

2000 SUMMARY REPORT

of

LEISURE LAKE

Lake County, Illinois

Prepared by the

**LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT**

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LAKE IDENTIFICATION AND LOCATION

Leisure Lake (T46N, R9E, Section 28) is a manmade lake located in Antioch Township, west of Grass Lake and north of Grass Lake Road. Leisure Lake is located in the Upper Chain O'Lakes drainage system in the Fox River Watershed. No major creeks, rivers, or tributaries flow into Leisure Lake. Water from the lake eventually flows into Mud Lake, then Grass Lake, and ultimately into the Fox River. The sole outlet is a culvert located on the northeastern corner of the lake. Three stormwater outlets enter the lake from the surrounding residential area.

A bathymetric (depth contour) map of Leisure Lake was created by Lake County Health Department staff in October 2000 (Figure 1, Table 1). Based on these calculations, Leisure Lake encompasses 10.45 acres and has a shoreline length of 0.89 miles. A maximum depth of 9.0 feet was measured at the northeastern section of the lake near the current location of the aerator. Leisure Lake has a mean depth of 7.2 feet and a volume of 67.96 acre-feet. The fetch (the greatest length) across the lake is 0.36 miles. This lake elevation is approximately 740 feet above mean sea level.

BRIEF HISTORY OF LEISURE LAKE

Leisure Lake was created in approximately 1972 during construction of Leisure Village. At the time of construction, the lake was designed to hold stormwater runoff from the adjacent neighborhoods. Leisure Village privately owns the entire lake.

SUMMARY OF CURRENT AND HISTORICAL LAKE USES

The lake is used for the recreational and aesthetic enjoyment of the residents of Leisure Village and their guests. A pier with a gazebo is used for nature viewing and fishing. Rowboats are available for residential use during daylight hours. No motors are allowed. No swimming is allowed. Access is prohibited once the lake freezes over. Fishing is allowed (except during winter), but fish size restrictions exist. Leisure Village is the managing entity. A five-member board made up of Leisure Village residents meets monthly.

The western and northwestern shores are adjacent to the Fox River Country Club Golf Course. A housing development is currently under construction adjacent to the western end of the lake. Silt fences were present during the 2000 season along this shore.

Leisure Lake is used for irrigation purposes. Leisure Village has one pump that is used to irrigate the small golf course and lawns in the village. The Fox Lake Country Club Golf Course also pumps water from upstream of Leisure Lake. Impacts of irrigation are likely minimal. No significant water fluctuations were seen on Leisure Lake in 2000.

An aerator (operating at 7 psi in summer, 5 psi in winter) was installed in the lake in the early 1980's to boost dissolved oxygen (DO) levels. A 1/3 horsepower (HP) compressor powers the aerator. The aerator was turned off on May 23, 2000 in order to assess its impact and need for boosting DO levels. The aerator was turned back on January 17, 2001, when DO levels dropped to 3 mg/L.

LIMNOLOGICAL DATA – WATER QUALITY

Two water samples were taken once a month, May through September, at the deep-hole location near the lake's center (Figure 2). See Appendix A for water sampling methods used.

Leisure Lake's water quality is similar to many lakes in Lake County (Table 2). Most of the water quality parameters measured were near the averages of other lakes the Health Department has monitored since 1995. Several important findings were noted in 2000.

Secchi disk transparency readings decreased significantly over the season. A high of 8.04 feet was found in May, and a low of 1.21 feet in August. The average (3.85 feet) is lower than the county average (5.00 feet). In correlation with Secchi disk readings, the 1% light penetration depth (the point where photosynthesis stops) decreased over the season. In May and June, light sufficient for plant growth was reaching the lake bottom. However, by July, and persisting through September, the 1% light levels were only reaching the 5 – 6 foot depths (see Aquatic Plant Assessment, below).

The poor Secchi disk readings were also correlated with high levels of Total Suspended Solids (TSS). See Figure 3. TSS are solids (both organic and inorganic) that are free-floating in the water column. TSS levels were approximately twice the county average in July, August, and September in both samples. The sources of TSS can be numerous, but most likely were washed into the lake via stormwater run-off. As mentioned earlier, several stormwater pipes that drain the surrounding neighborhoods enter Leisure Lake. In addition to high TSS levels, moderate planktonic algal blooms observed in August and September likely contributed to the poor water clarity. Carp, which are present in Leisure Lake, also contribute to poor water clarity by stirring up the bottom, which resuspends nutrients and sediment into the water column.

