancing fish diversity, feeding, growth, and reproduction.*
- *Plants influence spawning. The structure provided by plant beds is important to fish reproduction.*
- *Plants influence the physical environment. Aquatic plants can change water temperatures and available oxygen in habitats.*

Table 5: Common fish and their plant affinity during various life stages and their relationship with plants.

		Life Stage				Relationship	
Fish	**Plant Affinity**	**Larvae**	**Juvenile**	**Adult**	**Spawn**	**Forage**	**Predator avoidance**
Bluegill sunfish	High	X	X	X	X	X	X
Common carp	High	X	X	X	X	X	X
Largemouth bass	High	X	X	X	X	X	X
Musky	High	X	X	X	X	X	X
Northern Pike	High	X	X	X	X	X	X
Black crappie	Moderate		X	X	X	X	X
Smallmouth bass	Moderate		X	X		X	X
Yellow perch	Moderate	X	X			X	X
White crappie	Low		X			X	
Salmon, trout	Low		X				X
Shad	Low	X					
Walleye	Low			X		X	

Table adapted from Gettys, Lynn, William T. Haller and Marc Bellaud. "Biology and Control of Aquatic Plants: A Best Management Practices Handbook". 2009

AQUATIC PLANT MANAGEMENT OPTIONS

Aquatic plants are essential for maintaining a balanced, healthy lake, but sometimes plants can create a nuisance for recreation, lake aesthetics, and invasive plant species can outcompete native plant species. Aquatic plant management is both controlling undesirable species while encouraging desirable species in important habitat areas. Summerhill Estates Lake has a high density of aquatic plants, mostly due to the shallow nature of the lake and its water clarity which allows plants to grow throughout the entire lake. There options to control aquatic plant growth, especially for invasive species. The main types of plant control include: mechanical harvesting, manual harvesting, and herbicides. Mechanical harvesting involves the use of specially designed machines that cut and remove plant material from a lake. Harvesting only reduces the height of aquatic plants in the water column. Manual or hand harvesting is the most environmentally friendly is best for small scale operations. The most common control tool in aquatic plant management is the use of herbicides registered by the U.S. environmental Protection Agency. Below is a table that briefly summarizes some pros and cons of the different aquatic plant management techniques. This is not a comprehensive list and should only be used as a guide to understanding different management options available.

Two sided rake for manual harvesting

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

LAKE MANAGEMENT PLANS

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

What are the steps in creating a Lake Management Plan?

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

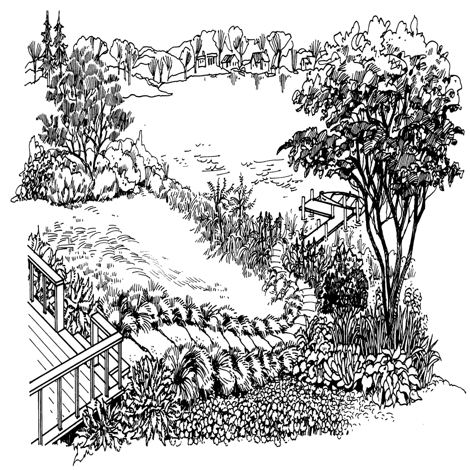
Follow these steps when getting started with writing Lake Management Plans. While each step is necessary, the level of effort and detail for each step will vary depending on the project's goals, size of the lake, and number of stakeholders.

LAKE RECOMMENDATIONS

Summerhill Estates Lake has improved water quality since the 2009 sampling date, likely a result of retired farmland by the Lake County Forest Preserve District. Despite improvements in water quality, Summerhill Estates Lake does suffer from nuisance algae blooms (filamentous), high nutrient levels, and high density of aquatic plant growth.

To improve the overall quality of Summerhill Estates Lake and prevent any decline the ES (Ecological Services) has the following recommendations:

- LCHD encourages Summerhill Estates homeowners to participate in the Volunteer Lake Monitoring Program to give yearly data for their lake. Participating in this program can provide useful data to observe changes in the lakes water clarity overtime. Contact the LCHD-ES at 847-377-8009 to get involved in the VLMP program.
- Develop a Lake Management Plan that incorporates aquatic plant management. Aquatic plant management should target invasive species and promotes native plant diversity. These plans should also consider the timing of pesticide applications and quantity of pesticide use. Early season herbicide use is better for the native plant community. Lake management plans can also include developing requests for proposals (RFPs) for herbicide application; which can better help associations properly manage their lake. Lake management plans must consider bottom ownership since bottom ownership is a mix of private and government.
- Updated fisheries survey to assess fish population and stocking recommendations.
- Increase or establish >25 ft buffer zones along homeowner shorelines. There are a variety of native plants that can be aesthetically pleasing and will help reduce nutrient runoff and stabilize shorelines
- Become familiar with the appearance of harmful algal blooms and report any blooms to the LCHD-ES by calling 847-837-8030. This should especially be noted for lake users with pets who allow their pets to drink or play in the water.



Lake County Health Department and Community Health Center

ECOLOGICAL SERVICES

Senior Biologist: Mike Adam

madam@lakecountyil.gov

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

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

For more information visit us at:

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

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

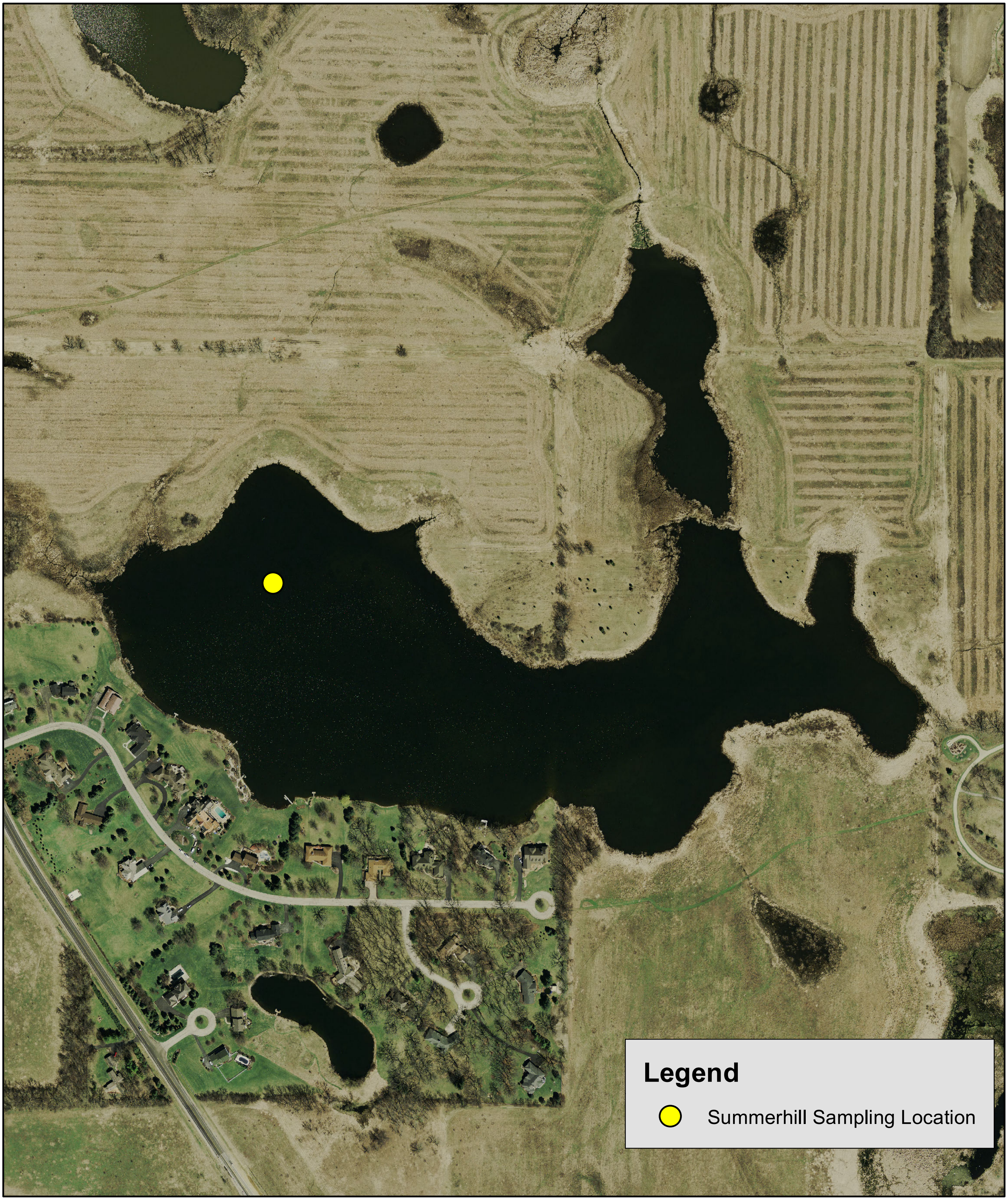
Environmental Service's goal is to monitor the quality of the county's surface water in order to:

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

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

Appendix A:
Figures

Summerhill Estates Lake Sampling Point Location



LakeCounty Health Department and Community Health Center

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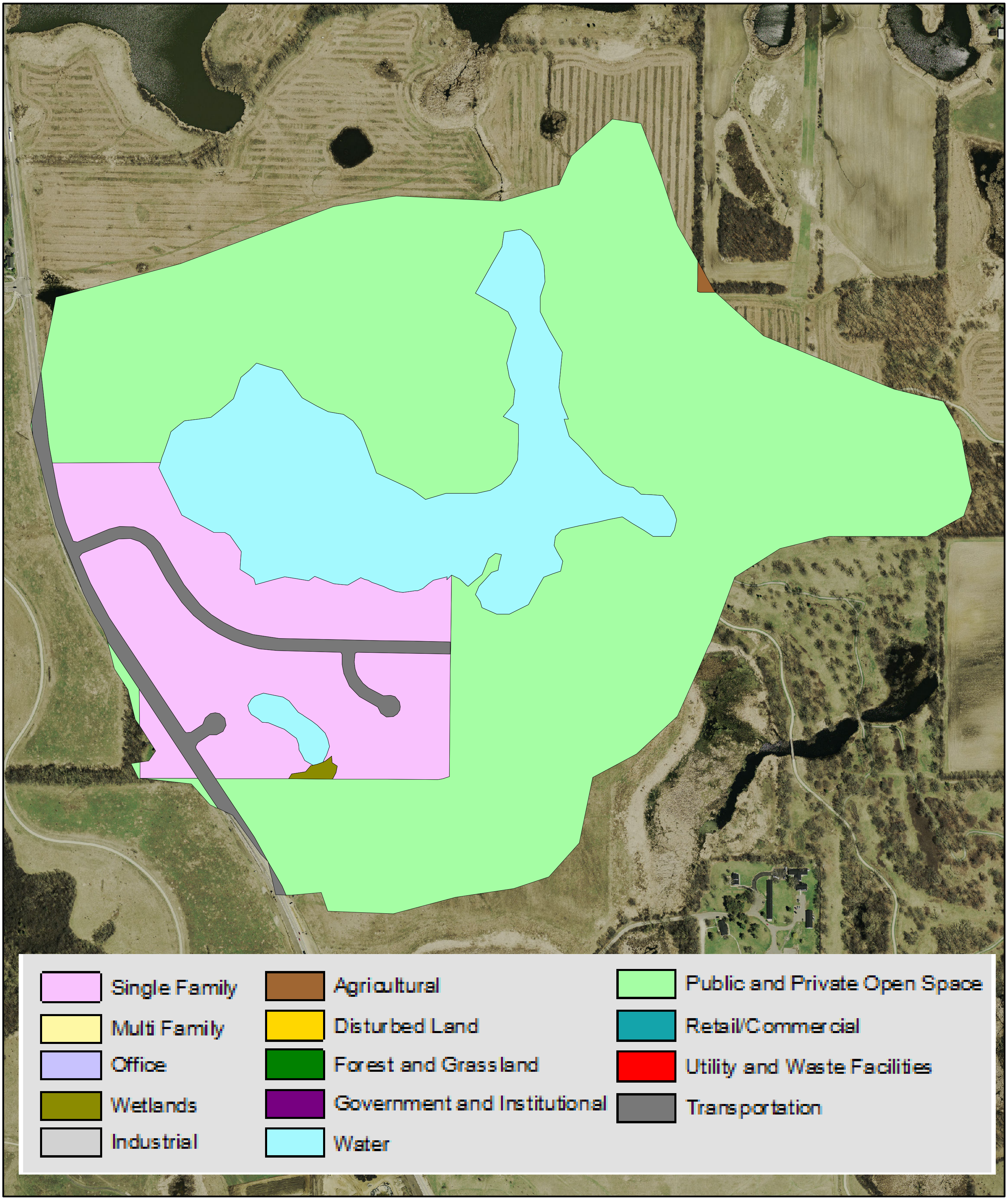
Ecological Services
Product Number SUM16
Revised 12/2016

Summerhill Estates Lake Watershed Boundary

LakeCounty
Health Department and
Community Health Center

Ecological Services
Product Number SUM16
Revised 12/2016

Summerhill Estates Lake Landuse



LakeCounty
Health Department and
Community Health Center

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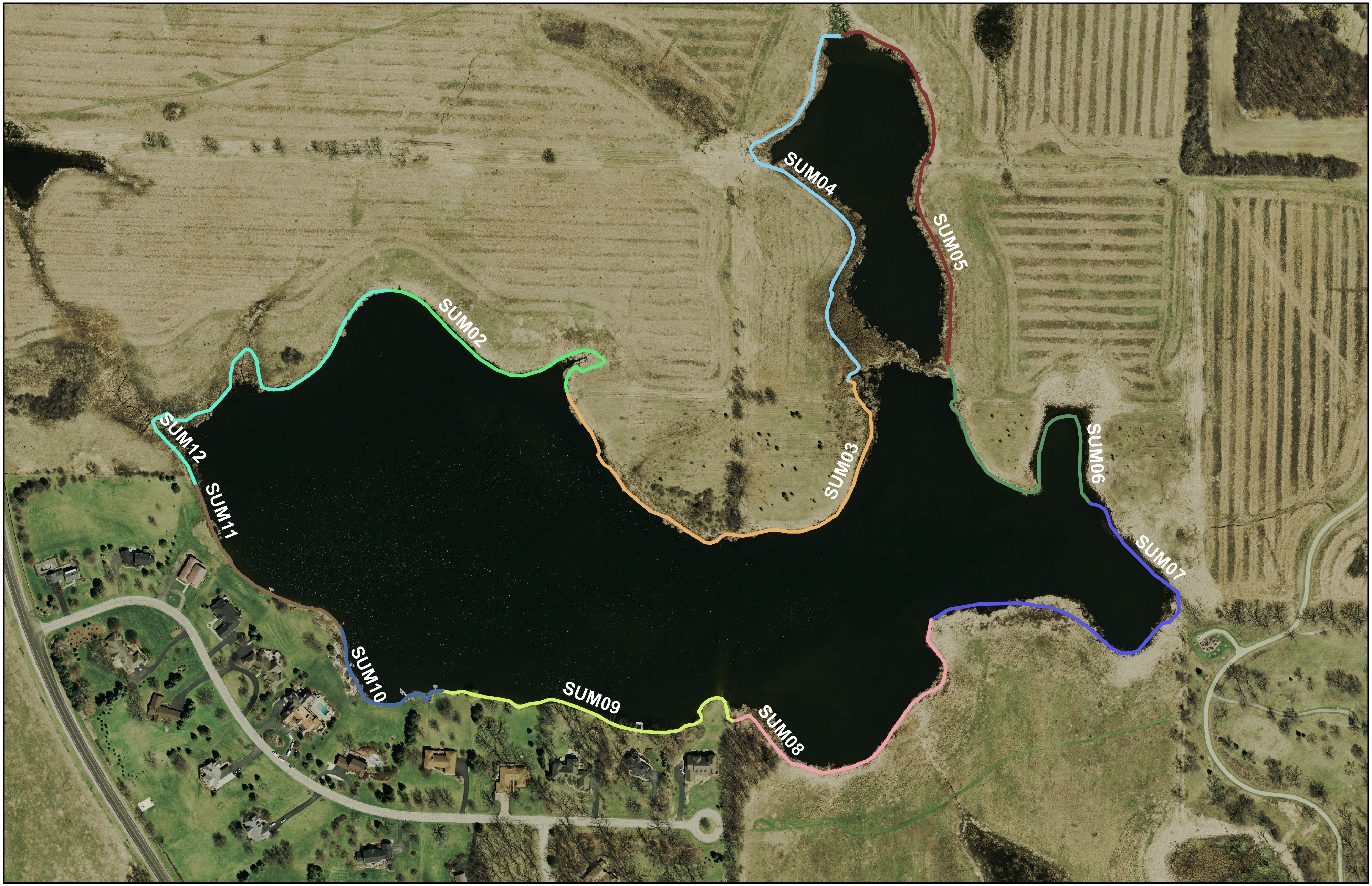
Ecological Services
Product Number SUM16
Revised 12/2016

Summerhill Shoreline Reaches 2016



LakeCounty
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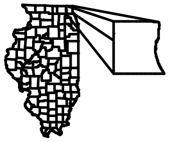
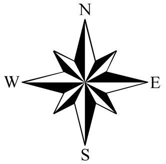
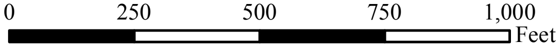
Community Health Center

