

LAKE COUNTY, ILLINOIS

2013 LAKE NAPASUWE SUMMARY REPORT



Lake NapaSuwe, 2013
Photo Credit: Joe Sallak

In 2013 Lake NapaSuwe, was selected as one of the lakes to be monitored as part of the “9-Lakes Planning Area”. The physical, chemical and biological data for Lake NapaSuwe along with other lakes in the region were assessed to facilitate the development of a watershed-based plan.

This report summarizes the water quality sampling results, aquatic plant survey, and shoreline erosion evaluation of Lake

NapaSuwe by the Lake County Health Department -Environmental Services (LCHD-ES). Similar reports have been written on data collected in 2009 and 2002.

Water samples were taken monthly May through September from the inlet and outlet of the lake. Surface samples were collected at the outlet on the north side of the lake from the dam structure. The inlet surface samples were collected from the

main body of the lake on the south end. They were analyzed for nutrients, solid concentrations and other physical parameters. The aquatic plant survey was conducted in July. Sampling sites were based on a grid system created by mapping software (ArcGIS), with each site located 60 meters apart. At each site the aquatic plant species and density was documented. Finally, the shoreline was reassessed in 2013 for changes in erosion since 2009.

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**LAKES SAMPLED
IN 2013**

- BANGS LAKE
- FAIRVIEW LAKE
- ISLAND LAKE
- LAKE BARRINGTON
- LAKE LAKELAND
- LAKE NAPASUWE
- NORTH TOWER LAKE
- SLOCUM LAKE
- TIMBER LAKE (SOUTH)
- TOWER LAKE
- WOODLAND LAKE

LAKE NAPASUWE SUMMARY

Lake NaPaSuWe is a shallow slough impoundment in southwestern Lake County. It is located within the Fox River watershed, in Wauconda and unincorporated Lake County, northwest of Fairfield Road and Bonner Road. Lake NaPaSuWe receives water from Ozaukee Lake (Drummond Lake). Water exits the lake by way of a spillway located at the northwest portion of the lake and empties into Mutton Creek, eventually flowing into the Fox River. Various stormwater inlets enter the lake from surrounding residential areas. Residential lots surround much of the lake except for two parks owned by the Orchard Hills

Homeowners Association and the Apple Country Homeowners Association. The lake is managed by the Lake NapaSuwe Homeowners Association and used by residents for aesthetics, fishing and non-motorized boating.

The water quality in Lake NapaSuwe declined since the 2009 lake survey. Water clarity, the transparency or clearness of the water, is an important indicator of lake health that affects designated uses such as swimming and other recreational activities. The average water clarity decreased 47% from 2009, however the average water clarity remained below the County median.

Water clarity is influenced by the amount of particles in the water column; this is measured by total suspended solids (TSS). The 2013 average TSS concentration was significantly above the county median, and a 379% increase from 2009.

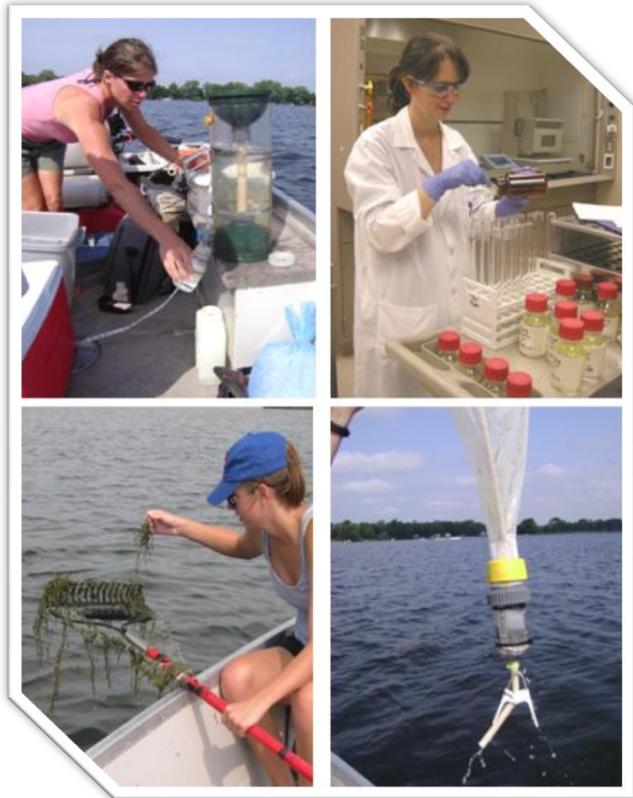
Typically in lakes the two nutrients critical for aquatic plant and algal growth is phosphorus and nitrogen. In 2013, nutrient availability indicated that Lake NapaSuwe, like most lakes in Lake County, was phosphorus limited. The 2013 average total phosphorus concentration exceeded the Illinois Environmental Protection Agency (IEPA) impairment level, and was a 281% increase from 2009. Also using phosphorus as an indicator, the trophic state index (TSI_p) ranked Lake NapaSuwe 151st out of 175 lakes in Lake County. The poor

water quality in 2013 is similar to the water quality in 2002 when Lake NapaSuwe was algae dominated, opposed to the 2009 water quality when the lake was aquatic plant dominated.

Conductivity concentrations are correlated with chloride concentrations and are influenced by winter road salting. Typically lakes in the county have experienced increases in chloride concentrations in the past 10 years many doubling in concentrations. The 2013 average conductivity concentration was above the county median and a 26% increase from 2009.

Aquatic plant sampling was conducted on Lake NapaSuwe in July. Only four species of aquatic plants were present covering 23% of the lake. Coontail and Sago Pondweed covered 21% and 3% of the lake, respectively. The 2013 aquatic plant community, exhibited a loss in diversity and density when compared to the 2009 population; resulting in decreased water quality. However, absent in the 2013 aquatic plant community were two exotic invasive species Eurasian Watermilfoil and Curlyleaf Pondweed.

The shoreline was reassessed in 2013 for significant changes in erosion since 2009. Based on the 2013 assessment, the overall shoreline erosion decreased slightly with approximately 21% of the shoreline having some degree of erosion.



LCHD-ES COLLECTING LAKE DATA

WATERSHED

The source of a lake's water supply is very important in determining its water quality and choosing management practices to protect the lake. Lake NapaSuwe is in an impoundment in the Mutton Creek watershed and receives water from Ozaukee (Drummond Lake) from the southeast inlet and from various stormwater inlets draining the surrounding residential areas. Water flows west from the northwest outlet and enters Island Lake, eventually draining into the Fox River.

When a stream is dammed to create a lake, the natural movement of the water will be restricted, causing sediment and nutrients to collect in the impoundment. Identifying and reducing sources of nutrients and sediments that enter Lake NapaSuwe from

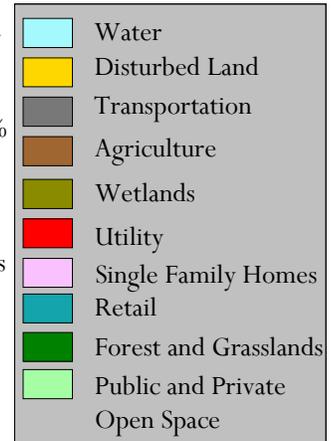
the land's surface is key to improving the lake's water quality. Typically water quality declines as pollutants accumulate from the top to the bottom of the watershed. However, water quality actually improves as it travels downstream from Ozaukee Lake. Ozaukee Lake is a small shallow algae dominated lake that could not support an increase in aquatic plant populations due to the low light availability and the competition from blue-green algae.

The 666 acre watershed carries storm water and pollutants into Lake NapaSuwe. Based on the 2010 data the current external sources affecting Lake NapaSuwe were from the following land uses: Single family homes (32%) and public and private open space (29%). The public and private space

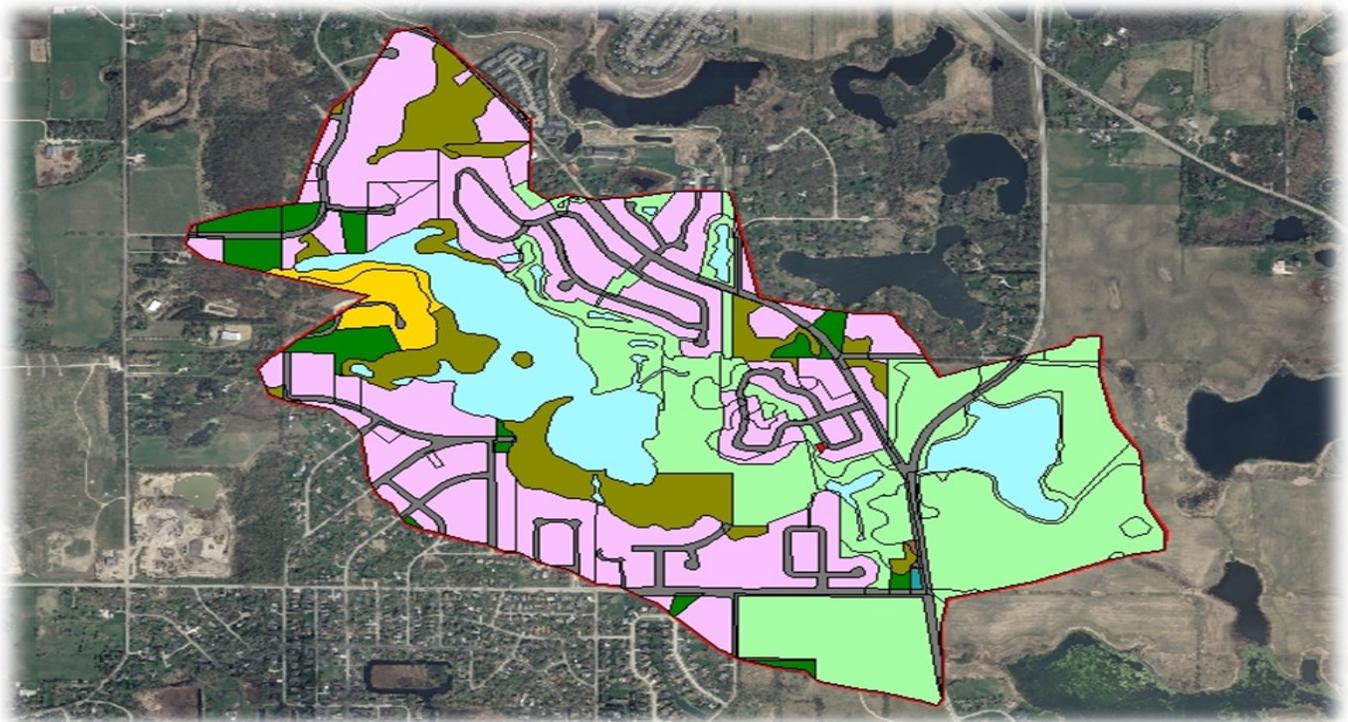
land use was a unique and valuable characteristic within a watershed as Lake County Forest Preserve has been acquiring land to preserve 20% of Lake County land as open space. Based on the amount of impervious surfaces each land use contributes varied amounts of runoff. Because impervious surfaces (parking lots, roads, buildings, compacted soil) do not allow rain to infiltrate into the ground, more runoff is generated than in the undeveloped condition. The two major sources of runoff for Lake NapaSuwe were single family homes (42%) and transportation (35%).

The size of the watershed feeding the lake relative to the lakes size is also an important factor in determining the amount of pollutants in the lake. The watershed to lake surface area

2013 LAND USE IN THE LAKE NAPASUWE WATERSHED



ratio is 8:1 and has a calculated retention time of approximately 0.30 years (109 days). Retention time is the amount of time it takes for water entering the lake to flow out of it. The short-retention time in Lake NapaSuwe allows the lake to respond quickly to management practices.



VOLUNTEER LAKE MONITORING PROGRAM

The VLMP was established in 1981 to gather information on Illinois inland lakes, and to provide an educational program for citizens.

The primary measurement by volunteers is the Secchi depth (water clarity). 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.

2013 LAKE COUNTY SECCHI DEPTH MEDIAN = 3.00 FEET

WATER CLARITY

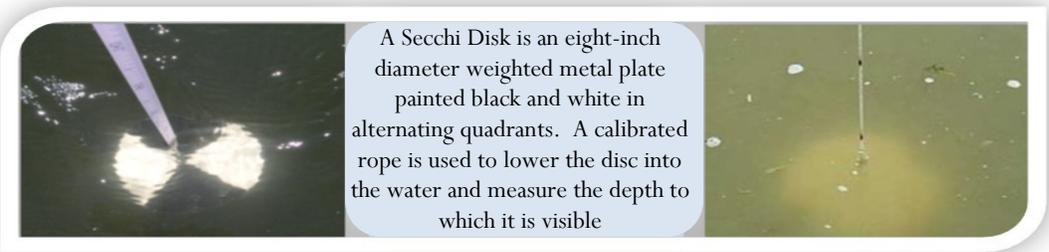
Water clarity is an indicator of water quality related to chemical and physical properties.

Measurements taken with a Secchi disk indicate the light penetration into a body of water. Algae, microscopic animals, water color, eroded soil, and resuspended bottom

sediment are factors that interfere with light penetration and reduce water transparency.