Total phosphorus (TP) levels were found to be high in both samples from June through September. Levels of TP > 0.03 mg/L are considered high. In Leisure Lake seasonal averages were 0.065 mg/L (epilimnion) and 0.073 mg/L (hypolimnion). Phosphorus is often the limiting factor for aquatic plant and algal growth. High phosphorus levels likely contributed to the algal blooms observed in August and September. The ratio between nitrogen and phosphorus for Leisure Lake was 25:1, indicating a phosphorus-limited system. 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. Phosphorus can come from many sources as well. Generally phosphorus comes from internal (lake sediment and nutrients loads) or external sources (i.e., stormwater run-off, lawn fertilizer, construction, waterfowl, etc.). Lakes that are

phosphorus-limited may be easier to manage, since controlling phosphorus is more feasible than controlling nitrogen or carbon. Control of phosphorus entering or already existing in Leisure Lake may help improve the water clarity.

Leisure Lake weakly stratified in August, when the thermocline was at the 5-foot depth. Typical conditions existed below the thermocline (i.e., the hypolimnion) at this time. DO conditions were anoxic and high concentrations of both ammonia nitrogen and total phosphorus existed. These conditions exist due to the barrier created by the temperature gradient between the surface and deeper waters. This barrier dissolved in September with cooler air and water temperatures. This mixing (termed fall turnover) re-oxygenates the lake.

DO concentrations on Leisure Lake were good throughout most of the season with the exception of August, when anoxic conditions (< 1 mg/L) existed below 6 feet. Morphometric calculations indicate only 17.5% of the total lake volume is below 6 feet deep. Leisure Lake has sufficient DO levels during the summer even with the aerator off. This is due, in part, to the shallow nature of the lake that allows wind and wave action to mix and reoxygenate the water.

The aeration system in Leisure Lake is undersized. The 1/3 HP compressor unit is insufficient to destratify or sufficiently oxygenate the lake. A 10.5 acre lake should have a 0.75-1 HP low pressure compressor unit generating 13-14 cubic feet/min or cfm (cost of a 1 HP compressor is approximately \$700). The current unit is generating only 3-4 cfm. This means that only a small portion of the lake is receiving any benefit from the aerator. Since DO concentrations in the water were good throughout most of the summer the aerator is not needed during this time. Not running the aerator during the summer will reduce electrical costs. Since DO levels drop in the winter months due to ice cover, the aerator should be turned on for a limited time. This will give fish a refugia in case of low DO levels. It is recommended that the aerator be turned on after approximately one month of ice cover (December or January) and remain on until after ice-off (usually March or April). This situation may change once adequate aquatic plant growth is established. Healthy aquatic plant populations may help keep DO levels high enough to where the aerator is not needed at all. In addition, allowing the lake to freeze over will also temporarily force Canada geese away from the lake.

Rain events probably contributed sediment or nutrients (like phosphorus) to a lake, which may have influenced the water sample results. Rain occurred within 48 hours prior to water sampling in each month except September (as recorded at the Stormwater Management Commission rain gauge in Wauconda), although all events were light (0.09 to 0.34 inches).

Based on data collected in 2000, standard classification indices compiled by the Illinois Environmental Protection Agency were used to determine the current condition of Leisure Lake. A general overall index that is commonly used is called a trophic state index or TSI. The TSI 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). This index is calculated using total phosphorus values obtained at or near the surface. The TSI for Leisure Lake classified it as a eutrophic lake. Eutrophic lakes are the most common types of lakes throughout the Midwest, and they are particularly common among man-made lakes. In Leisure Lake, the aquatic life impairment index was low, indicating a full degree of support for all aquatic organisms in the lake. However, due to high nutrient levels (particularly phosphorus) and poor water clarity (from high sediment and algae levels), the swimming and recreation use indices showed a partial impairment of these activities. The Health Department did not test for bacteria or other harmful pathogens in Leisure Lake in 2000.