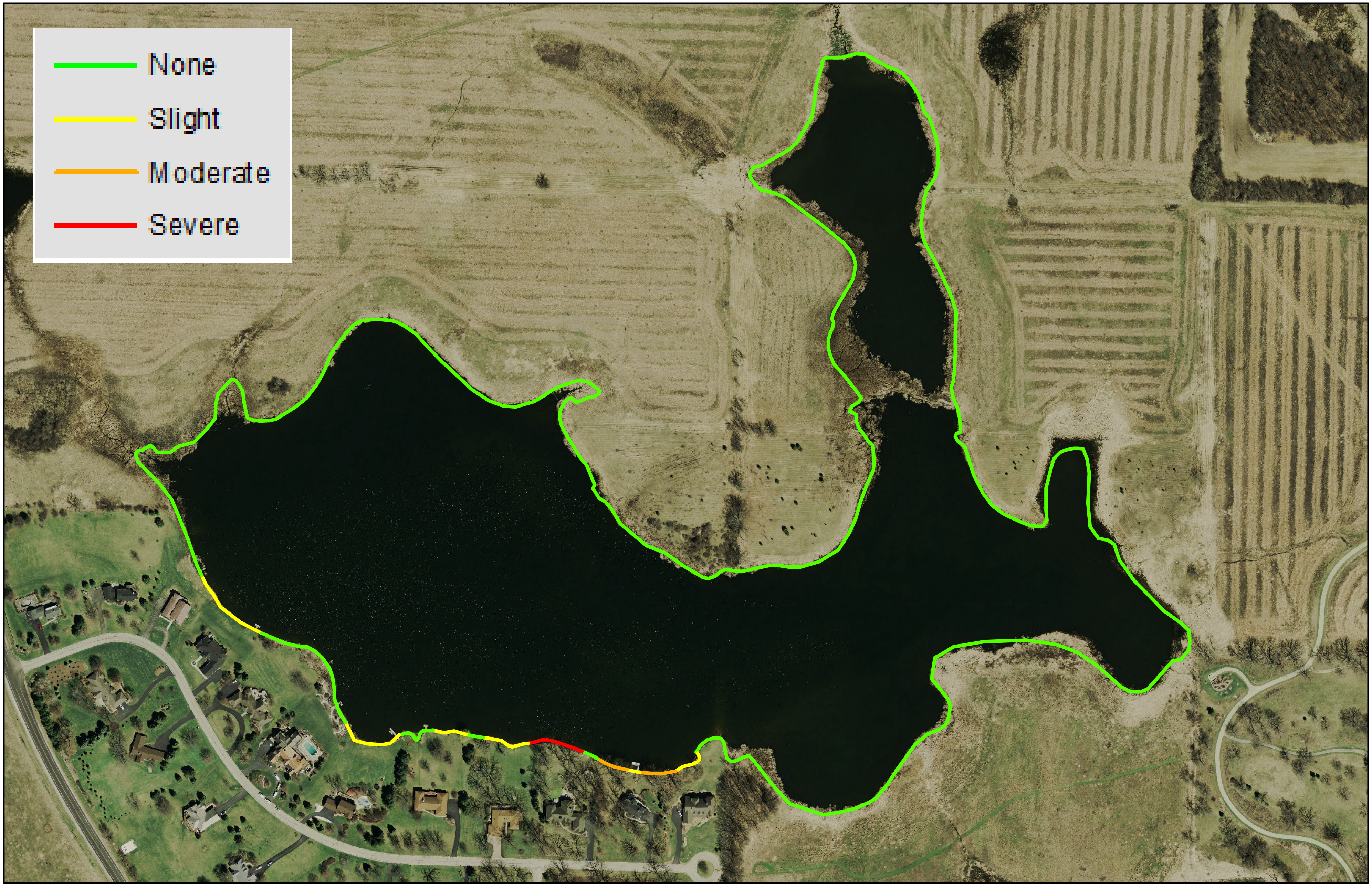


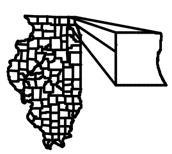


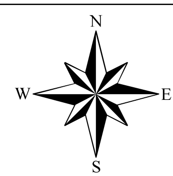


Ecological Services
Product Number SUM16
Revised 8/2016

Summerhill Lake Shoreline Erosion 2016







LakeCounty
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Ecological Services
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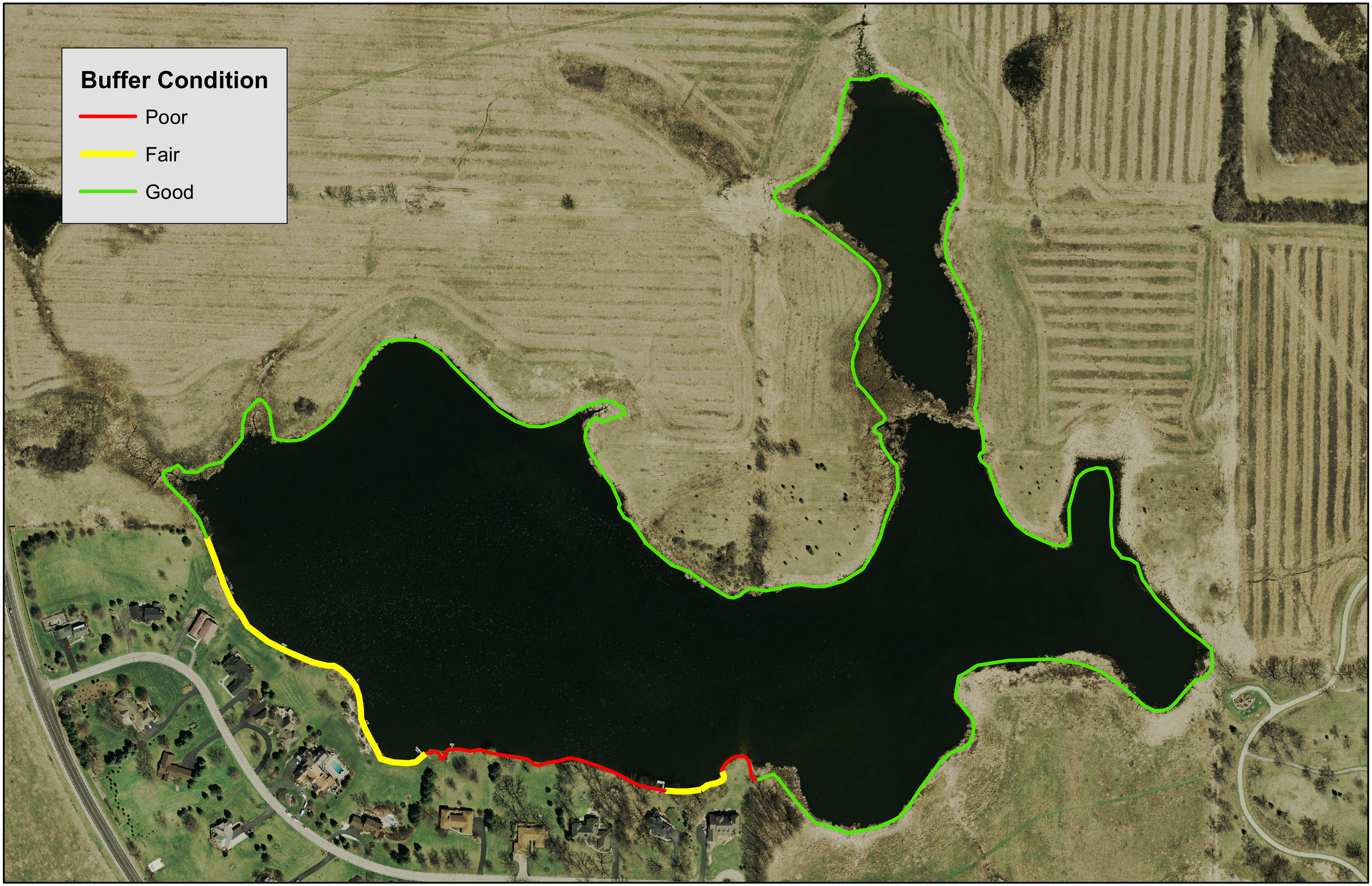
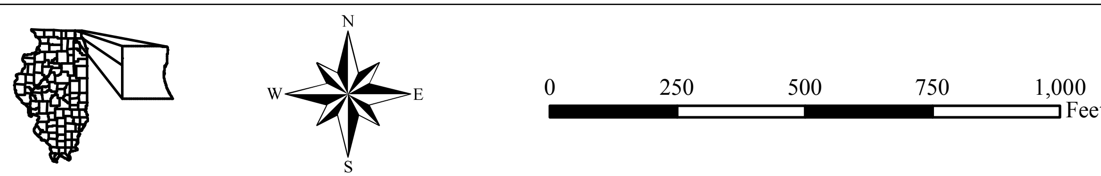
Revised 11/2016