The 2013 average water clarity in Lake NapaSuwe of 1.06 feet was below the county median (3.00 feet), and an 52.9% decrease in the lake's transparency since

2009 (2.25 feet). This reduction can be attributed to the reduction in the aquatic plant community following the herbicide treatment in 2012. The 2013 average water clarity is similar to the measurements in 2002 (0.98 feet) when the aquatic plant community was described as almost non-existent.



VOLUNTEER LAKE MONITORING PROGRAM (VLMP)

Additional water clarity measurements were taken in Lake NapaSuwe through participation in the Illinois Environmental Protection Agency's (IEPA) Volunteer Lake Monitoring Program (VLMP). Lake NapaSuwe residents participated in the VLMP in 2006-2008, 2012, and 2013. Current volunteers include citizens from three households

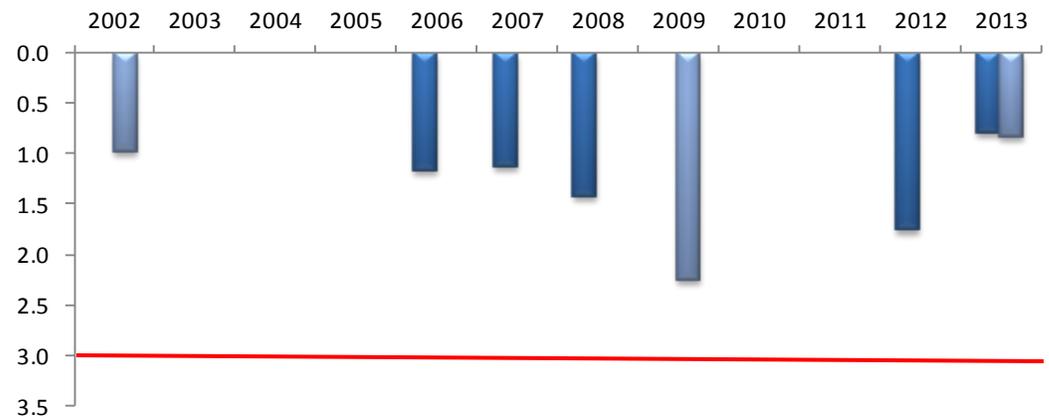
providing additional viewpoints from around the lake. Participation in the VLMP program has provided Lake NapaSuwe with annual baseline data that can be used to determine long-term water quality trends and support current lake management decision making. The average VLMP Secchi disk depth from 2012 and 2013 was 1.75 feet and 0.8 feet,

respectively. Annual VLMP readings have varied from 3.33 feet in 2012 to 0.42 feet in 2013.

The volunteers on Lake NapaSuwe have provided data that is vital for the continued monitoring and management of this lake. The LCHD-ES would like to thank them for their efforts and recommend continued involvement in the future.

SECCHI DISK AVERAGES FROM VLMP AND LCHD RECORDS FOR LAKE NAPASUWE 1994-2013.

■ VLMP
 ■ LCHD
 — LAKE COUNTY 2013 MEDIAN



TOTAL SUSPENDED SOLIDS

LAKE FACTS

HISTORICAL NAME

Mutton Lake/
Breedon Slough

WATERSHED

Fox River

SUB-WATERSHED

Mutton Creek

SURFACE AREA

85.3 acres

SHORELINE LENGTH

4.6 miles

MAXIMUM DEPTH

3.5 feet

AVERAGE DEPTH

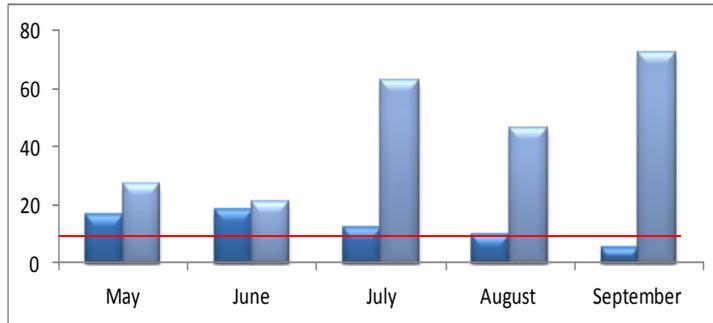
1.4 feet

LAKE VOLUME

126.2 acre-feet

LAKE TYPE

Impoundment



TOTAL SUSPENDED SOLIDS CONCENTRATIONS (MG/L) FOR LAKE NAPASUWE 2009 AND 2013.

■ VLMP
■ LCHD
— 2013 Lake County median , 8.0 mg/L

Another measure of water clarity is turbidity, which is caused by particles of matter rather than dissolved organic compounds. Suspended particles dissipate light, which affects the depth at which plants can grow. The total suspended solid (TSS) parameter (turbidity) is composed of nonvolatile suspended solids (NVSS), non-organic clay or sediment materials, and volatile suspended solids (TVS) (algae and other organic matter).

2013 TSS concentrations in Lake NapaSuwe averaged 45.8 mg/L which was nearly six times higher than the county median of 8.0 mg/L and a 379% increase from the 2009 concentration of 12.1 mg/L. High TSS values are typically correlated with poor water clarity (Secchi disk depth) and can be detrimental to many

aspects of the lake ecosystem including the plant and fish communities. Calculated nonvolatile suspended solids (NVSS) were 40.92 mg/L in September. This means 89% of the TSS concentration in 2013 can be attributed to sediment materials. Lake NapaSuwe will be additionally listed on the 303 (d) impaired water body for NVSS concentrations exceeding the IEPA limit of ≥ 12.0 mg/L. The 2013 NVSS concentrations are causing substantial impairments to the Aquatic Life Index and the Recreational Index. The increased turbidity in the water may hide hazards in the lake from swimmers and significantly reduces the amount of light that can penetrate through the water reducing aquatic plant growth and reduce a fish's ability to locate prey.

There are internal and external sources of sediment affecting the turbidity in Lake NapaSuwe. Internal sources of sediment suspension include the severe reduction in the aquatic plant community and a large Common Carp population. Aquatic plants stabilize the bottom sediments from wave action that re-suspends sediment into the water column. Common Carp

are one of the most damaging aquatic invasive species due to their feeding behavior that disrupts shallowly rooted plants, decreasing water clarity. External sources include sediments that are transported into the lake from bank erosion and other sources in the watershed. Due to the amount of residential area in the Lake NapaSuwe watershed, residents should be mindful of their land management practices and the impacts to the lake.

Additionally the average 2013 TVS concentrations (174 mg/L) caused by algae remained above the county median (119.0 mg/L) throughout the sampling season. May through September and were nearly double the 2009 concentration of 98 mg/L. NVSS values indicate that the major impairment for water clarity was from inorganic suspended particles such as sediment. However, at these high TVS concentrations the 11% of organic particles was significant. These trends in water quality of increased TSS and TVS are troublesome; indicating that the lake is starting to switch from being plant dominated to algae dominated.

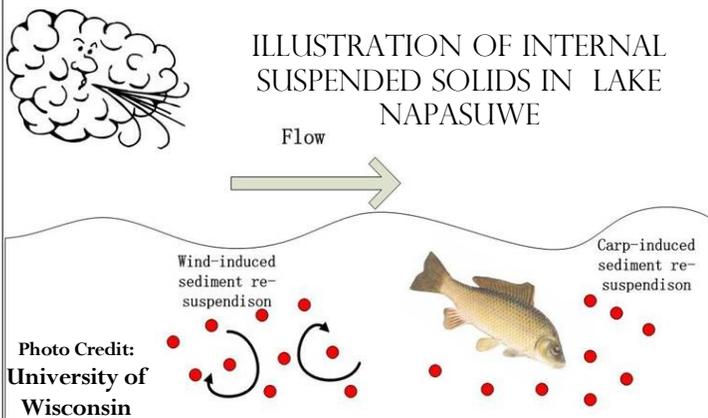
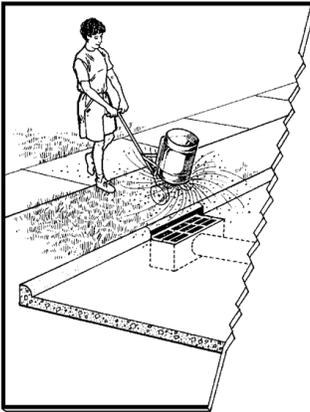
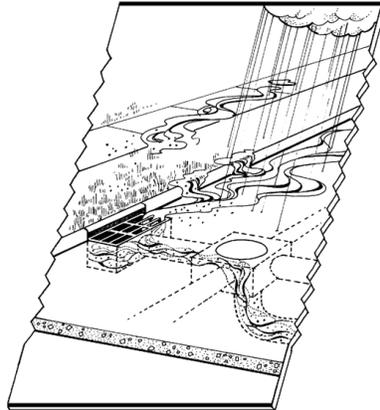


Photo Credit:
University of Wisconsin

NUTRIENTS



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. Land management practices influence lake water quality as pollutants may be picked up with stormwater and washed into Lake NapaSuwe.



Organisms take nutrients in from their environment. In a lake, the primary nutrients needed for aquatic plant and

controlling phosphorus is more feasible than controlling nitrogen or carbon. In Lake NapaSuwe, the limiting nutrient was phosphorus, which has a direct effect on how much aquatic plants and algae can grow in lakes. Phosphorus originates from a

mg/L. Lakes with concentrations exceeding 0.050 mg/L can support high densities of algae and aquatic plants, which can reduce water clarity and dissolved oxygen levels and are considered impaired by the IEPA. Increases in TP were correlated with increases in the TSS and NVSS concentrations indicating that sediment is a major source of TP in Lake NapaSuwe.

Nitrogen is the other nutrient critical for algal growth. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen, and is typically bound up in algal and plant cells. The average 2013 TKN for Lake NapaSuwe was 3.43 mg/L, which was nearly 3 times above the county median of 1.17 mg/L and a 235% increase since 2009. Increases in TKN were correlated with increases in the TVS concentrations. TKN and TVS concentrations nearly doubled from May to September in 2013. These water quality trends are comparable to the poor 2002 water quality and directly related the severe decline in the density of the aquatic plant community.

algal growth are phosphorus and nitrogen. In most lakes, phosphorus is the limiting nutrient, which means everything that plants and algae need to grow is available in excess: sunlight, warmth, and nitrogen. Nitrogen, as well as carbon, naturally occur in high concentrations and come from a variety of sources (soil, air, etc.) which are more difficult to control than sources of phosphorus. Lakes that are phosphorus-limited may be easier to manage, since

variety of sources, many of which are related to human activities which include: human and animal waste, soil erosion, detergents, septic systems, common carp, and runoff from lawns.

The 2013 average total phosphorus (TP) concentration in Lake NapaSuwe was 0.194 mg/L, this was a 281% increase from the average 2009 concentration (0.069 mg/L) and 5% lower than the 2002 average concentration of 0.203

2013 LAKE COUNTY TOTAL PHOSPHORUS MEDIAN = 0.067 MG/L

WHAT YOU CAN DO TO IMPROVE WATER QUALITY IN LAKE NAPASUWE

- *Do not throw leaves, grass clippings, pet waste, other organic debris into the street or driveway. Runoff carries these through storm sewers, directly to Lake NapaSuwe.
- *Build a rain garden to filter run-off from roofs, driveways, streets. This allows the phosphorus to be bound to the soil so it does not reach surface waters.
- *Sweep up fertilizer that is spilled or inadvertently applied to hard surface areas, do not hose it away.

TROPHIC STATE INDEX

Another way to look at phosphorus levels and how they affect lake productivity is to use a Trophic State Index (TSI) based on phosphorus (TSIp). TSIp values are commonly used to classify and compare lake productivity levels (trophic state). A lake's response to additional phosphorus is an accelerated rate of eutrophication. Eutrophication is a natural process where lakes become increasingly enriched with nutrients. Lakes start out with

clear water and few aquatic plants and over time become more enriched with nutrients and vegetation, until the lake becomes a wetland. This process takes thousands of years. However, human activities that supply lakes with additional phosphorus that drives eutrophication is speeding up this process significantly. The TSIp index classifies the lake into one of four categories: oligotrophic (nutrient-

poor, biologically unproductive), mesotrophic (intermediate nutrient availability and biological productivity), eutrophic (nutrient-rich, highly productive), or hypereutrophic (extremely nutrient-rich, productive).

In 2013, Lake NapaSuwe was hypereutrophic with a TSIp value of 80.0. Based on the TSIp, Lake NapaSuwe ranked 151st out of 175 lakes studied by the LCHD-ES from 2000-2013.

WHAT HAS BEEN DONE TO REDUCE PHOSPHORUS LEVELS IN ILLINOIS

December 2009- Cuba Township passed a resolution supporting the use of phosphorus free fertilizers

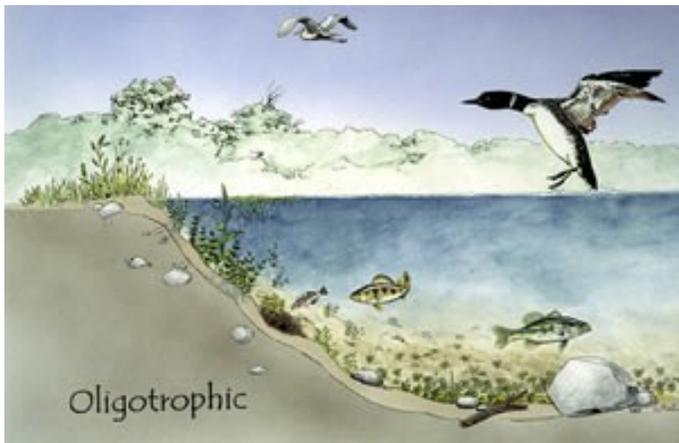
July 2010- The state of Illinois passed a law to reduce the amount of phosphorus content in dishwashing and laundry detergents.