LIMNOLOGICAL DATA – AQUATIC PLANT ASSESSMENT

Aquatic plant species presence and distribution in Leisure Lake were assessed monthly from May through September 2000 (see Appendix A for methods). Only trace amounts of three plant species and one macro-algae were found throughout the season (see Table 3, below). The average plant sample depth was 5.8 feet. The maximum depth at which a plant was found was 7.8 feet. Excessive weed growth in the lake was a problem several years ago. Aquatic plants were treated with herbicides on several occasions in the past, most recently in 1996, when the entire lake was treated with approximately 11 gallons of Aquathol – K[®]. Since this last treatment, plant growth has been almost non-existent. Aquatic plants are critically important if water clarity is to be improved and a healthy fishery sustained.

Lack of vegetation may be the result of several factors. Due to the poor water clarity, the 1% light levels decreased significantly over the season. This is supported by the similar drop in Secchi disk transparency readings and the presence of algal blooms during the same time periods. In addition, the substrate of the lake contributed to this scenario. The substrate from the shoreline out into the water about five linear feet consists of rocks on steep slopes. The water depth drops quickly from zero to six feet. Plants probably cannot root on this steep, rocky substrate. Once the lake bottom levels out, the substrate consists of silt and muck. While this substrate is suitable for plant growth, insufficient light levels at these depths during most of the season prohibited plant establishment. If water clarity is improved, revegetation of the lake is probable.

Table 3. Obligate hydrophitic plants recorded at Leisure Lake, May – September 2000.

Aquatic Plants

Curlyleaf Pondweed	<i>Potamogeton crispus</i>
Common Bladderwort	<i>Utricularia vulgaris</i>

Macro Algae

Chara/Nitella	<i>Chara/Nitella</i>
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LIMNOLOGICAL DATA – SHORELINE ASSESSMENT

A shoreline assessment was conducted in May 2000 to determine the condition of the lake shoreline (see Appendix A for methods). Of particular interest was the condition of the shoreline at the water/land interface. The shoreline of Leisure Lake consists almost entirely of small rock rip-rap. The exception is approximately 540 feet of the southwestern shoreline that is wooded.

As mentioned previously, a housing development is under construction along part of the western shoreline. Silt fences were present approximately 10 feet from the water's edge. Careful monitoring of this section of shoreline is recommended.

Severe erosion problems were found on the approximately 540 feet of southwestern shoreline. The erosion is moderate to severe in nature and should be addressed immediately. In addition, there were several areas along the shoreline where the small rock rip-rap had washed away and the underlying filter fabric was exposed. These areas should be repaired. If new rip-rap is installed, larger rocks are recommended. Residents of Leisure Village identified the shoreline along the northwestern section of the lake (approximately 700 feet), where the construction is taking place, as being a priority for rehabilitation. Leisure Village only owns approximately 3 feet of land along this shoreline. Additional loss of shoreline through erosion may eventually allow lake access to property owners other than Leisure Village. This section of shoreline may best be protected with a seawall.

Two exotic plant species, purple loosestrife (*Lythrum salicaria*) and buckthorn (*Rhamnus sp.*), were found around Leisure Lake. Loosestrife was found primarily along the western and southern shores. Buckthorn was found along the southwestern corner of the lake. Both species can cause significant problems as they quickly out-compete native vegetation and provide little value for wildlife. The loosestrife is currently not a problem, however, the buckthorn along the southwestern shoreline (same area as the erosion problem) should be controlled.

LIMNOLOGICAL DATA – WILDLIFE ASSESSMENT

Leisure Lake has had an active fish management program. Fish have been stocked on several occasions. Grass carp (*Ctenopharyngodon idella*) were stocked in the lake in 1986. Two fish electroshocking surveys have been conducted (1988 by Richmond Fisheries and 1998 by Northern Illinois Fisheries) on the lake. According to the 1998 report, bluegills, largemouth bass, channel catfish, black bullhead, common carp, and hybrid sunfish are present. Largemouth bass were the most abundant, followed by bluegill. The authors of the report stated concern over the limited number of bluegill, particularly smaller ones, in relation to largemouth bass. Lack of aquatic plant cover in the lake observed in 2000 may support this concern. Carp probably contribute to poor water quality conditions, since they frequently stir up the bottom. Another fish stocking is planned for spring 2001 (150 4-6" catfish, 150 2-3" hybrid sunfish, and 350 2-3" bluegill).