Summerhill Estates Lake Buffer Condition 2016





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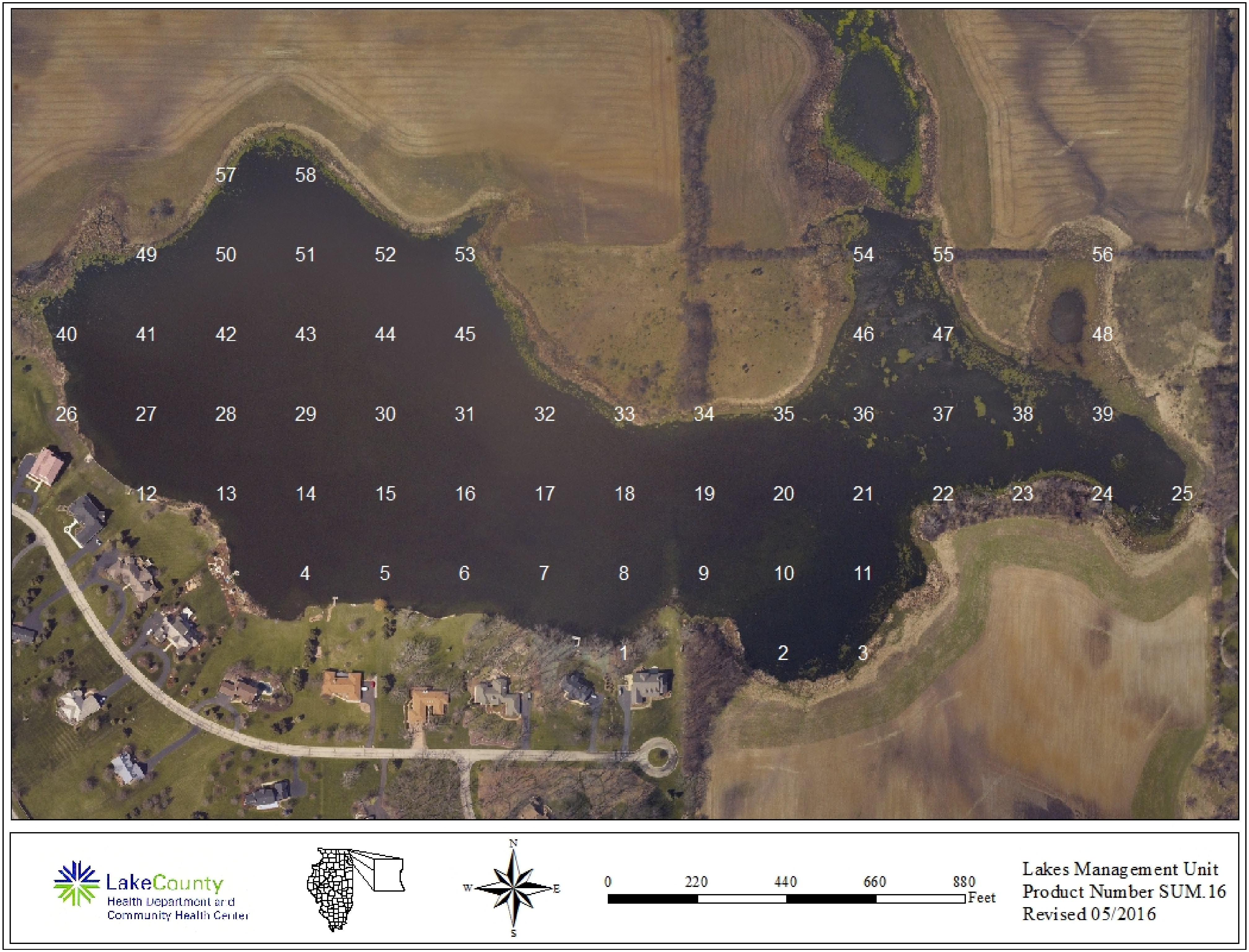
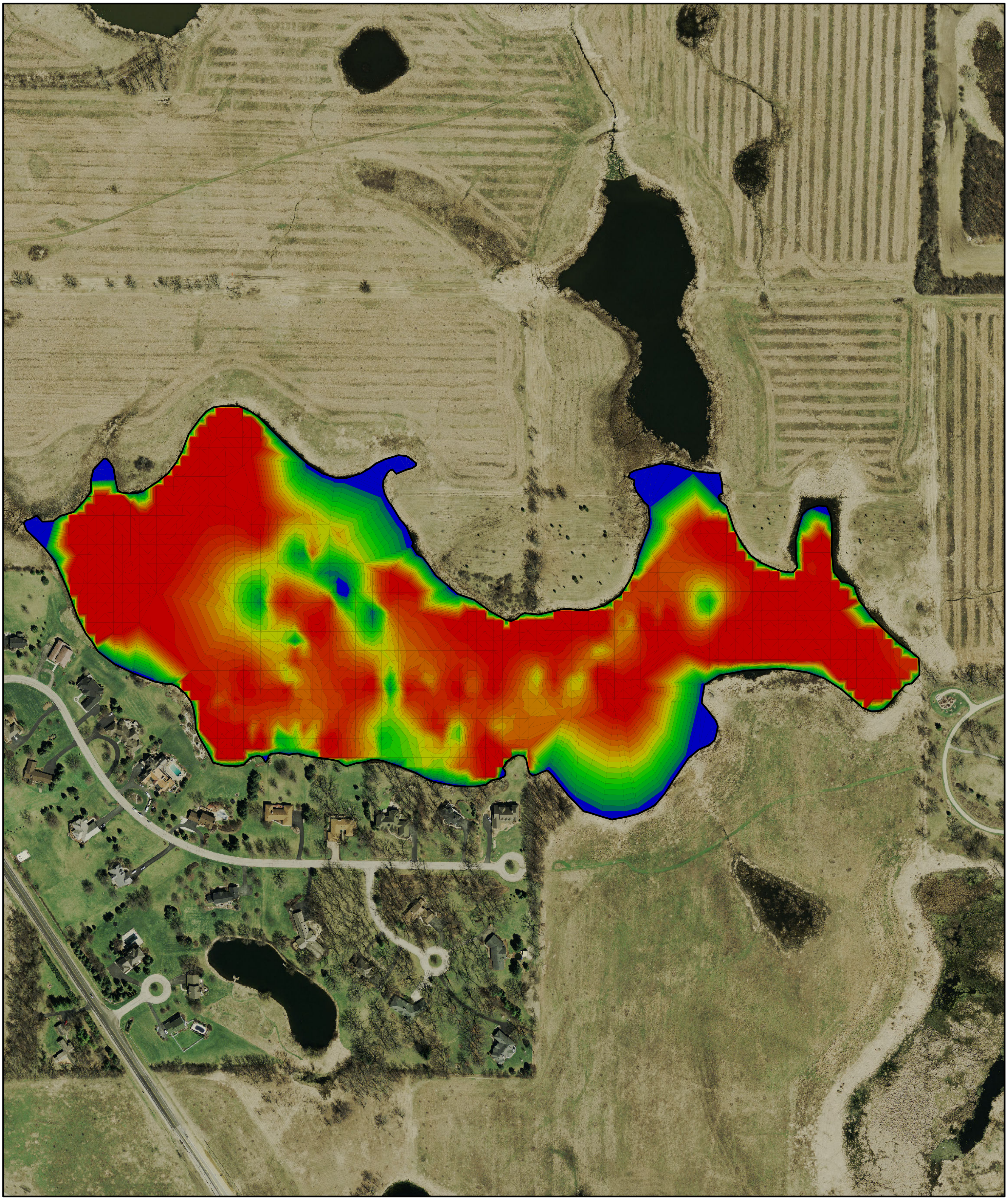
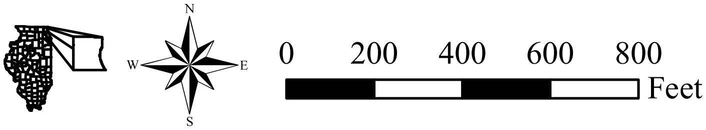
Summerhill 2016 Plant Grid