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

OLIGOTROPHIC:

LOW NUTRIENTS:

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



MESOTROPHIC:

MEDIUM NUTRIENTS:

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



EUTROPHIC:

HIGH NUTRIENTS:

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



Photo Credit: UW Extension

CONDUCTIVITY AND CHLORIDES

Another parameter measured during the 2013 assessment that is important in comparing data from year to year 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, the size of the watershed flowing into the lake, the land uses within that watershed, and

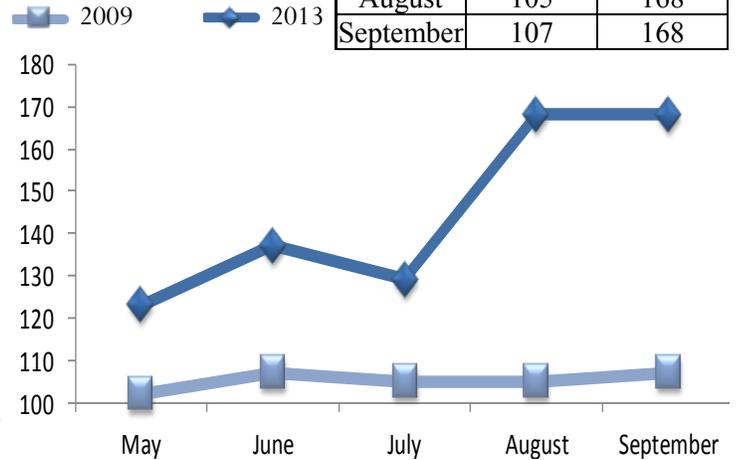
evaporation and bacterial activity. Conductivity has been shown to be highly correlated (in urban areas) with chloride ions found in road salt mixtures. Water bodies most subject to the impacts of road salts are streams, wetlands, or lakes draining major roadways.

In 2013, Lake Napa^{SU}we's average conductivity was 0.8980 mS/cm. This was above the county median of 0.7875 mS/cm and like other water quality parameters assessed in 2013 has increased since 2009 documenting a 26% increase (0.6644 mS/cm). 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 ferrocyanide salts.

Lake Napa^{SU}we 2013 average chloride concentration was 145 mg/L a 28% increase since 2009. These values are influenced by the winter road maintenance of N. Fairfield Road, N. Gossell Road, and residential surface streets. Typically lakes in the county

MONTHLY CHLORIDE CONCENTRATIONS (MG/L) IN LAKE NAPA^{SU}WE, 2009 AND 2013.

DATE	2009	2013
May	102	123
June	107	137
July	105	129
August	105	168
September	107	168



have experienced increases in chloride concentrations in the past 10 years many doubling in concentrations. However other lakes in the 9-lakes watershed planning area including: Bangs Lake, Lake Fairview, Timber Lake South, Lake Lakeland, Slocum Lake, Tower Lake, North Tower Lake and Lake Barrington had significant reductions in chloride concentrations. This was influenced by the mild winters (late 2012 and early 2013) and modernized snow removal equipment and techniques. The United States

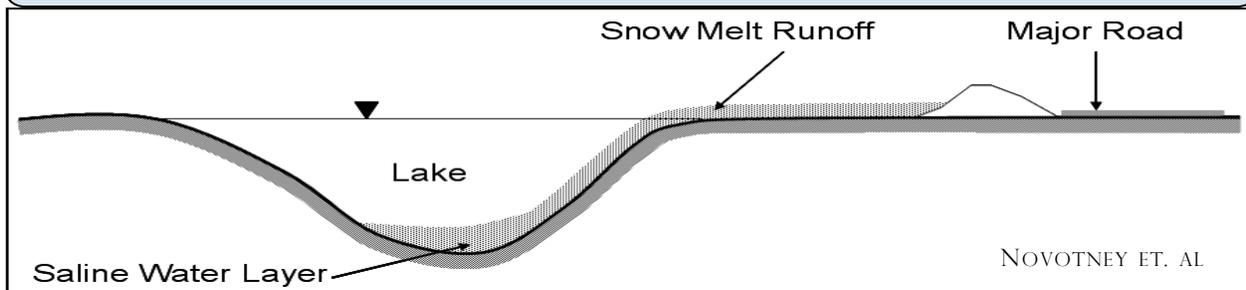
Environmental Protection Agency has determined that chloride concentrations higher than 230 mg/L can disrupt aquatic systems. Chlorides tend to accumulate within a watershed as these ions do not break down and are not utilized by plants or animals. High chloride concentrations may make it difficult for many of our native species to survive. While many of our invasive species, such as Eurasian Watermilfoil, Cattail and Common Reed, are tolerant to high chloride concentrations.

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.

AS SALTS DISSOLVE AND MOVE THROUGH THE WATERSHED WITH SNOWMELT AND STORMWATER RUNOFF THEY TEND TO REMAIN IN THE WATER CYCLE BY SETTLING. LAKE NAPA^{SU}WE HAS HIGHER CONCENTRATIONS OF CHLORIDES IN THE DEEPER PORTIONS OF THE LAKE.



WHAT HAS BEEN DONE TO REDUCE CHLORIDE LEVELS IN LAKE NAPASUWE



The Lake County Division of Transportation (LCDOT) and the Village of Wauconda Public Works are responsible for the winter road maintenance in the Lake Fairview watershed. Both entities use an environmentally friendly alternative to salt, a liquid by-product consisting of salt brine mix, beet juice (beet by

-product) and calcium chloride. This product will be mixed with the salt on the trucks to create oatmeal like substance, and then applied to the streets to help prevent salt from bouncing into the drainage areas along the road. The majority of the LCDOT fleet has innovative computer software and Global positioning systems (GPS which provided real-time tracking of these vehicles. These trucks are capable of transmitting to a central location a view out their windshield in real time the exact truck location by GPS locating, the speed of the

truck, the route it has traveled and is traveling, the air temperature, road temperature, dew point, the rate of material being put down and the rate of liquid being put down during a storm event. The data is then used to better coordinate and target services, saving on salt and gas. In addition the LCDOT have attended Lake County sponsored deicing workshops. These workshops focus on applications rates, calibration, and environmental effects.



AS SNOW MELTS CHLORIDES ENTER OUR LAKES FROM RUNOFF

ICE FACTS

- DE-ICERS 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.
- NA₂CO₃ (ROAD SALT) DOES NOT WORK ON COLD DAYS, LESS THAN 15° F.

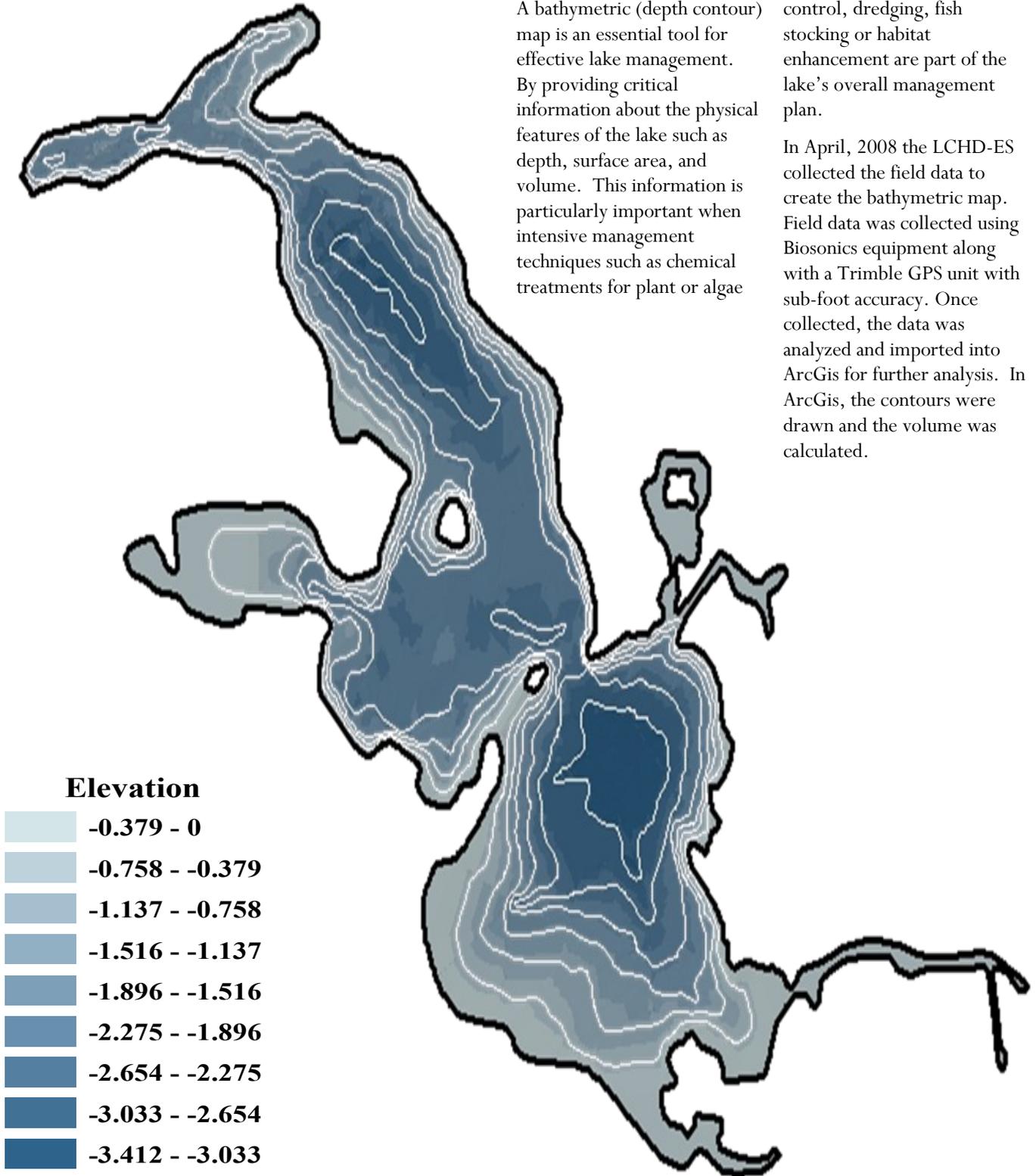
Pavement Temp. °F	One Pound of Salt (NaCL) melts	Melt Times
30°	46.3 lbs of ice	5 min.
25°	14.4 lbs of ice	10 min.
20°	8.6 lbs of ice	20 min
15°	6.3 lbs of ice	1 hour
10°	4.9 lbs of ice	Dry salt is ineffective and will blow away before it melts anything

BATHYMETRIC MAP

A bathymetric (depth contour) map is an essential tool for effective lake management. By providing critical information about the physical features of the lake such as depth, surface area, and volume. This information is particularly important when intensive management techniques such as chemical treatments for plant or algae

control, dredging, fish stocking or habitat enhancement are part of the lake's overall management plan.

In April, 2008 the LCHD-ES collected the field data to create the bathymetric map. Field data was collected using Biosonics equipment along with a Trimble GPS unit with sub-foot accuracy. Once collected, the data was analyzed and imported into ArcGis for further analysis. In ArcGis, the contours were drawn and the volume was calculated.



THIS MAP IS INTENDED FOR WATER QUALITY REFERENCE ONLY, NOT INTENDED FOR NAVIGATIONAL, SWIMMING, OR DIVING PURPOSES.

SHALLOW LAKES: ALGAE OR PLANT DOMINATED

In shallow lakes sunlight can reach the bottom of the lake; potentially causing aquatic plants to grow throughout the lake. There are two general types of shallow lakes, plant-dominated and algae-dominated lakes.

Plant dominated lakes have fairly clear water, dense plant growth and are excellent habitat for fish, ducks, bugs, and other wildlife. The plants in these shallow lakes lock up nutrients in their tissues limiting dense algae growth. They also produce oxygen throughout the water from the process of photosynthesis. These plants also keep the bottom sediments stable, minimizing resuspension into the water column. Algae-dominated shallow lakes are the ones that look like pea soup. These shallow lakes have mostly muck on the bottom instead of plants because the sunlight cannot get through. Algae-dominated shallow lakes are also not as good of habitat for fish and wildlife. The

oxygen at the bottom of these shallow lakes is usually depleted because of all the decomposition of dead algae that sinks to the bottom. Controlling the vegetation of a lake can create unexpected management issues.