Numerous species of wildlife, primarily birds, were seen at Leisure Lake (see Table 4, below). Wildlife habitat in the area is poor to moderate. The turfgrass along the eastern and northeastern shores provides minimal habitat. The northern shoreline has a few trees, but the adjacent golf course is an attraction for Canada geese. Geese were observed throughout the sampling season around the lake. They were seen on the Leisure Village side (east shoreline) of the lake and near the golf course. Residents have identified geese as a problem.

Several bird nesting boxes are mounted around the lake. Tree sparrows, bluebirds, and house sparrows were seen in and around the boxes. However, apparently only house sparrows successfully nested in the boxes. Barn swallows were noted nesting under the gazebo.

Cost-share and technical assistance for the protection, restoration, and enhancement of aquatic resources with secondary benefits to wildlife habitats in the Fox River Watershed is available from the Lake County Soil and Water Conservation District (847-223-1056). Cost-share payments for all eligible practices are at a rate of 75%. Two deadline dates, March 15 and August 15, 2001 currently exist.

Table 4. Wildlife species observed on Leisure Lake, May – September 2000.

<u>Birds</u>	
Canada Goose	<i>Branta canadensis maxima</i>
Mallard	<i>Anas platyrhynchos</i>
Green Heron	<i>Butorides striatus</i>
Killdeer	<i>Charadius vociferus</i>
Spotted Sandpiper	<i>Actitis macularia</i>
Mourning Dove	<i>Zenaida macroura</i>
Ring-necked Pheasant	<i>Phasianus colchicus</i>

Red-bellied Woodpecker	<i>Melanerpes carolinus</i>
Eastern Kingbird	<i>Tyrannus tyrannus</i>
Eastern Pewee	<i>Contopus virens</i>
Barn Swallow	<i>Hirundo rustica</i>
Tree Swallow	<i>Iridoprocne bicolor</i>
American Crow	<i>Corvus brachyrhynchos</i>
Blue Jay	<i>Cyanocitta cristata</i>
Black-capped Chickadee	<i>Poecile atricapillus</i>
White-breasted Nuthatch	<i>Sitta carolinensis</i>
House Wren	<i>Troglodytes aedon</i>
Marsh Wren	<i>Cistothorus palustris</i>
American Robin	<i>Turdus migratorius</i>
Eastern Bluebird	<i>Sialia sialis</i>
Cedar Waxwing	<i>Bombycilla cedrorum</i>
Yellow Warbler	<i>Dendroica petechia</i>
Red-winged Blackbird	<i>Agelaius phoeniceus</i>
Common Grackle	<i>Quiscalus quiscula</i>
Starling	<i>Sturnus vulgaris</i>
House Sparrow	<i>Passer domesticus</i>
Northern Cardinal	<i>Cardinalis cardinalis</i>
House Finch	<i>Carpodacus mexicanus</i>
American Goldfinch	<i>Carduelis tristis</i>
Chipping Sparrow	<i>Spizella passerina</i>
Song Sparrow	<i>Melospiza melodia</i>

Mammals

Muskrat	<i>Ondatra zibethicus</i>
Gray Squirrel	<i>Sciurus carolinensis</i>

Amphibians

None noted

Reptiles

Northern Water Snake	<i>Nerodia sipedon</i>
Snapping Turtle	<i>Chelydra serpentina</i>

EXISTING LAKE QUALITY PROBLEMS

- *Poor water clarity*

Leisure Lake had poor water clarity in July, August and September 2000. The result of this poor clarity was likely from high sediment and nutrient loads in the lake. Exasperating the poor water clarity were algal blooms in August and September, which were caused by high nutrient (particularly phosphorus) levels. Improvement of water clarity is needed if aquatic vegetation is desired. Reducing total phosphorus with an alum treatment is recommended.

- *Lack of aquatic vegetation*

Minimal aquatic vegetation was found in Leisure Lake in 2000. Poor water clarity that limits sufficient light penetration, along with the steep, rocky slopes along the lake bottom near the shoreline likely inhibits plant growth. Presence of aquatic plants are important to improve water clarity and provide habitat for fish and other organisms. If water clarity is improved, light penetration will increase, which will aid in revegetation of the lake.