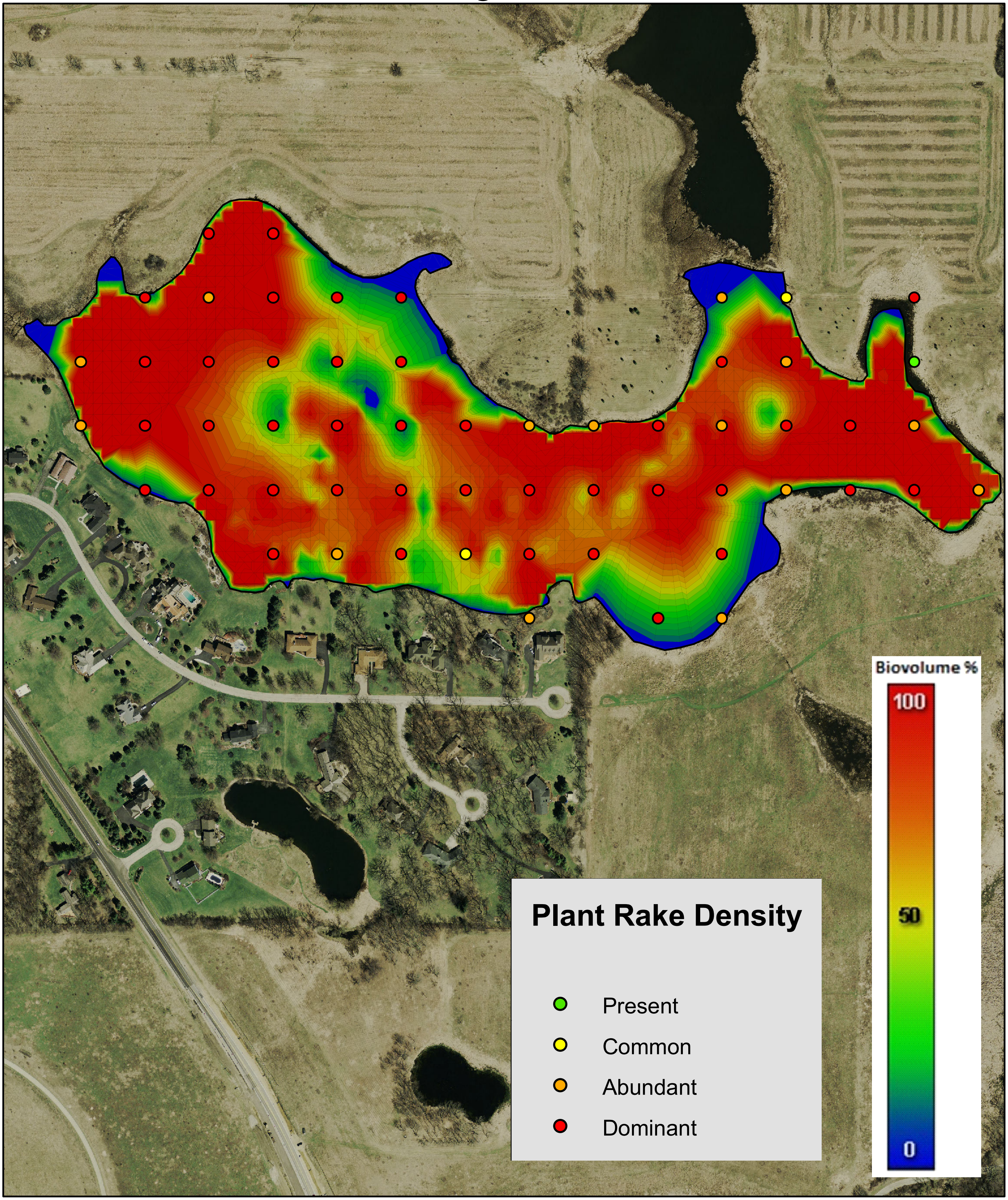
Summerhill Lake Plant Biovolume, August 2016





Ecological Services
Product Number SUM16
Revised 12/2016

Summerhill Lake Coontail Abundance and Plant Biovolume, August 2016



Lake County Health Department and Community Health Center

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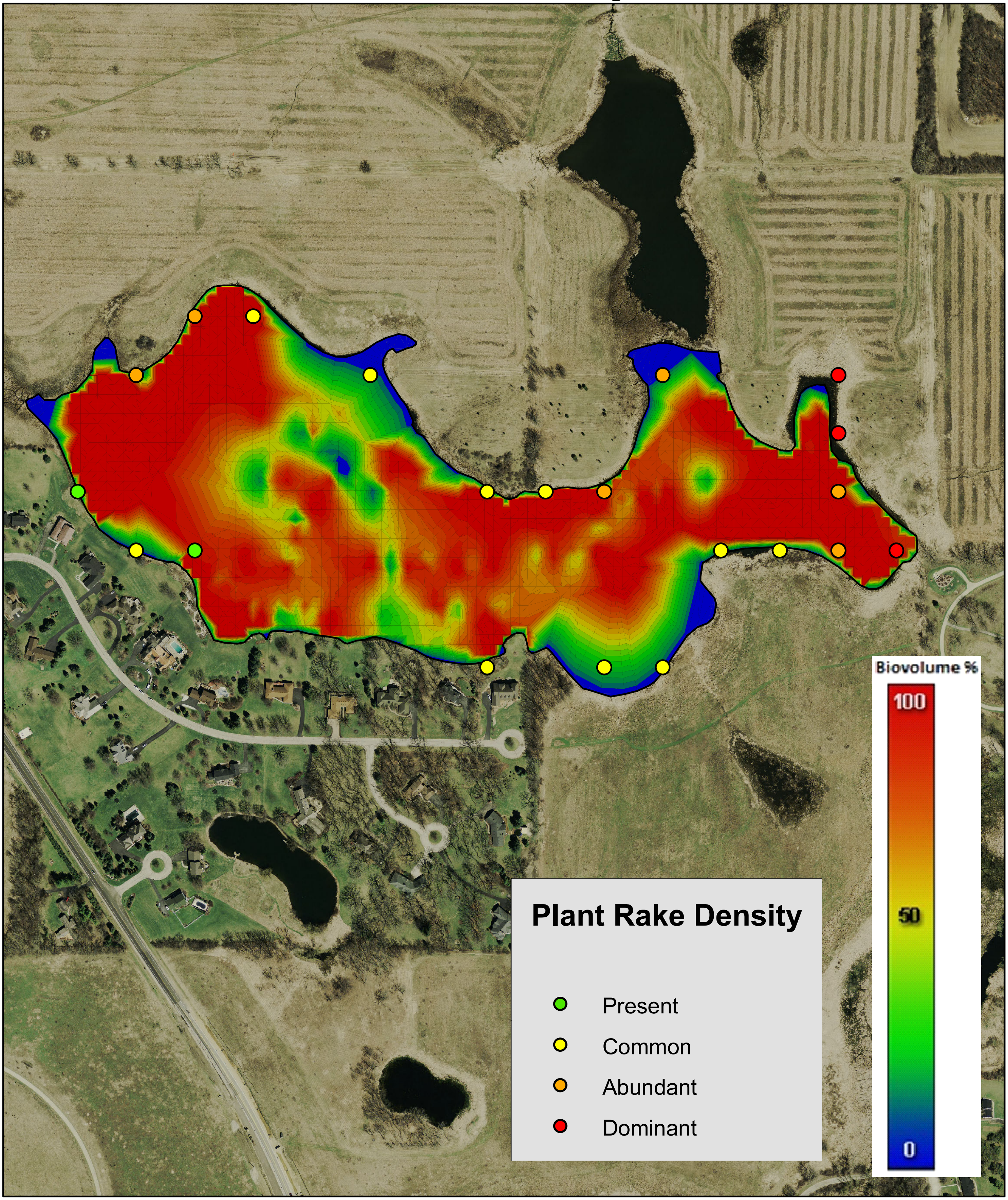
Ecological Services
Product Number SUM16
Revised 12/2016

Summerhill Estates Lake White Water Lily Abundance and Plant Biovolume,August 2016



LakeCounty Health Department and Community Health Center

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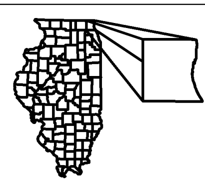
Ecological Services
Product Number SUM16
Revised 12/2016

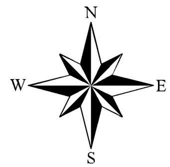
Bathymetric Map of Summerhill Estates Lake, Lake County, IL

Morphometric Data
Surface Area: 53.95 acres
Maximum Depth: 6.89 feet
Average Depth: 2.82 feet
Lake Volume: 152.56 acre-feet
Shoreline Length: 2.20 miles
Lake Elevation: 808.50 feet, msl

Survey Data Collected April 29, 2009
This map is intended for water quality reference only, not intended for navigational, swimming, or diving purposes.

LakeCounty
Health Department and Community Health Center





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Lakes Management Unit
Product Number: SUM Bathymap09
Revised 7/2009

Appendix B:
Tables

2016	Epilimnion														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
19-May	3	142	0.79	<0.100	<0.05	0.031	0.005	93	333	4.0	351	89	4.75	0.5673	8.84	12.44
15-Jun	3	144	0.79	<0.100	<0.05	0.046	<0.005	106	352	2.6	379	108	4.00	0.6049	7.75	2.49
13-Jul	3	162	1.13	<0.100	<0.05	0.070	0.006	106	362	7.5	406	124	4.00	0.6252	8.74	11.54
16-Aug	3	119	1.10	<0.100	<0.05	0.050	0.009	103	321	4.5	331	70	NA[a]	0.5441	9.69	12.39
14-Sep	3	116	1.22	0.148	<0.05	0.060	0.006	104	318	4.8	346	99	2.60	0.5390	9.55	11.57
	Average	137	1.01	0.110[k]	<0.05	0.051	.006[k]	102	337	4.7	363	98	3.84[b]	0.5761	8.91	10.09

2009	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
12-May	3	92	0.85	<0.1	<0.05	0.056	0.009	87	NA	6.1	275	78	6.07	0.4720	10.40	10.18
9-Jun	0	124	1.22	<0.1	<0.05	0.287	0.184	85	NA	4.4	323	84	4.36	0.5250	8.96	6.11
14-Jul	3	159	1.36	<0.1	<0.05	0.311	0.110	87	NA	14.0	362	96	2.72	0.5960	8.44	8.29
11-Aug	3	162	1.53	<0.1	<0.05	0.241	0.075	87	NA	15.0	371	98	1.47	0.6020	8.63	9.59
15-Sep	3	153	1.33	<0.1	<0.05	0.102	0.021	88	NA	7.3	353	88	1.75	0.5810	8.71	8.87
	Average	138	1.26	<0.1	<0.05	0.199	0.080	87	NA	9.4	337	89	3.27	0.5552	9.03	8.61