Manipulating one component of a lake ecosystem has consequences for other components of the lake. For example, aquatic plants and algae growth are inversely related. Lakes with abundant algae and poor water clarity generally have fewer submersed aquatic plants. However, management efforts that reduce algae often result in increased growth of the remaining aquatic plants. Removing the remaining plants increases the effects of wind turbulence and redissolves nutrients in the sediments into the water. This results in an algal bloom, which turns the water green and has the opposite of the desired effect. The trade-off is clear water with abundant submersed



BEFORE EWM TREATMENT



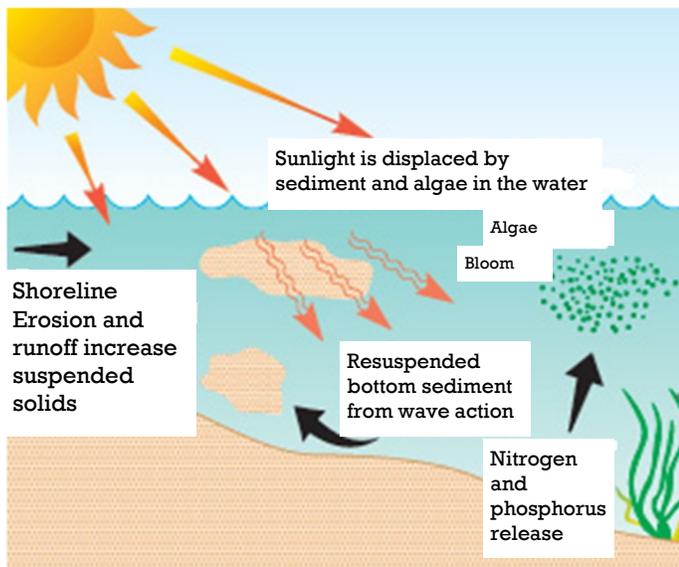
AFTER EWM TREATMENT

plants versus an algae bloom with low water clarity and few aquatic plants. A problem arises for homeowners when plants interfere with recreational activities such as swimming, boating, and fishing. Exotic plants have the additional effect of displacing native plant species, interfering with the food chain, and reducing fish populations.

treatment a complete removal of the exotic Eurasian Watermilfoil from the aquatic plant community was documented. The remaining aquatic plants should be allowed to grow and expand; this will help to improve the water quality in Lake NapaSuwe.

The 2009 exotic invasive population of Eurasian Watermilfoil in Lake NapaSuwe was negatively impacting recreational opportunities. A whole lake herbicide treatment was implemented by the Lake NapaSuwe Association in 2012. The impact of this treatment severely reduced the water quality of Lake NapaSuwe with increased TSS, TVS, NVSS, and TP concentrations. Visually there was a reduction in water clarity and an increase in algae blooms. Following the

The goals of a management plan should be clearly identified in advance. The expectation of a perfectly clear, vegetation- and algae-free lake is unrealistic, and leads to disappointing results. To help keep shallow lakes healthy, work to preserve the vegetation in the lake that ties up phosphorus. Restore the shoreline to native grasses and plants so they can soak up and filter runoff. Also, prevent more phosphorus from entering the lake by keeping your yard free of pet waste and unbagged piles of leaves.



The “bushy” stem resembles the tail of a Raccoon



COONTAIL
CERATOPHYLLUM DEMERSUM
OVERWINTERS AS A EVERGREEN PLANT, IT PROVIDES IMPORTANT HABITAT TO MANY INVERTEBRATES AND FISH.

DISTRIBUTION OF LAKE DENSITY ACROSS ALL SAMPLE SITES IN 2013 (LEFT) AND 2009 (RIGHT)

Rake Density (coverage)	% of Sites 2013	% of Sites 2009
No Plants	77	1.1
>0-10%	17	0.0
10-40%	4	1.1
40-60%	1	4.5
60-90%	0	5.6
>90%	0	87.6
Total Sites with Plants	23	98.9
Total # of Sites	100	100.0

AQUATIC PLANTS

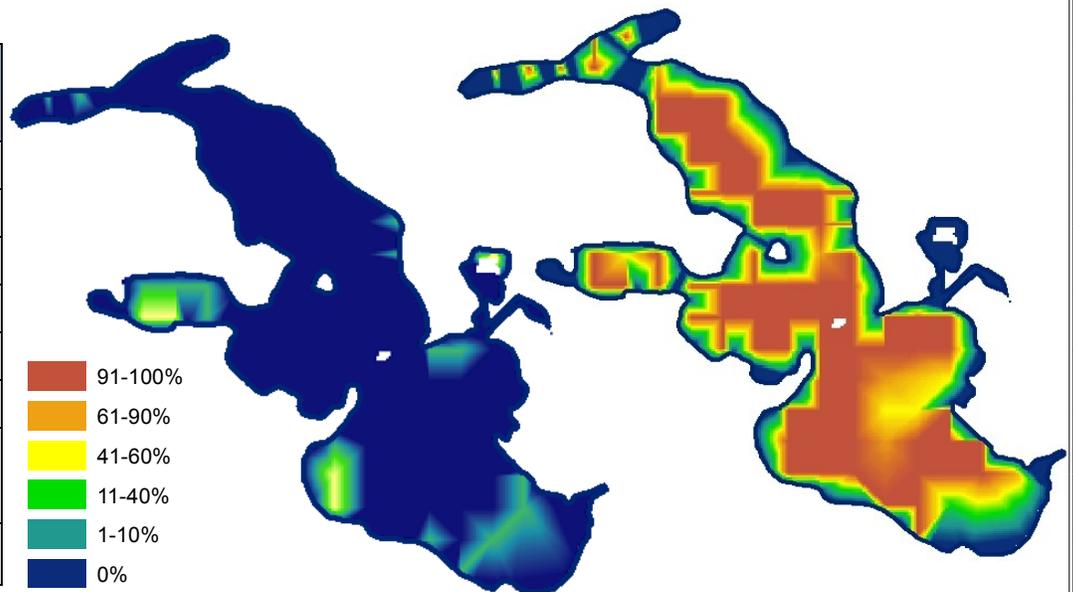
Plants growing in our lakes, ponds, and streams are called macrophytes. These aquatic plants appear in many shapes and sizes. Some have leaves that float on the water surface, while others grow completely underwater. In moderation, aquatic plants are aesthetically pleasing and desirable environmentally. Their presence is natural and normal in lakes.

Aquatic plant sampling was conducted on Lake NapaSuwe at the same locations in July of 2009 and 2013. There were 92 points generated based on a computer grid system with points 60 meters apart. In 2013 Aquatic plants occurred at 21 of the sites (23% total lake coverage) that included four aquatic plant species. Species diversity decreased from 2009 with the loss of two floating aquatic plants: Star Duckweed and Watermeal and two submerged plants both exotic

and invasive species: Curlyleaf Pondweed and Eurasian Watermilfoil. The overall aquatic plant density has changed since 2009 when aquatic plants covered 98% of the lake bottom. This reduction in density and diversity can be contributed to the lake wide herbicide treatment. Coontail was the most abundant species in 2009 and 2013 being found at 93% and 21%, respectively of the sample sites. Coontail is a submersed aquatic plant with coarse, bushy stems and no roots. Lacking true roots, the plants may drift between a variety of depths during the growing season. Coontail overwinters as an evergreen plant, providing habitat to invertebrates and fish year round.

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 the surface light level, plants can no longer grow. The 1% light level in Lake NapaSuwe in 2013 ranged from 0.6 feet in August to 3 feet in June indicating that the light level could have supported plants across most of the lake bottom. Plants were found at a maximum depth of 2.5 feet. A healthy aquatic plant population is critical to good lake health. Aquatic vegetation provides important wildlife habitat and food sources. Additionally, aquatic plants provide many water quality benefits such as sediment stabilization and competition with algae for available resources. Empirically this can be seen in Lake NapaSuwe by the increase in TP, TSS, TVS, NVSS, TKN and the decrease in water clarity from 2009 to 2013.



FLORISTIC QUALITY INDEX

Floristic quality index (FQI) is an assessment tool designed to evaluate the closeness the flora of an area is to that of undisturbed conditions. It can be used to: 1) 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 submersed plant species found in the lake. An 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 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 2000-2013 was 12.5. Lake NapaSuwe had an FQI of 11.0 ranking 102th out of 162 lakes.

AQUATIC PLANTS: WHERE DO THEY GROW?

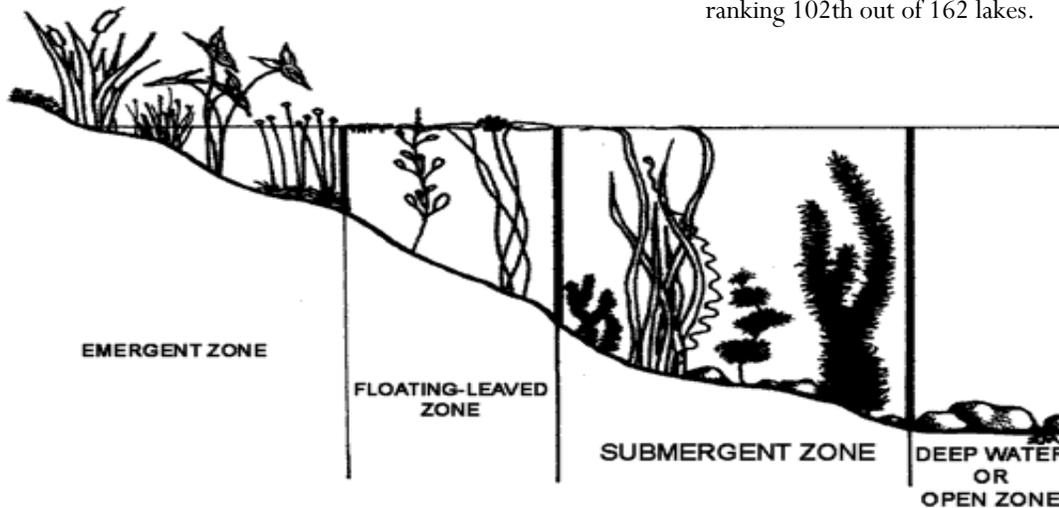
Littoral Zone– the area that aquatic plants grow in a lake.

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

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

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

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



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.

EURASIAN WATERMILFOIL

Eurasian Watermilfoil (EWM) is a feathery submerged aquatic plant that can quickly form thick mats in shallow areas of lakes and rivers in North America. These mats can interfere with swimming and entangle propellers, which hinders boating fishing, and waterfowl hunting. Heavy infestations may reduce property values. Matted milfoil can displace native aquatic plants, impacting fish and wildlife. Since it was

discovered in North America in the 1940's, EWM has invaded nearly every US state and at least three Canadian Provinces. Milfoil spreads when plant pieces break off and float on water currents. It can cross land to new waters by clinging to sailboats, personal watercraft, powerboats, motors, trailers, and fishing gear.

In 2009 the EWM population was at nuisance levels and present at most sample sites; reducing the recreation

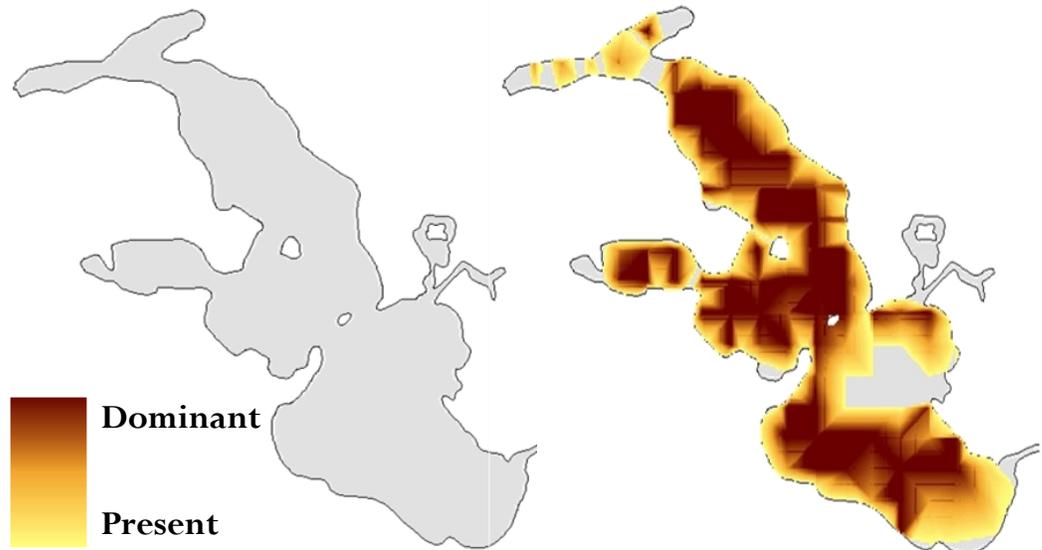
opportunities on the lake. Populations were most dense in the main body of the lake near the Orchard Hills Subdivision. The abundance of EWM in Lake NapaSuwe has decreased by 89% since 2009. In 2012 chemical applications greatly reduced the EWM populations; the presence of EWM was not documented during the July 2013 aquatic plant assessment.

An aquatic plant management plan is critical to maintaining

the health of the lake and a balanced aquatic plant community. The plan should be based on the management goals of the lake and involve usage issues, habitat maintenance/restoration, and limitations of the lake. The primary focus of the plan must include the removal of exotic aquatic species and maintain a diverse native aquatic plant community. Lake NapaSuwe should develop a long-term plant management plan.