- *Shoreline erosion*

Moderate to severe erosion was identified along approximately 540 feet of the southwestern section of the lake shoreline. The erosion should be addressed in the immediate future. Areas with exposed filter fabric around the entire lake should also be repaired. The 700 feet along the northwest shoreline is a high priority for rehabilitation. Due to the narrow width of land along this shoreline owned by Leisure Village, rehabilitation techniques will be limited. A steel or vinyl seawall may be the only viable option.

- *Canada Geese*

Geese were present at each visit to Leisure Lake. Residents have identified geese as a problem. A plan to address this problem should be implemented. Allowing the lake to freeze over in winter and the use of buffer strips, chemical repellants, or dogs are recommended.

- *Exotic plant species on shoreline*

Purple loosestrife and common buckthorn are present along the shoreline. The loosestrife is currently not a problem, however, the buckthorn along the southwestern shoreline (same area as the erosion problem) should be controlled.

- *Limited wildlife habitat*

Wildlife habitat around Leisure Lake could be improved. Several artificial nest structures are currently in place. Additional natural structures could help attract more wildlife. Natural buffer strips could be established along much of the shoreline. Cost-share and technical assistance is available from the Lake County Soil and Water Conservation District.

- *Carp populations*

Carp in Leisure Lake likely contribute to the poor water clarity by resuspending the bottom sediment into the water column. Control of carp is recommended. Total eradication of carp will be difficult without completely poisoning the lake.

POTENTIAL OBJECTIVES FOR LEISURE LAKE MANAGEMENT PLAN

- I. Reduction of In-Lake Phosphorus
- II. Aquatic Plant Revegetation
- III. Shoreline Erosion Control
- IV. Exotic Plant Species Control
- V. Canada Goose Control
- VI. Enhance Wildlife Habitat Conditions
- VII. Eradication of Carp

ALTERNATIVE FOR ACHIEVING THE LEISURE LAKE MANAGEMENT PLAN OBJECTIVES

Objective I: Reduction of In-Lake Phosphorus

A possible remedy to excessive algal growth is to eliminate or greatly reduce the amount of phosphorus. This can be accomplished by using aluminum sulfate (alum). Alum does not directly kill algae as copper sulfate does. Instead, alum binds phosphorus making it unavailable, thus reducing algal growth. Alum binds water-borne phosphorus and forms a flocculent layer that settles on the bottom, which can then prevent sediment bound phosphorus from entering the water column. Phosphorus inactivation using alum has been in use for 25 years. However, cost and unreliable results deterred its wide spread use. Currently, alum is commonly being used in ponds, and its use in larger lakes is increasing. Alum treatment typically lasts 1 to 20 years depending on various parameters. Lakes with low mean depth to surface area are good candidates. This encompasses many lakes within Lake County. Lakes that are thermally stratified experience longer inactivation than non-stratified lakes due to isolation of the flocculent layer. Lakes with small watersheds are also better candidates because external phosphorus sources can be limited. Alum treatments must be carefully planned and carried out by an experienced professional. If not properly done, there may be many detrimental side effects.

Pros

Phosphorus inactivation is a possible long-term solution for controlling nuisance algae and increasing water clarity. Alum treatments can last as long as 20 years. This makes alum more cost effective in the long-term compared to continual treatment with algaecides. Studies have shown reductions in phosphorus concentrations by 66% in spring and 68% in summer. Chlorophyll *a*, a measure of algal biomass, was reduced by 61%. Reduction in algal biomass caused an increase in dissolved oxygen and a 79% increase in secchi disk readings. Effects of alum treatments can be seen in as little as a few days. The increase in clarity can have many positive effects on the lake's ecosystem. With increased clarity, plant populations could expand or reestablish. This in turn would improve fish habitat and provide improved food sources for other organisms. Recreational activities such as swimming and fishing would be improved due to increased water clarity and healthy plant populations. Typically, there is a slight invertebrate decline immediately following treatment but populations recover fully by the following year.