2004	Epilimnion															
DATE	DEPTH	ALK	TKN	NH3-N	NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
19-May	3	100	1.16	<0.1	<0.05	0.113	0.046	NA	274	3.4	305	89	0.00[a]	0.5250	9.85	5.05
16-Jun	3	122	1.51	<0.1	0.150	0.143	0.058	NA	302	2.7	327	103	4.63	0.5430	8.88	1.38
21-Jul	3	166	1.68	<0.1	<0.05	0.198	0.041	NA	306	6.1	359	108	4.4	0.6200	7.95	5.38
18-Aug	3	167	1.87	<0.1	<0.05	0.132	0.011	NA	356	8.5	390	126	3	0.6230	8.15	7.67
22-Sep	3	161	1.88	<0.1	<0.05	0.106	<0.005	NA	332	10.0	387	124	2.56	0.6180	8.30	8.74
	Average	143	1.62	<0.1	0.150[k]	0.138	0.039[k]	NA	314	6.1	354	110	3.65[b]	0.5858	8.63	5.64

Glossary

ALK = Alkalinity, mg/L $CaCO_3$	TDS = Total dissolved solids, mg/L
TKN = Total Kjeldahl nitrogen, mg/L	TSS = Total suspended solids, mg/L
NH_3-N = Ammonia nitrogen, mg/L	TS = Total solids, mg/L
NO_2+NO_3-N = Nitrate + Nitrite nitrogen, mg/L	TVS = Total volatile solids, mg/L
NO_3-N = Nitrate + Nitrite nitrogen, mg/L	SECCHI = Secchi disk depth, ft.
TP = Total phosphorus, mg/L	COND = Conductivity, milliSiemens/cm
SRP = Soluble reactive phosphorus, mg/L	DO = Dissolved oxygen, mg/L
Cl^- = Chloride, 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
a = Secchi depth was obstructed by plants
b = Secchi disk depth average does not include data from when Secchi disk was obstructed by plants

Summerhill Estates Lake Landuse 2016

Land Use	Acreage	% of Total
Agricultural	0.18	0.1%
Public and Private Open Space	189.59	65.2%
Single Family	44.33	15.2%
Transportation	8.97	3.1%
Water	47.35	16.3%
Wetlands	0.37	0.1%
Total Acres	**290.78**	**100.0%**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Agricultural	0.18	0.05	0.0	0.0%
Public and Private Open Space	189.59	0.15	78.2	57.6%
Single Family	44.33	0.30	36.6	26.9%
Transportation	8.97	0.85	21.0	15.4%
Water	47.35	0.00	0.0	0.0%
Wetlands	0.37	0.05	0.1	0.0%
TOTAL	**290.78**		**135.8**	100.0%

Lake volume	**152.56**	**acre-feet**
Retention Time (years)= lake volume/runoff	**1.12**	**years**
	410.02	**days**

Table 1: Summerhill Estates Lake Shoreline Erosion Condition 2016

Reach	No Erosion		Slight Erosion		Moderate Erosion		Severe Erosion		Total	Lateral Recession Rate
	ft.	%	ft.	%	ft.	%	ft.	%	ft	ft/yr
SUM02	910.1	100%	0.0	0%	0.0	0%	0.0	0%	910.1	0.01
SUM03	1463.0	100%	0.0	0%	0.0	0%	0.0	0%	1463.0	0.01
SUM04	1367.2	100%	0.0	0%	0.0	0%	0.0	0%	1367.2	0.01
SUM05	1161.3	100%	0.0	0%	0.0	0%	0.0	0%	1161.3	0.01
SUM06	1060.5	100%	0.0	0%	0.0	0%	0.0	0%	1060.5	0.01
SUM07	1252.7	100%	0.0	0%	0.0	0%	0.0	0%	1252.7	0.01
SUM08	997.7	100%	0.0	0%	0.0	0%	0.0	0%	997.7	0.01
SUM09	264.6	27%	362.1	37%	194.2	20%	159.2	16%	980.2	0.10
SUM10	298.6	61%	194.6	39%	0.0	0%	0.0	0%	493.2	0.02
SUM11	389.6	62%	243.7	38%	0.0	0%	0.0	0%	633.3	0.02
SUM12	1290.3	100%	0.0	0%	0.0	0%	0.0	0%	1290.3	0.01
Total	10455.5	90%	800.4	7%	194.2	2%	159.2	1%	11609.3	

Table 2: Summerhill Estates Lake Lakeshore Buffer Condition 2016

Reach	Poor		Fair		Good		Total
	ft.	%	ft.	%	ft.	%	ft
SUM02	0.0	0%	0.0	0%	910.1	100%	910.1
SUM03	0.0	0%	0.0	0%	1463.0	100%	1463.0
SUM04	0.0	0%	0.0	0%	1367.2	100%	1367.2
SUM05	0.0	0%	0.0	0%	1161.3	100%	1161.3
SUM06	0.0	0%	0.0	0%	1060.5	100%	1060.5
SUM07	0.0	0%	0.0	0%	1252.7	100%	1252.7
SUM08	0.0	0%	0.0	0%	997.7	100%	997.7
SUM09	781.6	80%	198.6	20%	0.0	0%	980.2
SUM10	123.1	25%	370.1	75%	0.0	0%	493.2
SUM11	0.0	0%	633.3	100%	0.0	0%	633.3
SUM12	0.0	0%	0.0	0%	1290.3	100%	1290.3
Total	904.6	8%	1202.0	10%	9502.7	82%	11609.3

Aquatic plants found at all sampling sites on Summerhill Estates Lake in August 2016.
The maximum depth that plants were found was 5.5 feet.

Plant Density	Chara	Coontail	Curlyleaf Pondweed	Duckweed	Elodea	Eurasian Watermilfoil	Sago Pondweed	Watermeal	White Water Lily	Star Duckweed
Absent	57	1	56	55	41	44	51	50	37	57
Present	0	1	2	2	7	4	4	2	2	0
Common	0	2	0	1	8	8	2	4	10	1
Abundant	1	14	0	0	1	2	1	2	6	0
Dominant	0	40	0	0	1	0	0	0	3	0
% Plant Occurrence	1.7	98.3	3.4	5.2	29.3	24.1	12.1	13.8	36.2	1.7
Total Sites	58	58	58	58	58	58	58	58	58	58

Distribution of Rake Density Across all Sampling Sites.

Density (coverage)	# of Sites	% of Sites
No Plants	0	0.0
>0-10%	0	0.0
10-40%	1	1.7
40-60%	4	6.9
60-90%	14	24.1
>90%	39	67.2
Total Sites with Plants	58	100%
Total # Sites	58	100%

Morphometric Features of Summerhill Estates Lake ~
Data From the April 29, 2009 Bathymetric Survey, LCHD Environmental Service

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	53.95	100.0%	46.18	0 - 1	15.13	28.0%	30.3%
1	38.82	72.0%	35.85	1 - 2	5.86	10.9%	23.5%
2	32.96	61.1%	30.24	2 - 3	5.37	9.9%	19.8%
3	27.59	51.1%	23.78	3 - 4	7.43	13.8%	15.6%
4	20.16	37.4%	13.59	4 - 5	12.22	22.6%	8.9%
5	7.95	14.7%	2.93	5 - 6	7.87	14.6%	1.9%
6	0.07	0.1%	0.12	6+	0.07	0.1%	0.1%
			152.56		53.95	100%	100%

Maximum Depth of Lake: 6.89 Feet
Average Depth of Lake: 2.82 Feet
Volume of Lake: 152.56 Acre-Feet

Area of Lake: 53.95 Acres
Shoreline Length: 2.20 Miles
Water Elevation at 808.50 Feet Above Mean Sea Level

LakeCounty
Health Department and
Community Health Center

Lake County average Floristic Quality Index (FQI) ranking 2000-2016.