DISTRIBUTION OF EWM ACROSS ALL SAMPLE SITES IN 2013 (LEFT) AND 2009 (RIGHT)

Plant Density	% of Sites 2013	% of Sites 2009
Present	0	2
Common	0	10
Abundant	0	19
Dominant	0	48
% Plant Occurrence	0	88.8



EURASIAN WATERMILFOIL *MYRIOPHYLLUM SPICATUM* **EXOTIC***

COMMON NAMES:

EURASIAN WATERMILFOIL

ORIGIN: EXOTIC

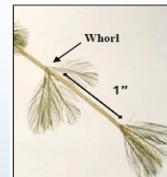
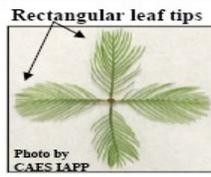
EUROPE AND ASIA. FOUND THROUGHOUT LAKE COUNTY AND ILLINOIS

IMPORTANCE:

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

LOOK ALIKES:

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



KEY FEATURES:

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

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

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

CURLYLEAF PONDWEED

Curlyleaf Pondweed (CLP) is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. This aquatic plant has an unusual life history. Unlike our native pondweeds it begins growing in the early spring. CLP has even been documented growing under the ice in lakes! The plant then reaches maturity in mid summer typically June in Lake County when our natives are starting to emerge. CLP becomes invasive in some areas because of its adaptations for low light tolerance and low water

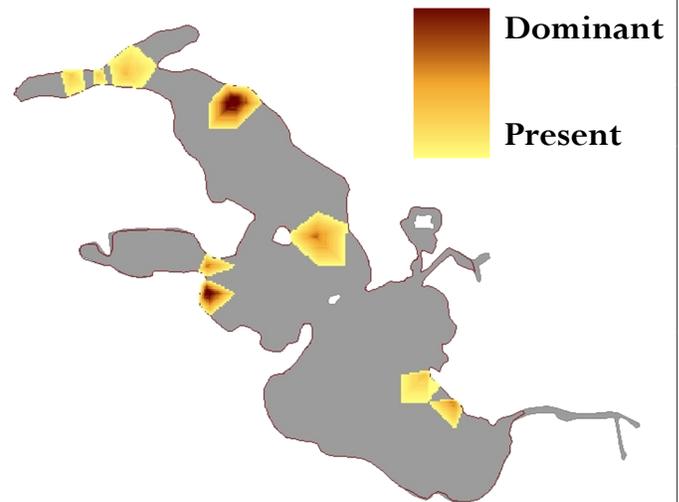
temperatures which allow the plant to get a head start and outcompete native plants in the spring. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Large populations of CLP also can cause changes in nutrient availability. In midsummer, CLP plants usually die back which is typically followed by an increase in phosphorus availability that may fuel nuisance algal blooms. CLP can form dense mats that may interfere with boating and other recreational uses.

In July 2009 in Lake NapaSuwe the CLP population was low; plants being found at 9 sampled sites (10% of lake). At that time the density of CLP was not causing fluctuations in nutrient availability. The herbicide treatment in 2012 also greatly reduced the CLP

populations. CLP was not documented during the July 2013 assessment. Follow up is critical to achieve long-term success. A good aquatic plant management plan considers both the short and long-term needs of the lake. To encourage the growth of the native aquatic plant community; remove CLP and EWM that may resurface in the aquatic plant community

by hand or rake while populations are low. This will reduce the need for further chemical applications and help to improve water

Distribution of CLP in July, 2009.



POTAMOGETON CRISPUS *EXOTIC**



Turion



KEY FEATURES:

STEM: ARE FLATTENED, BRANCHED, CAN FORM DENSE STANDS IN WATER UP TO 15 FEET DEEP.

LEAF: ALTERNATE ALL SUBMERSED, OBLONG, STIFF, TRANSLUCENT LEAVES HAVE DISTINCTLY WAVY EDGES WITH FINE TEETH AND 3 MAIN VEINS.

FLOWER: TINY, WITH 4 PETAL-LIKE LOBES. IN SPIKES 1-3CM LONG ON STALKS UP TO 7CM LONG. (MAY SEE TURIONS WHICH OVER WINTERS AS A HARD, BROWN, BUR-LIKE BUD WITH CROWDED, SMALL HOLLY-LIKE LEAVES).

COMMON NAMES:

CURLYLEAF PONDWEED

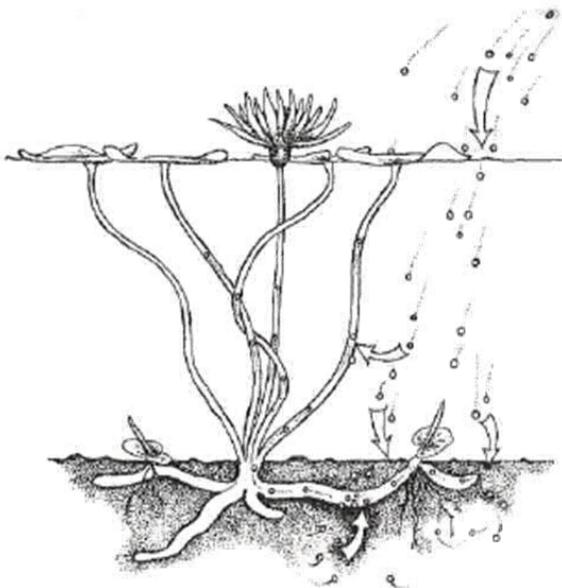
ORIGIN: EXOTIC*

ASIA, AFRICA, AND EUROPE FOUND THROUGHOUT LAKE COUNTY AND ILLINOIS

IMPORTANCE:

INVASIVE: HAS A TOLERANCE FOR LOW LIGHT AND WATER TEMPERATURES THAT ALLOW THE PLANT TO GET A HEAD START ON NATIVE PLANTS. BY MID SUMMER WHEN MOST AQUATIC PLANTS ARE GROWING, CURLYLEAF PLANTS ARE DYING OFF. WHICH MAY RESULT IN A CRITICAL LOSS OF DISSOLVED OXYGEN AND AN INCREASE IN NUTRIENTS.

FLURIDONE



Fluridone is a broad spectrum herbicide used to reduce the populations of a variety of submerged, emergent, and floating plants, and shoreline plants. Fluridone is a photosynthetic inhibitor; the application blocks the light reactions of photosynthesis where plants convert the energy from sunlight into food. Depending on conditions symptoms of the treatment can be observed 7-10 days after treatment. Leaves will appear pale green, yellow, or yellow-white in

color. Fluridone is a systemic herbicide, so the chemical is absorbed through the leaves and shoots and from the soil through the roots. It is usually used at low concentrations with a long contact time (45-90 days). Environmental Aquatic Management applied fluridone in Lake NapaSuwe in 2012 at 20 ppb to reduce aquatic plant populations. A chemical fact sheet from the Wisconsin Division of Natural Resources can be found in the appendix.

Movement of systemic herbicides Illinois Pesticide Applicator Training Manual 39-6

NEW PERMIT REQUIREMENTS FOR APPLYING PESTICIDES IN WATERS

New regulations are now in effect that will significantly affect how pesticides are used in Illinois waters. A National Pollutant Discharge Elimination System (NPDES) permit will now be required to apply any type of pesticides over or into waters of the State.

Who has to get a permit? According to the language in the permit, anyone who qualifies as an "operator", which is defined as: "any

person, persons, group, or entity in control over the financing for, or over the decision to perform pest control activities, or applying pesticides that will result in a discharge to waters of the State". Homeowner associations or even individuals may need to get a permit. Regardless of the size of treatment, a permit will be needed. If the treatment area or total annual area exceeds certain thresholds then

additional requirements will be required such as a Pesticide Discharge Management Plan and an annual report.

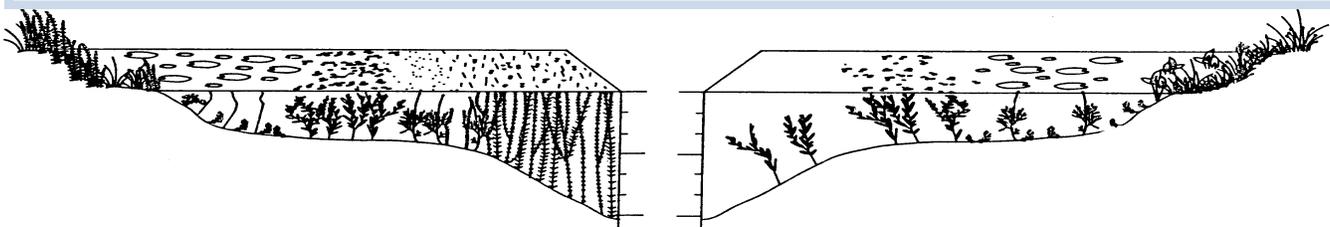
Historically Lake NapaSuwe has used herbicides to manage aquatic plants and algae. Current application rates are unknown to LCHD-ES.

Anyone or any group planning to treat Lake Lakeland this year should take into account these new requirements.

**FOR FULL
DETAILS OF THE
RULE SEE:**

[HTTP://
WWW.EPA.STAT
E.IL.US/WATER/
PERMITS/
PESTICIDE/
INDEX.HTML](http://www.epa.statelil.us/water/permits/pesticide/index.html)

A KEY TO A HEALTHY LAKE IS A WELL-BALANCED AQUATIC PLANT POPULATION



SHORELINE EROSION



2009 there was a notable increase in moderate erosion (4%) and severe erosion (1%) along the Lake Napasuwe Shoreline. Areas of moderate and severe erosion were fragmented around the lake, but were common along the northern shoreline. Areas that were exhibiting signs of slight erosion in 2009 had increased in severity in 2013. These areas should be addressed soon; it is much easier and less costly to mitigate slightly eroding shorelines than those with more severe erosion. Typically the areas with no erosion or slight erosion had some types of native vegetation incorporated into the shoreline. Native plants have deep roots which can stabilize sediments and filter nutrients before entering the lake; while hard structures may cause resuspension of sediment from deflected wave action.

**LAKE NAPASUWE SHORELINE
EROSION, 2009 (TOP) AND 2013
(BOTTOM)**

Erosion is the natural process of weathering and transport of solids (sediment, soil, rock and other particles) in the natural environment. It usually occurs due to transport by (wind, water, or ice), by down-slope creep of soil and other material under the force of gravity, or by living organisms, such as burrowing animals. However, this process has been increased dramatically by human land use, especially industrial, agriculture, deforestation, and urban sprawl.

The shoreline was reassessed in 2013 for significant changes in erosion since 2009. Based on the 2013 assessment, the overall shoreline erosion decreased slightly with approximately 21% of the shoreline having some degree of erosion. Improvements to the shoreline occurred along the Orchard Hills Homeowners Association park area. Overall, 79% of the shoreline had no erosion, 11% had slight erosion, 8% moderate erosion, and 2% had signs of serious erosion. Since



9 LAKES WATERSHED PLANNING

The Chicago Metropolitan Agency for Planning (CMAP) received Clean Water Act funds from Illinois EPA to facilitate the development of a watershed-based plan for the “9 Lakes Planning Area” in southwestern Lake and southeastern McHenry Counties. The plan will utilize data and information that an ongoing TMDL (Total Maximum Daily Load) analysis will provide. The ultimate goal of the planning process is to determine where and which best management practices (BMPs) can best be implemented in order to reduce pollutant loads to the

following lakes as well as the Fox River: Island Lake, Woodland Lake, Lake Napa Suwe, Ozaukee Lake, Slocum Lake, Tower Lake, Lake Fairview, Timber Lake, and Lake Barrington.

Through the assessment of physical, chemical, and biological data collected by Illinois EPA and the Lake County Health Department – Environmental Services, lakes in the planning area (as well as the section of the Fox River to which the planning area drains) have been found to not support certain of their designated uses (e.g., aquatic

life, primary contact recreation) due to various causes of impairment including total phosphorus, total suspended solids, and fecal coli form. Lake NapaSuwe is currently listed on the 303(d) impaired waters list for total phosphorus, total suspended solids, and pH levels exceeding the impairment level in 2009. Following the 2013 assessment Lake NapaSuwe will remain on the 303(d) list for total phosphorus and total suspended solid concentrations.

**A TMDL
(TOTAL MAXIMUM
DAILY LOAD)**

IS A CALCULATION OF THE MAXIMUM AMOUNT OF A POLLUTANT THAT A WATERBODY CAN RECEIVE AND STILL MEET WATER QUALITY STANDARDS, AND AN ALLOCATION OF THAT LOAD AMONG THE VARIOUS SOURCES OF THAT POLLUTANT.

Watershed Planning in the Fox River Basin

9 Lakes TMDL Implementation Planning Project



Chicago Metropolitan Agency for Planning





STORMWATER MANAGEMENT COMMISSION



LakeCounty Health Department and Community Health Center

4 Lakes Initiative



LAKE LEVEL

Lakes with stable water levels potentially have less shoreline erosion problems. A fluctuation in lake levels was observed during the sampling season. Data from the Stormwater Management Commission’s Wauconda rain gauge was correlated to rain events and lake level increases. Over the sample period May to September the

lake level decreased 1.1 feet. Lake NapaSuwe appears to be influenced by rainfall, during dry seasons and drier months the lake level significantly decreases and the lake level increases following rain events. The highest water level occurred in July following 6.32 inches of precipitation. The most significant decrease in lake

level occurred from July to August with a decrease in lake level of 0.60 feet. 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).