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	Lake of the Hollow	23.0	24.8
23	Nippersink Lake (Fox Chain)	22.4	23.2
24	Countryside Glen Lake	21.9	22.8
25	Grass Lake	21.5	22.2
26	Davis Lake	21.4	21.4
27	Timber Lake (North)	20.9	23.4
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	Potomac Lake	17.8	17.8
46	Lake Zurich	17.7	18.9
47	Redhead Lake	17.7	18.7
48	Long Lake	17.7	15.8
49	Hendrick Lake	17.7	17.7
50	Rollins Savannah 2	17.7	17.7
51	Grandwood Park Lake	17.2	19.0
52	Seven Acre Lake	17.0	15.5
53	Lake Miltmore	16.8	18.7
54	Petite Lake	16.8	18.7
55	Channel Lake	16.8	18.7
56	McDonald Lake 1	16.7	17.7
57	Highland Lake	16.7	18.9
58	Almond Marsh	16.3	17.3

Lake County average Floristic Quality Index (FQI) ranking 2000-2016.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
59	Owens Lake	16.3	17.3
60	Windward Lake	16.3	17.6
61	Butler Lake	16.1	18.1
62	Grays Lake	16.1	16.1
63	White Lake	16.0	17.0
64	Dunns Lake	15.9	17.0
65	Dog Bone Lake	15.7	15.7
66	Osprey Lake	15.5	17.3
67	Heron Pond	15.1	15.1
68	Ames Pit	15.1	17.6
69	North Churchill Lake	15.0	15.0
70	Hastings Lake	15.0	17.0
71	Forest Lake	14.8	15.9
72	Dog Training Pond	14.7	15.9
73	Summerhill Estates Lake	14.5	15.5
74	Grand Ave Marsh	14.3	16.3
75	Nippersink Lake	14.3	16.3
76	Taylor Lake	14.3	16.3
77	Manning's Slough	14.1	16.3
78	Tower Lake	14.0	14.0
79	Dugdale Lake	14.0	15.1
80	Eagle Lake (S1)	14.0	15.1
81	Crooked Lake	14.0	16.0
82	Spring Lake	14.0	15.2
83	Lake Matthews	13.9	15.5
84	Longview Meadow Lake	13.9	13.9
85	Fischer Lake	13.6	14.7
86	Bishop Lake	13.4	15.0
87	Mary Lee Lake	13.1	15.1
88	Old School Lake	13.1	15.1
89	Lake Tranquility (S1)	12.6	12.6
90	Buffalo Creek Reservoir 1	12.5	11.4
91	Buffalo Creek Reservoir 2	12.5	11.4
92	McDonald Lake 2	12.5	12.5
93	Rollins Savannah 1	12.5	12.5
94	Stone Quarry Lake	12.5	12.5
95	Kemper Lake 1	12.2	13.4
96	Pond-A-Rudy	12.1	12.1
97	Stockholm Lake	12.1	13.5
98	Lake Leo	12.1	14.3
99	Lambs Farm Lake	12.1	14.3
100	Bresen Lake	12.0	13.9
101	Grassy Lake	12.0	12.0
102	Flint Lake Oulet	11.8	13.0
103	Albert Lake	11.5	10.3
104	Rivershire Pond 2	11.5	13.3
105	Hook Lake	11.3	13.4
106	Briarcrest Pond	11.2	12.5
107	Lake Naomi	11.2	12.5
108	Pulaski Pond	11.2	12.5
109	Lake Napa Suwe	11.0	11.0
110	Redwing Marsh	11.0	11.0
111	West Meadow Lake	11.0	11.0
112	Nielsen Pond	10.7	12.0
113	Lake Holloway	10.6	10.6
114	Sylvan Lake	10.6	10.6
115	Echo Lake	10.4	10.4
116	Gages Lake	10.2	12.5

Lake County average Floristic Quality Index (FQI) ranking 2000-2016.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
117	College Trail Lake	10.0	10.0
118	Valley Lake	9.9	9.9
119	Werhane Lake	9.8	12.0
120	Fish Lake	9.6	10.6
121	Lake Carina	9.5	12.5
122	Columbus Park Lake	9.2	9.2
123	Lake Lakeland Estates	9.2	9.2
124	Waterford Lake	9.2	9.2
125	Bluff Lake	9.1	11.0
126	Lake Fairfield	9.0	10.4
127	Des Plaines Lake	8.6	9.9
128	Antioch Lake	8.5	8.5
129	Loch Lomond	8.5	8.5
130	Lake Fairview	8.5	6.9
131	Timber Lake (South)	8.5	6.9
132	East Meadow Lake	8.5	8.5
133	South Churchill Lake	8.5	8.5
134	Kemper Lake 2	8.5	9.8
135	Lake Christa	8.5	9.8
136	Lake Farmington	8.5	9.8
137	Lucy Lake	8.5	9.8
138	Lake Louise	8.4	8.4
139	Bittersweet Golf Course #13	8.1	8.1
140	Lake Linden	8.0	8.0
141	Sand Lake	8.0	10.4
142	Countryside Lake	7.7	11.5
143	Fairfield Marsh	7.5	8.7
144	Lake Eleanor	7.5	8.7
145	Banana Pond	7.5	9.2
146	Slocum Lake	7.1	5.8
147	Lucky Lake	7.0	7.0
148	North Tower Lake	7.0	7.0
149	Lake Forest Pond	6.9	8.5
150	Ozaukee Lake	6.7	8.7
151	Leisure Lake	6.4	9.0
152	Peterson Pond	6.0	8.5
153	Little Bear Lake	5.8	7.5
154	Deer Lake Meadow Lake	5.2	6.4
155	ADID 127	5.0	5.0
156	Island Lake	5.0	5.0
157	Liberty Lake	5.0	5.0
158	Oak Hills Lake	5.0	5.0
159	Slough Lake	5.0	5.0
160	International Mining and Chemical Lake	5.0	7.1
161	Lochanora Lake	5.0	5.0
162	Diamond Lake	3.7	5.5
163	Lake Charles	3.7	5.5
164	Big Bear Lake	3.5	5.0
165	Sand Pond (IDNR)	3.5	5.0
166	Harvey Lake	3.3	5.0
167	Half Day Pit	2.9	5.0
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	**13.9**	**14.9**
	Median	**13.4**	**14.7**

Lake County average TSI phosphorus (TSIp) ranking 2000-2016.

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	41.14
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	Timber Lake (North)	0.0210	48.05
18	Lake Zurich	0.0210	48.05
19	Cross Lake	0.0216	48.46
20	Dog Training Pond	0.0220	48.72
21	Sun Lake	0.0220	48.72
22	Deep Lake	0.0230	49.36
23	Lake of the Hollow	0.0230	49.36
24	Round Lake	0.0230	49.36
25	Stone Quarry Lake	0.0230	49.36
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	Waterford Lake	0.0400	57.34
48	Hook Lake	0.0410	57.70
49	Lake Tranquility (S1)	0.0412	57.77
50	Nielsen Pond	0.0450	59.04
51	Seven Acre Lake	0.0460	59.36

Lake County average TSI phosphorus (TSIp) ranking 2000-2016.

RANK	LAKE NAME	TP AVE	TSIp
52	Turner Lake	0.0460	59.36
53	Willow Lake	0.0460	59.36
54	East Meadow Lake	0.0480	59.97
55	Lucky Lake	0.0480	59.97
56	Old Oak Lake	0.0490	60.27
57	College Trail Lake	0.0500	60.56
58	Summerhill Estates Lake	0.0514	60.96
59	Hastings Lake	0.0520	61.13
60	West Meadow Lake	0.0530	61.40
61	Lucy Lake	0.0550	61.94
62	Lake Linden	0.0570	62.45
63	Lake Christa	0.0580	62.70
64	Owens Lake	0.0580	62.70
65	Briarcrest Pond	0.0580	62.70
66	Honey Lake	0.0586	62.85
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	Crooked Lake	0.0710	65.62
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	Broberg Marsh	0.0780	66.97
90	Echo Lake	0.0790	67.16
91	Countryside Lake	0.0800	67.34
92	Lake Nippersink	0.0800	67.34
93	Woodland Lake	0.0800	67.34
94	Redwing Slough	0.0822	67.73
95	Tower Lake	0.0830	67.87
96	Antioch Lake	0.0850	68.21
97	Potomac Lake	0.0850	68.21
98	White Lake	0.0862	68.42
99	Grand Ave Marsh	0.0870	68.55
100	North Churchill Lake	0.0870	68.55
101	McDonald Lake 1	0.0880	68.71
102	Pistakee Lake	0.0880	68.71

Lake County average TSI phosphorus (TSIp) ranking 2000-2016.

RANK	LAKE NAME	TP AVE	TSIp
103	Lake Fairview	0.0890	68.88
104	Rivershire Pond 2	0.0900	69.04
105	South Churchill Lake	0.0900	69.04
106	McGreal Lake	0.0910	69.20
107	Lake Charles	0.0930	69.51
108	Deer Lake	0.0940	69.66
109	Eagle Lake (S1)	0.0950	69.82
110	International Mine and Chemical Lake	0.0950	69.82
111	Valley Lake	0.0950	69.82
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	Dunn's Lake	0.1070	71.53
121	Lake Forest Pond	0.1070	71.53
122	Long Lake	0.1070	71.53
123	Grass Lake	0.1090	71.80
124	Des Plaines Lake	0.1090	71.80
125	Spring Lake	0.1100	71.93
126	Kemper 2	0.1100	71.93
127	Bittersweet Golf Course #13	0.1100	71.93
128	Osprey Lake	0.1110	72.06
129	Bluff Lake	0.1120	72.19
130	Middlefork Savannah Outlet 1	0.1120	72.19
131	Lochanora Lake	0.1120	72.19
132	Round Lake Marsh North	0.1130	72.32
133	Deer Lake Meadow Lake	0.1160	72.70
134	Lake Matthews	0.1180	72.94
135	Taylor Lake	0.1180	72.94
136	Island Lake	0.1210	73.31
137	Columbus Park Lake	0.1230	73.54
138	Lake Holloway	0.1320	74.56
139	Fischer Lake	0.1380	75.20
140	Slocum Lake	0.1500	76.40
141	Lakewood Marsh	0.1510	76.50
142	Pond-A-Rudy	0.1510	76.50
143	Forest Lake	0.1540	76.78
144	Bresen Lake	0.1580	77.15
145	Middlefork Savannah Outlet 2	0.1590	77.24
146	Grassy Lake	0.1610	77.42
147	Salem Lake	0.1650	77.78
148	Half Day Pit	0.1690	78.12
149	Lake Louise	0.1810	79.11
150	Lake Eleanor	0.1810	79.11
151	Lake Farmington	0.1850	79.43
152	ADID 127	0.1890	79.74

Lake County average TSI phosphorus (TSIp) ranking 2000-2016.