**EXAMPLE OF A
PERMANENT STAFF
GAUGE**



ENVIRONMENTAL SERVICES

Senior Biologist: Mike Adam

madam@lakecountyil.gov

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

Phone: 847-377-8030

Fax: 847-984-5622

For more information visit us at:

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

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

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

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

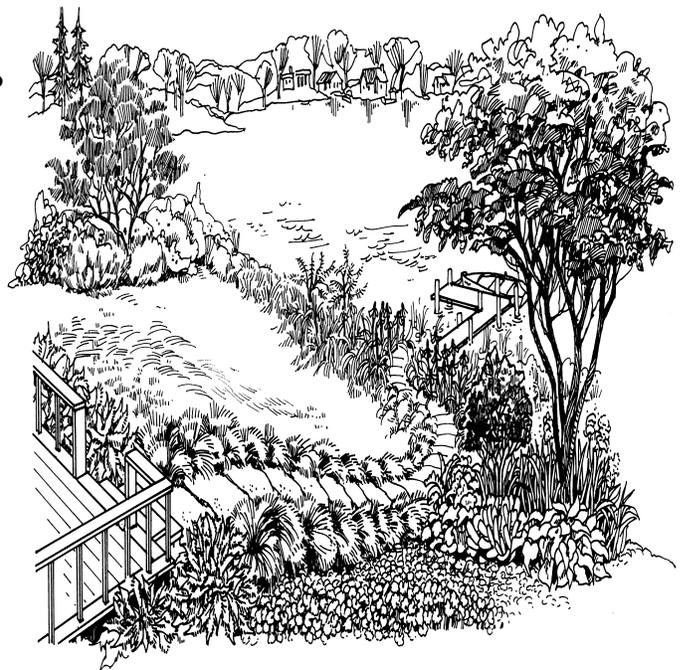
Services provided are either of a technical or educational nature and are provided by a professional staff of scientists to government agencies (county, township and municipal), lake property owners' associations and private individuals on all bodies of water within Lake County.

LAKE RECOMMENDATIONS

Lake NapaSuwe water quality has decreased since 2009. Documented increases in total phosphorus, total suspended solids, total volatile solids, nonvolatile solids, and decreased water clarity, were influenced by the decrease in density of the aquatic plant community. Significant reductions in the exotic Eurasian Watermilfoil and Curlyleaf Pondweed were made from an herbicide treatment. Overall shoreline erosion has decreased in 2013, the areas of moderate and severe erosion are a concern.

To improve the overall quality of Lake NapaSuwe; the ES (Environmental Services) has the following recommendations:

- **Remove resurfacing EWM and CLP manually to allow the density of the native aquatic plants to increase.**
- **Develop an aquatic plant management plan that increases the diversity of aquatic plant species**
- **Install a permanent staff gage to monitor lake level fluctuations.**
- **Assess the current fish population.**
- **Address areas of severe shoreline erosion.**
- **Encourage homeowners to incorporate native plants in their landscaping through rain gardens or shoreline filter strips.**
- **Use road salt alternatives and proper application procedures for homeowners.**



Lake NapaSuwe Water Quality Summaries for 2013, 2009, and 2002.

2013		Inlet														
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃ -N	TP	SRP	TDS	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
15-May	0	167	2.62	0.123	<0.05	0.138	0.006	NA	123	27.0	571	152	1.10	NA	NA	NA
12-Jun	0	217	2.77	<0.1	0.06	0.156	<0.005	504	137	21.0	610	131	1.61	0.8980	8.2600	9.54
9-Jul	0	204	3.67	<0.1	<0.05	0.231	<0.005	465	129	63.0	620	162	0.54	0.8330	8.3600	7.58
14-Aug	0	167	3.47	<0.1	<0.05	0.222	<0.005	521	168	46.0	680	213	0.30	0.9260	8.5900	9.78
11-Sep	0	167	4.60	<0.1	<0.05	0.222	<0.005	526	168	72.0	680	213	0.58	0.9350	8.8200	10.23
Average		184	3.43	0.123	0.06^k	0.194	0.006^k	504	145	45.8	632	174	0.83	0.8980	8.51	9.28

2009		Inlet														
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃ -N	TP	SRP	TDS	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
12-May	3	187	1.58	<0.1	<0.05	0.103	<0.005	NA	102	16.0	460	99	1.87	0.7460	9.29	7.85
9-Jun	0	152	1.68	<0.1	<0.05	0.095	<0.005	NA	107	18.0	440	108	1.48	0.6920	8.90	8.47
14-Jul	3	132	1.55	<0.1	<0.05	0.075	0.006	NA	105	12.0	392	101	2.03	0.6300	9.13	7.27
11-Aug	0	120	1.25	<0.1	<0.05	0.041	<0.005	NA	105	9.4	373	91	3.60	0.6130	9.29	8.11
15-Sep	0	135	1.24	<0.1	<0.05	0.029	<0.005	NA	107	5.1	393	92	NA	0.6410	8.97	6.83
Average		145	1.46	<0.1	<0.05	0.069	0.006^k	NA	105	12.1	412	98	2.25	0.6644	9.12	7.71

2002		Inlet														
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₃ -N	TP	SRP	TDS	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
30-Apr	3	266	2.28	<0.1	<0.05	0.165	<0.005	632	NA	31.0	667	205	1.39	1.0300	8.19	9.29
5-Jun	3	239	2.95	<0.1	<0.05	0.195	<0.005	640	NA	42.2	653	187	1.05	0.9523	7.81	4.96
9-Jul	0	233	1.23	<0.1	<0.05	0.206	0.006	612	NA	45.0	655	193	0.79	0.9936	8.31	6.07
6-Aug	0	207	4.62	<0.1	<0.05	0.267	0.008	607	NA	69.0	692	222	0.85	1.0090	8.45	6.06
4-Sep	0	192	3.15	0.242	<0.05	0.184	<0.005	516	NA	30.0	596	198	0.82	0.8902	8.13	7.35
Average		227.4	2.85	0.242^k	<0.05^k	0.203	0.007^k	601	NA	43.4	653	201	0.98	0.9750	8.18	6.75

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

Lake NapaSuwe Water Quality Summaries for 2013, 2009, and 2002.

2013		Outlet														
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃ -N	TP	SRP	TDS	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
15-May	0	165	2.29	<0.1	<0.05	0.141	0.006	NA	120	32	599	175	1.7	NA	NA	NA
12-Jun	0	217	2.69	0.197	0.146	0.151	<0.005	NA	137	34	654	164	1.5	NA	8.09	8.1
9-Jul	0	184	3.32	<0.1	<0.05	0.173	<0.005	461	134	45	590	162	NA	0.8260	8.33	8.02
14-Aug	0	204	5.53	<0.1	<0.05	0.219	<0.005	524	143	70.0	673	194	NA	0.9310	8.39	8.9
11-Sep	0	163	5.40	<0.1	<0.05	0.290	0.01	532	167	90	699	215	NA	0.9450	8.62	8.54
Average		187	3.85	0.197 ^k	0.146 ^k	0.195	0.008 ^k	506	140	54.2	643	182	1.6	0.9007	8.36	8.39

2009		Outlet														
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃ -N	TP	SRP	TDS	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
12-May	0	141	0.87	<0.1	<0.05	0.034	<0.005	NA	105	9.6	403	99	1.87	0.7480	9.83	4.45
9-Jun	0	108	1.20	<0.1	<0.05	0.045	0.007	NA	106	6.5	364	83	2.13	0.5980	9.66	9.57
14-Jul	0	122	1.67	<0.1	<0.05	0.102	0.040	NA	109	92.4	460	138	NA	0.6080	9.61	7.31
11-Aug	0	125	1.47	<0.1	<0.05	0.082	<0.005	NA	109	20.0	393	110	NA	0.6340	9.37	8.17
15-Sep	0	126	1.26	<0.1	<0.05	0.020	<0.005	NA	105	3.5	372	96	NA	0.6070	9.2	4.97
Average		124	1.29	<0.1	<0.05	0.057	0.024 ^k	NA	107	26.4	398	105	NA	0.6390	9.53	6.89

2002		Outlet														
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₃ -N	TP	SRP	TDS	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
30-Apr	0	259	2.21	<0.1	<0.05	0.127	<0.005	594	NA	25.0	652	216	1.28	1.0180	8.17	9.08
5-Jun	0	238	2.72	0.153	0.056	0.181	<0.005	576	NA	52.0	595	157	0.92	0.8878	7.74	5.63
9-Jul	0	238	3.46	<0.1	<0.05	0.245	0.014	577	NA	59.0	661	193	0.56	0.9949	7.94	3.46
6-Aug	0	224	5.62	<0.1	<0.05	0.373	0.029	587	NA	122.0	763	250	0.72	1.0190	8.04	4.62
4-Sep	0	199	3.49	0.721	<0.05	0.226	0.020	536	NA	44.0	587	176	0.59	0.8846	7.61	3.06
Average		232	3.50	0.437 ^k	0.056 ^k	0.230	0.021 ^k	574	NA	60.4	652	198	0.81	0.9609	7.90	5.17

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

NapaSuWe Lake 2013 IEPA Ranking

TROPHIC STATUS

Carlson's TSIp 82.1 Hypereutrophic

IMPAIRMENT ASSESSMENTS

Total Phosphorus Yes
 Total Nitrogen None
 pH None
 Low DO None
 Total Dissolved Solids None
 Total Suspended Solids Yes
 Aquatic Plants-Native None
 Non-Native Aquatic Plants None
 Non-Native Animals Yes

AQUATIC LIFE USE IMPAIRMENT INDEX

Median Trophic State
 Macrophyte Impairment
 Sediment Impairment (NVSS)
 Degree of Use Support

RECREATION USE IMPAIRMENT INDEX

Median Trophic State Index
 Macrophyte Impairment
 Sediment Impairment (NVSS)
 Degree of Use Support

Overall Use Index

<u>Weighting Criteria</u>	<u>Points</u>	<u>Overall Use Support Points</u>	<u>Degree of Support</u>
82.1	50		
Minimal	0		
Substantial	15		
	65	0	Full
82.1	82.1		
Moderate	10		
Substantial	15		
	107	2	Nonsupport
		1.00	Partial

Lake NapaSuwe 2013 Multiparameter data

INLET Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient
5/15/2013	NA										
OUTLET Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet		
5/15/2013	NA										
INLET Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient
6/12/2013	0		24.71	9.54	115.1	0.8980	8.26	NA	Surface		
6/12/2013	1		24.85	9.48	114.6	0.8980	8.28	NA	Surface		
6/12/2013	2		24.85	9.05	107.0	0.9010	8.25	NA			
6/12/2013	3		24.24	4.62	55.3	0.9110	8.03	NA			
6/12/2013	4		23.06	0.99	10.2	0.8960	7.70	NA			
OUTLET Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet		
6/12/2013	0.000		23.83	8.10	91.2	0.5980	8.09	NA	Surface		
INLET Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient
7/10/2013	0	0.60	28.09	8.09	103.7	0.8380	8.34	3528.9	Surface		1.70
7/10/2013	1	1.01	28.20	7.73	99.3	0.8370	8.38	1087.9	Surface	100%	
7/10/2013	2	2.04	28.13	7.64	98.0	0.8380	8.38	557.1	0.288	51%	2.324
7/10/2013	3	3.01	28.13	7.64	98.1	0.8380	8.38	62.3	1.256	6%	1.744
7/10/2013	4	4.01	27.42	4.21	53.4	0.8490	7.02	6.2	2.257	1%	1.022
OUTLET Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient
7/10/2013	0	0.49	31.10	8.56	115.7	0.8250	8.36	2229.1			

Lake NapaSuwe 2013 Multiparameter data

INLET	Text								Depth of		
Date	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Light Meter	% Light	Extinction
MMDDYY	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Transmission	Coefficient
											Average
8/14/2013	0	0.55	22.23	9.70	111.8	0.9260	8.57	NA			
8/14/2013	1	1.02	22.24	9.77	112.5	0.9260	8.59	NA			
8/14/2013	2	2.04	22.14	9.78	112.5	0.9280	8.60	NA			
8/14/2013	3	3.06	21.33	9.04	102.3	0.9310	8.56	NA			
8/14/2013	4	4.02	21.55	5.89	67.0	0.9400	8.11	NA			
OUTLET											
Date	Text								Depth of		
MMDDYY	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Light Meter		
	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet		
8/14/2013	0	0.54	23.98	8.89	105.8	0.9330	8.38	NA			
INLET											
Date	Text								Depth of		
MMDDYY	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Light Meter	% Light	Extinction
	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Transmission	Coefficient
											Average
9/11/2013	0		25.98	10.23	126.4	0.9350	8.82	NA			
9/11/2013	1		25.50	9.75	119.4	0.9390	8.81	NA			
9/11/2013	2		25.40	8.45	103.2	0.9380	8.76	NA			
9/11/2013	3		25.07	5.54	67.2	0.9410	8.01	NA			
OUTLET											
Date	Text								Depth of		
MMDDYY	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Light Meter		
	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet		
9/11/2013	0		26.99	9.54	119.9	0.9450	8.62	NA			

Lake County average TSI phosphorus (TSIp) ranking 2000-2013.