RANK	LAKE NAME	TP AVE	TSIp
153	Lake Napa Suwe	0.1940	80.11
154	Loch Lomond	0.1960	80.26
155	Patski Pond	0.1970	80.33
156	Dog Bone Lake	0.1990	80.48
157	Redwing Marsh	0.2070	81.05
158	Stockholm Lake	0.2082	81.13
159	Bishop Lake	0.2160	81.66
160	Ozaukee Lake	0.2200	81.93
161	Kemper 1	0.2220	82.06
162	Hidden Lake	0.2240	82.19
163	McDonald Lake 2	0.2250	82.25
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	***0.1113***	***65.8***

Lake County Secchi Disk Clarity Ranking, 2000-2016.

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	Timber Lake (North)	7.37	48.33
30	Lake Miltmore	7.35	48.37
31	Lake Leo	7.31	48.45
32	Schreiber Lake	7.25	48.57
33	Nielsen Pond	7.23	48.61
34	Honey Lake	7.17	48.73
35	Lake Minear	7.13	48.81
36	Round Lake	7.01	49.05
37	Highland Lake	6.97	49.14
38	Lake Helen	6.43	50.30
39	Sun Lake	6.33	50.52
40	Lake Barrington	6.12	51.01
41	Cranberry Lake	5.94	51.44
42	Lake Fairfield	5.89	51.56
43	Gages Lake	5.45	52.68
44	Owens Lake	5.30	53.08
45	Valley Lake	5.05	53.78
46	McGreal Lake	5.04	53.81
47	Old Oak Lake	4.85	54.36
48	Waterford Lake	4.70	54.82
49	Lake Linden	4.60	55.13
50	Timber Lake (South)	4.46	55.57
51	Peterson Pond	4.51	55.41

Lake County Secchi Disk Clarity Ranking, 2000-2016.

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	Crooked Lake	4.28	56.17
56	Deer Lake	4.20	56.45
57	Seven Acre 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	White Lake	3.96	57.29
62	Hook Lake	3.95	57.32
63	Turner Lake	3.92	57.43
64	Leisure Lake	3.85	57.69
65	Summerhill Estates Lake	3.84	57.73
66	North Tower Lake	3.89	57.74
67	Salem Lake	3.77	58.00
68	Lake Fariview	3.75	58.07
69	Duck Lake	3.71	58.23
70	Countryside Glen Lake	3.64	58.50
71	Fish Lake	3.57	58.78
72	Lochanora	3.52	58.99
73	Taylor Lake	3.52	58.99
74	Hastings Lake	3.52	58.99
75	Bishop Lake	3.47	59.19
76	Lake Lakeland Estates	3.41	59.44
77	Lake Holloway	3.40	59.49
78	Stockholm Lake	3.38	59.57
79	East Loon Lake	3.30	59.92
80	Lucky Lake	3.22	60.27
81	Diamond Lake	3.17	60.50
82	Liberty Lake	3.16	60.54
83	International Mining and Chemical Lake	3.08	60.91
84	Long Lake	3.05	61.05
85	Lake Christa	3.01	61.24
86	Lucy Lake	2.99	61.34
87	Lake Catherine	2.9	61.78
88	St. Mary's Lake	2.79	62.34
89	Channel Lake	2.77	62.44
90	Werhane Lake	2.71	62.76
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
102	Buffalo Creek Reservoir 2	2.30	65.12

Lake County Secchi Disk Clarity Ranking, 2000-2016.

RANK	LAKE NAME	SECCHI AVE	TSIsd
103	Woodland Lake	2.28	65.25
104	Rivershire Pond 2	2.23	65.57
105	Lake Charles	2.20	65.76
106	Fischer Lake	2.70	62.81
107	College Trail Lake	2.18	65.89
108	Loch Lomond	2.17	65.96
109	Redhead Lake	2.16	66.03
110	Pistakee Lake	2.15	66.09
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	Des Plaines Lake	2.14	66.16
120	Sylvan Lake	1.98	67.28
121	Bittersweet Golf Course #13	1.98	67.28
122	Spring Lake	1.78	68.82
123	Kemper Lake 2	1.77	68.90
124	Fourth Lake	1.77	68.90
125	Nippersink Lake	1.73	69.23
126	Deer Lake Meadow Lake	1.73	69.23
127	Lake Louise	1.68	69.65
128	Willow Lake	1.63	70.09
129	Slough Lake	1.63	70.09
130	Rasmussen Lake	1.62	70.17
131	Lake Farmington	1.62	70.17
132	Half Day Pit	1.60	70.35
133	Lake Marie	1.56	70.72
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	McDonald Lake 1	1.13	75.37
141	Lake Napa Suwe	1.06	76.29
142	Rollins Savannah 1	1.05	76.43
143	Osprey Lake	1.03	76.70
144	Manning's Slough	1.00	77.13
145	Rollins Savannah 2	0.95	77.87
146	Dog Bone Lake	0.94	78.02
147	Redwing Marsh	0.88	78.97
148	Flint Lake Oulet	0.83	79.82
149	Fairfield Marsh	0.81	80.17
150	Slocum Lake	0.81	80.17
151	Oak Hills Lake	0.79	80.53
152	Grass Lake	0.78	80.71
153	Lake Nippersink	0.77	80.90

Lake County Secchi Disk Clarity Ranking, 2000-2016.

RANK	LAKE NAME	SECCHI AVE	TSIsd
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	Ozaukee Lake	0.51	86.84
160	McDonald Lake 2	0.50	87.12

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.

Plankton Sampling

Plankton were sampled at the same location as water quality samples. Using the Hydrolab DataSonde® 4a or YSI 6600 Sonde® 1% light level depth (depth where the water light is 1% of the surface irradiance) was determined. A plankton net/tow, with 63μm mesh, was then lowered to the pre-determined 1% light level depth and retrieved vertically. On the way up the water column, plankton were collected within a small cup on the bottom of the tow. The collected sample was then emptied into a pre-labeled brown plastic bottle. The net was rinsed with deionized water into the bottle in order to ensure all the plankton were collected. The sample was then transferred to a graduated cylinder to measure the amount of milliliters (mL) that the sample was. The sample was then returned to the bottle and preserved with Lugol's iodine solution (5 drops/mL). The sample bottle was then closed and stored in a cooler until returning to the lab, where it was transferred to the refrigerator until enumeration. Enumeration was performed within three months, but ideally within one month, under a microscope. Prior to sub-sample being removed for enumeration, the sample bottle was inverted several times to ensure proper homogenization. An automated pipette was used to retrieve 1 mL of sample, which was then placed in a Sedgewick Rafter slide. This is a microscope slide on which a rectangular chamber has been constructed, measuring 50 mm x 20 mm in area and 1 mm deep. The slide was then placed under the microscope and counted at a 20X magnification (phytoplankton) or 10X magnification (zooplankton). For phytoplankton, twenty fields of view were randomly counted with all species within each field counted. Due to their larger size, zooplankton were counted throughout the entire slide. Through calculations, it was determined how many of each species were in 1 mL of lake water.

Phytoplankton (algae) are free-floating and microscopic and are distinguished from plants because they lack roots, stems and leaves. There are four distinct groups of phytoplankton found in Lake County lakes: blue-greens, greens, diatoms, and dinoflagellates/chrysophytes. Blue-greens are also known as cyanobacteria because they are the only group of bacteria that obtain their energy from photosynthesis like plants. Some of these species can be toxic. Green algae are the closest ancestors of land plants and are the most common group. Diatoms are unique because they are encased in a cell wall made of silica that can be very ornate. Dinoflagellates and chrysophytes are almost always flagellated (able to move by flagella, a whip-like tail) and some can both photosynthesize and consume bacteria for food.

Zooplankton are made up of rotifers and two crustacean groups; the cladocerans and the copepods (broken down further into calanoids and cyclopoids). Rotifers are smaller and most have a crown of cilia (hair-like structure) used for movement and drawing in suspended particles to eat. Crustaceans have jointed appendages and are enclosed in an exoskeleton. Cladocerans, such as the "water flea" Daphnia species, are filter-feeding like rotifers, while the copepod group contains both filter-feeders (calanoids and cyclopoids) and raptorial species (cyclopoids).

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