RANK	LAKE NAME	TP AVE	TSIp
1	Lake Carina	0.0100	37.35
2	Sterling Lake	0.0100	37.35
3	Independence Grove	0.0130	41.14
4	Lake Zurich	0.0135	41.68
5	Druce Lake	0.0140	42.00
6	Windward Lake	0.0160	44.13
7	Sand Pond (IDNR)	0.0165	44.57
8	West Loon	0.0170	45.00
9	Pulaski Pond	0.0180	45.83
10	Banana Pond	0.0200	47.35
11	Cedar Lake	0.0200	47.35
12	Gages Lake	0.0200	47.35
13	Lake Kathryn	0.0200	47.35
14	Lake Minear	0.0200	47.35
15	Highland Lake	0.0202	47.49
16	Lake Miltmore	0.0210	48.00
17	Timber Lake (North)	0.0210	48.05
18	Cross Lake	0.0220	48.72
19	Dog Training Pond	0.0220	48.72
20	Sun Lake	0.0220	48.72
21	Deep Lake	0.0230	49.36
22	Lake of the Hollow	0.0230	49.36
23	Round Lake	0.0230	49.36
24	Stone Quarry Lake	0.0230	49.36
25	Bangs Lake	0.0240	50.00
26	Little Silver Lake	0.0250	50.57
27	Lake Leo	0.0260	51.13
28	Cranberry Lake	0.0270	51.68
29	Dugdale Lake	0.0270	51.68
30	Peterson Pond	0.0270	51.68
31	Fourth Lake	0.0360	53.00
32	Lake Fairfield	0.0300	53.20
33	Third Lake	0.0300	53.20
34	Lake Catherine	0.0310	53.67
35	Lambs Farm Lake	0.0310	53.67
36	Old School Lake	0.0310	53.67
37	Grays Lake	0.0310	54.00
38	Harvey Lake	0.0320	54.50
39	Hendrick Lake	0.0340	55.00
40	Honey Lake	0.0340	55.00
41	Sand Lake	0.0380	56.00
42	Sullivan Lake	0.0370	56.22
43	Channel Lake	0.0380	56.60
44	Ames Pit	0.0390	56.98
45	Diamond Lake	0.0390	56.98
46	East Loon	0.0400	57.34

Lake County average TSI phosphorus (TSIp) ranking 2000-2013.

RANK	LAKE NAME	TP AVE	TSIp
47	Schreiber Lake	0.0400	57.34
48	Waterford Lake	0.0400	57.34
49	Hook Lake	0.0410	57.70
50	Duck Lake	0.0430	58.39
51	Nielsen Pond	0.0450	59.04
52	Seven Acre Lake	0.0460	59.36
53	Turner Lake	0.0460	59.36
54	Willow Lake	0.0460	59.36
55	East Meadow Lake	0.0480	59.97
56	Lucky Lake	0.0480	59.97
57	Old Oak Lake	0.0490	60.27
58	College Trail Lake	0.0500	60.56
59	Hastings Lake	0.0520	61.13
60	Butler Lake	0.0530	61.40
61	West Meadow Lake	0.0530	61.40
62	Lucy Lake	0.0550	61.94
63	Lake Linden	0.0570	62.45
64	Lake Christa	0.0580	62.70
65	Owens Lake	0.0580	62.70
66	Briarcrest Pond	0.0580	63.00
67	Lake Barrington	0.0600	63.10
68	Lake Lakeland Estates	0.0620	63.66
69	Lake Naomi	0.0620	63.66
70	Lake Tranquility (S1)	0.0620	63.66
71	Liberty Lake	0.0630	63.89
72	North Tower Lake	0.0630	63.89
73	Werhane Lake	0.0630	63.89
74	Countryside Glen Lake	0.0640	64.12
75	Countryside Lake	0.0660	65.00
76	Davis Lake	0.0650	64.34
77	Leisure Lake	0.0650	64.34
78	St. Mary's Lake	0.0670	64.78
79	Little Bear Lake	0.0680	65.00
80	Buffalo Creek Reservoir 1	0.0680	65.00
81	Mary Lee Lake	0.0680	65.00
82	Wooster Lake	0.0700	65.41
83	Crooked Lake	0.0710	66.00
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	Bluff Lake	0.0730	66.02
89	Long Lake	0.0730	66.02
90	Spring Lake	0.0730	66.02
91	Broberg Marsh	0.0780	66.97
92	Woodland Lake	0.0800	68.00

Lake County average TSI phosphorus (TSIp) ranking 2000-2013.

RANK	LAKE NAME	TP AVE	TSIp
93	Redwing Slough	0.0822	67.73
94	Tower Lake	0.0830	67.87
95	Petite Lake	0.0830	67.87
96	Lake Marie	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	Lake Fairview	0.0890	68.00
103	Rivershire Pond 2	0.0900	69.04
104	South Churchill Lake	0.0900	69.04
105	McGreal Lake	0.0910	69.20
106	Lake Charles	0.0930	69.40
107	Deer Lake	0.0940	69.66
108	Dunn's Lake	0.0950	69.82
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	Big Bear Lake	0.0960	69.97
113	Buffalo Creek Reservoir 2	0.0960	69.97
114	Fish Lake	0.0960	69.97
115	Lochanora Lake	0.0960	69.97
116	Nippersink Lake	0.1000	70.56
117	Sylvan Lake	0.1000	70.56
118	Longview Meadow Lake	0.1020	70.84
119	Lake Forest Pond	0.1070	71.53
120	Bittersweet Golf Course #13	0.1100	71.93
121	Fox Lake	0.1100	71.93
122	Kemper 2	0.1100	71.93
123	Middlefork Savannah Outlet 1	0.1120	72.00
124	Osprey Lake	0.1110	72.06
125	Bresen Lake	0.1130	72.32
126	Round Lake Marsh North	0.1130	72.32
127	Deer Lake Meadow Lake	0.1160	72.70
128	Taylor Lake	0.1180	72.94
129	Island Lake	0.1210	73.00
130	Columbus Park Lake	0.1230	73.54
131	Lake Nipperink	0.1240	73.66
132	Echo Lake	0.1250	73.77
133	Grass Lake	0.1290	74.23
134	Lake Holloway	0.1320	74.56
135	Redhead Lake	0.1410	75.51
136	Antioch Lake	0.1450	75.91
137	Slocum Lake	0.1500	77.00
138	Lakewood Marsh	0.1510	76.50

Lake County average TSI phosphorus (TSIp) ranking 2000-2013.

RANK	LAKE NAME	TP AVE	TSIp
139	Pond-A-Rudy	0.1510	76.50
140	Lake Matthews	0.1520	76.59
141	Forest Lake	0.1540	76.78
142	Middlefork Savannah Outlet 2	0.1590	77.00
143	Pistakee Lake	0.1590	77.24
144	Grassy Lake	0.1610	77.42
145	Salem Lake	0.1650	77.78
146	Half Day Pit	0.1690	78.12
147	Lake Eleanor	0.1810	79.11
148	Lake Farmington	0.1850	79.43
149	Lake Louise	0.1850	79.43
150	ADID 127	0.1890	79.74
151	Lake Napa Suwe	0.1940	80.00
152	Patski Pond	0.1970	80.33
153	Dog Bone Lake	0.1990	80.48
154	Summerhill Estates Lake	0.1990	80.48
155	Redwing Marsh	0.2070	81.05
156	Stockholm Lake	0.2082	81.13
157	Bishop Lake	0.2160	81.66
158	Ozaukee Lake	0.2200	81.93
159	Kemper 1	0.2220	82.08
160	Hidden Lake	0.2240	82.19
161	McDonald Lake 2	0.2250	82.28
162	Fischer Lake	0.2280	82.44
163	Oak Hills Lake	0.2790	85.35
164	Loch Lomond	0.2950	86.16
165	Heron Pond	0.2990	86.35
166	Rollins Savannah 1	0.3070	87.00
167	Fairfield Marsh	0.3260	87.60
168	ADID 182	0.3280	87.69
169	Manning's Slough	0.3820	90.22
170	Slough Lake	0.3860	90.03
171	Rasmussen Lake	0.4860	93.36
172	Albert Lake, Site II, outflow	0.4950	93.67
173	Flint Lake Outlet	0.5000	93.76
174	Rollins Savannah 2	0.5870	96.00
175	Almond Marsh	1.9510	113.00

**Aquatic Plants found at the 92 sampling sites on Lake NapaSuwe in July, 2013.
The maximum depth that plants were found was 2.5 feet.**

Plant Density	Coontail	Duckweed	Giant Duckweed	Sago Pondweed
Absent	73	91	91	89
Present	14	1	1	3
Common	4	0	0	0
Abundant	1	0	0	0
Dominant	0	0	0	0
% Plant Occurrence	20.7	1.1	1.1	3.3

Distribution of rake density across all sampling sites.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	71	77
>0-10%	16	17
10-40%	4	4
40-60%	1	1
60-90%	0	0
>90%	0	0
Total Sites with Plants	21	23
Total # of Sites	92	100

Site:
 Locale: Lake NapaSuwe
 Date: July, 2013 4 hours
 By: Deem
 File: Untitled study

FLORISTIC QUALITY DATA		Native		Adventive	
4	NATIVE SPECIES	Tree	0 0.0%	Tree	0 0.0%
4	Total Species	Shrub	0 0.0%	Shrub	0 0.0%
5.5	NATIVE MEAN C	W-Vine	0 0.0%	W-Vine	0 0.0%
5.5	W/Adventives	H-Vine	0 0.0%	H-Vine	0 0.0%
11.0	NATIVE FQI	P-Forb	2 50.0%	P-Forb	0 0.0%
11.0	W/Adventives	B-Forb	0 0.0%	B-Forb	0 0.0%
-5.0	NATIVE MEAN W	A-Forb	2 50.0%	A-Forb	0 0.0%
-5.0	W/Adventives	P-Grass	0 0.0%	P-Grass	0 0.0%
AVG:	Obl. Wetland	A-Grass	0 0.0%	A-Grass	0 0.0%
		P-Sedge	0 0.0%	P-Sedge	0 0.0%
		A-Sedge	0 0.0%	A-Sedge	0 0.0%
		Cryptogam	0 0.0%		

ACRONYM	C SCIENTIFIC NAME	W WETNESS	PHYSIOGNOMY	COMMON NAME
CERDEM	5 <i>Ceratophyllum demersum</i>	-5 OBL	Nt P-Forb	HORNWORT
LEMMIO	5 <i>Lemna minor</i>	-5 OBL	Nt A-Forb	SMALL DUCKWEED
POTPEC	5 <i>Potamogeton pectinatus</i>	-5 OBL	Nt P-Forb	SAGO PONDWEED
SPIPOL	7 <i>Spirodela polyrhiza</i>	-5 OBL	Nt A-Forb	GREAT DUCKWEED

Lake County average Floristic Quality Index (FQI) ranking 2000-2013.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	38.0	36.6
2	East Loon Lake	34.7	36.1
3	Cranberry Lake	29.7	29.7
4	Deep Lake	29.7	31.2
5	Bangs Lake	29.6	26.0
6	Little Silver Lake	29.6	31.6
7	Round Lake Marsh North	29.1	29.9
8	West Loon Lake	27.1	29.5
9	Sullivan Lake	26.9	28.5
10	Third Lake	25.1	22.5
11	Fourth Lake	24.7	27.1
12	Independence Grove	24.6	27.5
13	Sterling Lake	24.5	26.9
14	Sun Lake	24.3	26.1
15	Lake Zurich	24.3	27.1
16	Redwing Slough	24.0	25.8
17	Schreiber Lake	23.9	24.8
18	Lakewood Marsh	23.8	24.7
19	Deer Lake	23.5	24.4
20	Round Lake	23.5	25.9
21	Honey Lake	23.3	25.1
22	Lake of the Hollow	23.0	24.8
23	Wooster Lake	22.8	21.1
24	Cross Lake	22.4	24.2
25	Countryside Glen Lake	21.9	22.8
26	Davis Lake	21.4	21.4
27	Butler Lake	21.4	23.1
28	Lake Barrington	21.2	21.2
29	Duck Lake	21.1	22.9
30	Timber Lake (North)	20.9	23.4
31	ADID 203	20.5	20.5
32	Broberg Marsh	20.5	21.4
33	McGreal Lake	20.2	22.1
34	Lake Kathryn	19.6	20.7
35	Fish Lake	19.3	21.2
36	Redhead Lake	19.3	21.2
37	Druce Lake	19.1	21.8
38	Turner Lake	18.6	21.2
39	Salem Lake	18.5	20.2
40	Lake Helen	18.0	18.0
41	Old Oak Lake	18.0	19.1
42	Potomac Lake	17.8	17.8
43	Long Lake	17.7	15.8
44	Hendrick Lake	17.7	17.7
45	Rollins Savannah 2	17.7	17.7
46	Grandwood Park Lake	17.2	19.0
47	Seven Acre Lake	17.0	15.5
48	Lake Miltmore	16.8	18.7
49	McDonald Lake 1	16.7	17.7
50	Highland Lake	16.7	18.9
51	Bresen Lake	16.6	17.8
52	Almond Marsh	16.3	17.3
53	Owens Lake	16.3	17.3
54	Windward Lake	16.3	17.6

Lake County average Floristic Quality Index (FQI) ranking 2000-2013.

Rank	LAKE NAME	FQI (w/A)	FQI (native)
55	Grays Lake	16.1	16.1
56	White Lake	16.0	17.0
57	Dog Bone Lake	15.7	15.7
58	Osprey Lake	15.5	17.3
59	Heron Pond	15.1	15.1
60	North Churchill Lake	15.0	15.0
61	Hastings Lake	15.0	17.0
62	Lake Tranquility (S1)	15.0	17.0
63	Forest Lake	14.8	15.9
64	Dog Training Pond	14.7	15.9
65	Island Lake	14.7	16.6
66	Grand Ave Marsh	14.3	16.3
67	Nippersink Lake	14.3	16.3
68	Taylor Lake	14.3	16.3
69	Manning's Slough	14.1	16.3
70	Tower Lake	14.0	14.0
71	Dugdale Lake	14.0	15.1
72	Eagle Lake (S1)	14.0	15.1
73	Crooked Lake	14.0	16.0
74	Longview Meadow Lake	13.9	13.9
75	Bishop Lake	13.4	15.0
76	Ames Pit	13.4	15.5
77	Mary Lee Lake	13.1	15.1
78	Old School Lake	13.1	15.1
79	Dunn's Lake	12.7	13.9
80	Summerhill Estates Lake	12.7	13.9
81	Buffalo Creek Reservoir 1	12.5	11.4
82	Buffalo Creek Reservoir 2	12.5	11.4
83	McDonald Lake 2	12.5	12.5
84	Rollins Savannah 1	12.5	12.5
85	Stone Quarry Lake	12.5	12.5
86	Kemper Lake 1	12.2	13.4
87	Pond-A-Rudy	12.1	12.1
88	Stockholm Lake	12.1	13.5
89	Lake Carina	12.1	14.3
90	Lake Leo	12.1	14.3
91	Lambs Farm Lake	12.1	14.3
92	Grassy Lake	12.0	12.0
93	Lake Matthews	12.0	12.0
94	Flint Lake Outlet	11.8	13.0
95	Albert Lake	11.5	10.3
96	Rivershire Pond 2	11.5	13.3
97	Antioch Lake	11.3	13.4
98	Hook Lake	11.3	13.4
99	Briarcrest Pond	11.2	12.5
100	Lake Naomi	11.2	12.5
101	Pulaski Pond	11.2	12.5
102	Lake Napa Suwe	11.0	11.0
103	Redwing Marsh	11.0	11.0
104	West Meadow Lake	11.0	11.0
105	Lake Minear	11.0	13.9
106	Nielsen Pond	10.7	12.0
107	Lake Holloway	10.6	10.6
108	Sylvan Lake	10.6	10.6
109	Crooked Lake	10.2	12.5
110	Gages Lake	10.2	12.5

Lake County average Floristic Quality Index (FQI) ranking 2000-2013.

Rank	LAKE NAME	FQI (w/A)	FQI (native)
111	College Trail Lake	10.0	10.0
112	Valley Lake	9.9	9.9
113	Werhane Lake	9.8	12.0
114	Loch Lomond	9.4	12.1
115	Columbus Park Lake	9.2	9.2
116	Lake Lakeland Estates	9.2	9.2
117	Waterford Lake	9.2	9.2
118	Lake Fairfield	9.0	10.4
119	Lake Louise	9.0	10.4
120	Fischer Lake	9.0	11.0
121	Lake Fariview	8.5	6.9
122	Timber Lake (South)	8.5	6.9
123	East Meadow Lake	8.5	8.5
124	South Churchill Lake	8.5	8.5
125	Kemper Lake 2	8.5	9.8
126	Lake Christa	8.5	9.8
127	Lake Farmington	8.5	9.8
128	Lucy Lake	8.5	9.8
129	Bittersweet Golf Course #13	8.1	8.1
130	Lake Linden	8.0	8.0
131	Sand Lake	8.0	10.4
132	Countryside Lake	7.7	11.5
133	Fairfield Marsh	7.5	8.7
134	Lake Eleanor	7.5	8.7
135	Banana Pond	7.5	9.2
136	Slocum Lake	7.1	5.8
137	Lucky Lake	7.0	7.0
138	North Tower Lake	7.0	7.0
139	Lake Forest Pond	6.9	8.5
140	Ozaukee Lake	6.7	8.7
141	Leisure Lake	6.4	9.0
142	Peterson Pond	6.0	8.5
143	Little Bear Lake	5.8	7.5
144	Deer Lake Meadow Lake	5.2	6.4
145	ADID 127	5.0	5.0
146	Island Lake	5.0	5.0
147	Liberty Lake	5.0	5.0
148	Oak Hills Lake	5.0	5.0
149	Slough Lake	5.0	5.0
150	International Mining and Chemical Lake	5.0	7.1
151	Diamond Lake	3.7	5.5
152	Lake Charles	3.7	5.5
153	Big Bear Lake	3.5	5.0
154	Sand Pond (IDNR)	3.5	5.0
155	Harvey Lake	3.3	5.0
156	Half Day Pit	2.9	5.0
157	Lochanora Lake	2.5	5.0
158	Echo Lake	0.0	0.0
159	Hidden Lake	0.0	0.0
160	St. Mary's Lake	0.0	0.0
161	Willow Lake	0.0	0.0
162	Woodland Lake	0.0	0.0
	<i>Mean</i>	13.8	14.8
	<i>Median</i>	12.5	13.9

**APPENDIX A. 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

In previous years a complete assessment of the shoreline was done. However, this year we did a visual estimate to determine changes in the shoreline. The degree of shoreline erosion was categorically defined as none, slight, moderate, or severe. Below are brief descriptions of each category.

None – Includes man-made erosion control such as beach, 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”.

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.

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.

<i>Parameter</i>	<i>Method</i>
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 18 th ed. Electrode method, #4500 NH ₃ -F Detection Limit = 0.1 mg/L
Total Kjeldahl nitrogen	SM 18 th 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 18 th ed, Method #2540B
Total suspended solids	SM 18 th ed, Method #2540D Detection Limit = 0.5 mg/L
Chloride	SM 18 th ed, Method #4500C1-D
Total volatile solids	SM 18 th ed, Method #2540E, from total solids
Alkalinity	SM 18 th ed, Method #2320B, potentiometric titration curve method
Conductivity	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Total phosphorus	SM 18 th ed, Methods #4500-P B 5 and #4500-P E Detection Limit = 0.01 mg/L
Soluble reactive phosphorus	SM 18 th 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 C. 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 2000-2009 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. When 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 2000-2009 was 0.063 mg/L and ranged from a non-detectable minimum of <0.010 mg/L on five lakes to a maximum of 3.880 mg/L on Albert Lake. The median anoxic TP concentration in Lake County lakes from 2000-2009 was 0.167 mg/L and ranged from a minimum of 0.012 mg/L in Independence Grove Lake to a maximum of 3.880 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 7.9 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 132.8 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, but was discontinued due to the strong correlation of TDS to conductivity and chloride concentrations.

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 the plant and fish communities, as well as the levels of phosphorus in a lake. The detrimental impacts of low Secchi depth to plants has already been discussed. 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 average Secchi depth for Lake County lakes is 3.12 feet. From 2000-2009, Ozaukee Lake had the lowest Secchi depths (0.25 feet) and West Loon Lake had the highest (24.77 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.

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 but 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 8.34, with a minimum 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	$\geq 40 < 50$	$> 0.012 \leq 0.024$	$\geq 6.56 < 13.12$
Eutrophic	$\geq 50 < 70$	$> 0.024 \leq 0.096$	$\geq 1.64 < 6.56$
Hypereutrophic	≥ 70	> 0.096	< 1.64

Fluridone Chemical Fact Sheet

Formulations

Fluridone is an aquatic herbicide that was initially registered with the EPA in 1986. The active ingredient is 1-methyl-3-phenyl-5-3-(trifluoromethyl)phenyl-4H-pyridinone. Both liquid and slow-release granular formulations are available. Fluridone is sold under the brand names Avast!, Sonar, and Whitecap (product names are provided solely for your reference and should not be considered endorsements).

Aquatic Use and Considerations

Fluridone is an herbicide that stops the plant from making a protective pigment that keeps chlorophyll from breaking down in the sun. Treated plants will turn white or pink at the growing tips after a week and will die in one to two months after treatment as it is unable to make food for itself. It is only effective if plants are growing at the time of treatment.

Fluridone is used at very low concentrations, but a very long contact time is required (45-90 days). If the fluridone is removed before the plants die, they will once again be able to produce chlorophyll and grow.

Fluridone moves rapidly through water, so it is usually applied as a whole-lake treatment to an entire waterbody or basin. There are pellet slow-release formulations that may be used as spot treatments, but the efficacy of this is undetermined. Fluridone has been applied to rivers through a drip system to maintain the concentration for the required contact time.

Plants vary in their susceptibility to fluridone, so typically some species will not be affected even though the entire waterbody is treated.

Plants have been shown to develop resistance to repeated fluridone use, so it is recommended to rotate herbicides with different modes of action when using fluridone as a control.

Fluridone is effective at treating the invasive Eurasian watermilfoil (*Myriophyllum spicatum*). It also is commonly used for control of invasive hydrilla (*Hydrilla verticillata*) and water hyacinth (*Eichhornia crassipes*), neither of which are present in Wisconsin yet. Desirable native species that are usually affected at concentrations used to treat the invasives include native milfoils, coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), elodea (*Elodea canadensis*) and duckweeds (*Lemna* spp.). Lilies (*Nymphaea* spp. and *Nuphar* spp.) and bladderworts (*Utricularia* spp.) also can be affected.

Post-Treatment Water Use Restrictions

There are no restrictions on swimming, eating fish from treated water bodies, human drinking water or pet/livestock drinking water. Depending on the type of waterbody treated and the type of plant being watered, irrigation restrictions may apply for up to 30 days. Certain plants, such as tomatoes and peppers and newly seeded lawn, should not be watered with treated water until the concentration is less than 5 parts per billion (ppb).

Herbicide Degradation, Persistence and Trace Contaminants

The half-life of fluridone (the time it takes for half of the active ingredient to degrade) ranges from 4 to 97 days depending on water conditions. After treatment, the fluridone concentration in the water is reduced through dilution due to water movement, uptake by plants, adsorption to the sediments, and break down from light and microbial action.

There are two major degradation products from fluridone: n-methyl formamide (NMF) and 3-trifluoromethyl benzoic acid. NMF has not been detected in studies of field conditions, including those at the maximum label rate.

Fluridone residues in sediments reach a maximum in one to four weeks after treatment and decline in four months to a year depending on environmental conditions. Fluridone adsorbs to clay and soils with high organic matter, especially in pellet form, and can reduce the concentration of fluridone in the water. Adsorption to the sediments is reversible; fluridone gradually dissipates back into the water where it is subject to chemical breakdown.

Impacts on Fish and Other Aquatic Organisms

Fluridone does not appear to have any apparent short-term or long-term effects on fish at application rates.

Fish exposed to water treated with fluridone absorb fluridone into their tissues. Residues of fluridone in fish decrease as the herbicide disappears from the water. The EPA has established a tolerance for fluridone residues in fish of 0.5 parts per million (ppm).

Studies on Fluridone's effects on aquatic invertebrates (i.e. midge and water flea) have shown increased mortality at label application rates.

Studies on birds indicate that fluridone would not pose an acute or chronic risk to birds. No studies have been conducted on amphibians or reptiles.

Human Health

The risk of acute exposure to fluridone would be primarily to chemical applicators. The acute toxicity risk from oral and inhalation routes is minimal. Concentrated fluridone may cause some eye or skin irritation. No personal protective equipment is required on the label to mix or apply fluridone.

Fluridone does not show evidence of causing birth defects, reproductive toxicity, or genetic mutations in mammals tested. It is not considered to be carcinogenic nor does it impair immune or endocrine function.

There is some evidence that the degradation product NMF causes birth defects. However, since NMF has only been detected in the lab and not following actual fluridone treatments, the manufacturer and EPA have indicated that fluridone use should not result in NMF

concentrations that would adversely affect the health of water users. In the re-registration assessment that is currently underway for fluridone, the EPA has requested additional studies on both NMF and 3-trifluoromethyl benzoic acid.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade,
and Consumer Protection
<http://datcp.wi.gov/Plants/Pesticides/>

Wisconsin Department of Natural Resources
608-266-2621
<http://dnr.wi.gov/lakes/plants/>

Wisconsin Department of Health Services
<http://www.dhs.wisconsin.gov/>

National Pesticide Information Center
1-800-858-7378
<http://npic.orst.edu/>

Hamelink, J.L., D.R. Buckler, F.L. Mayer, D.U. Palawski, and H.O. Sanders. 1986. Toxicity of Fluridone to Aquatic Invertebrates and Fish. *Environmental Toxicology and Chemistry* 5:87-94.

Fluridone ecological risk assessment by the Bureau of Land Management, Reno Nevada:
http://www.blm.gov/pgdata/etc/medialib/blm/wo/Planning_and_Renewable_Resources/veis.Par.91082.File.tmp/Fluridone%20Ecological%20Risk%20Assessment.pdf