Cons

There are several drawbacks to alum. External nutrient inputs must also be reduced or eliminated for alum to provide long-term effectiveness. With larger watersheds this could prove to be physically and financially impossible. Phosphorus inactivation may be shortened by excessive plant growth or motorboat traffic, which can disturb the flocculent layer and allow phosphorus to be released. Also, lakes that are shallow, non-stratified, and wind blown typically do not achieve long term control due to disruption of the flocculent layer. If alum is not properly applied toxicity problems may occur. Typically aluminum toxicity occurs if pH is below 6 or above 9. Most of Lake County's lakes are in this safe range. Using the incorrect amounts of alum, pH of the lake could drastically change. Due to these dangers, it is highly recommended that a lake management professional plans and administers the alum treatment.

Costs

An alum treatment on Leisure Lake would cost approximately \$3,200 depending on several factors. These costs could be reduced with a partial draw-down of the lake. Tests need to be completed in order to determine the appropriateness and degree of alum needed.

Objective II: Aquatic Plant Revegetation

Revegetation should only be done when existing nuisance vegetation, such as Eurasian water milfoil, are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, these problems must be addressed before a revegetation plan is undertaken. Without adequate light penetration, revegetation will not work. At maximum, planting depth light levels must be greater than 1-5% of the surface light levels for plant growth and photosynthesis.

There are two methods by which reestablishment can be accomplished. The first is use of existing plant populations to revegetate other areas within the lake. Plants from one part of the lake are allowed to naturally expand into adjacent areas thereby filling the niche left by the nuisance plants. Another technique utilizing existing plants is to transplant vegetation from one area to another. The second method of reestablishment is to import native plants from an outside source. A variety of plants can be ordered from nurseries that specialize in native aquatic plants. These plants are available in several forms such as seeds, roots, and small plants. These two methods can be used in conjunction with one another in order to increase both quantity and biodiversity of plant populations. Additionally, plantings must be protected from herbivory by waterfowl and other wildlife. Simple cages made out of wooden or metal stakes and chicken wire are erected around planted areas for at least one season. The cages are removed once the plants are established and less vulnerable. If large-scale revegetation is needed it would be best to use a consultant to plan and conduct the restoration. Table 5 lists common, native plants that should be considered when developing a revegetation plan. Included in this list are aquatic shoreline vegetation (rushes, cattails, etc) and deeper water plants (pondweeds, *Vallisneria*, etc). Prices, planting depths, and planting densities are included and vary depending on plant species.

Pros

By revegetating newly opened areas that were once infested with nuisance species, the lake will benefit in several ways. Once established, expanded native plant populations will help to control growth of nuisance vegetation. This provides a more natural approach as compared to other management options. In addition, using established native plants to control excessive invasive plant growth is less expensive than other options. Expanded native plant populations will also help with sediment stabilization. This in turn will have a positive effect on water clarity by reducing suspended solids and nutrients that decrease clarity and cause excessive algal growth. Properly revegetating shallow water areas with plants such as cattails, bulrushes, and water lilies can help reduce wave action that can lead to shoreline erosion. Increases in desirable vegetation will increase the plant biodiversity and also provide better quality habitat and food sources for fish and other wildlife. Recreational uses of the lake such as fishing and boating will also increase due to the improvement in water quality and the suppression of weedy species.

Cons

There are few negative impacts to revegetating a lake. One possible drawback is the possibility of new vegetation expanding to nuisance levels and needing control. However, this is an unlikely outcome. Another drawback could be high costs if extensive revegetation is needed using imported plants. If a consultant is used costs would be substantially higher. Additional costs could be associated with constructing proper herbivory protection measures.

Costs

See Table 5 for pricing.

Objective III: Shoreline Erosion Control

Erosion is a potentially serious problem to lake shorelines and occurs as a result of wind, wave, or ice action or from overland rainwater runoff. While some erosion to shorelines is natural, human alteration of the environment can accelerate and exacerbate the problem. Erosion not only results in loss of shoreline, but negatively influences the lake's overall water quality by contributing nutrients, sediment, and pollutants into the water. This effect is felt throughout the food chain since poor water quality negatively affects everything from microbial life to sight feeding fish and birds to people who want to use the lake for recreational purposes. The resulting increased amount of sediment will over time begin to fill in the lake, decreasing overall lake depth and volume and potentially impairing various recreational uses.

Residents of Leisure Village identified the shoreline along the northwestern section of the lake (approximately 700 feet) as being a priority for rehabilitation. Due to the narrow width of land along this shoreline owned by Leisure Village, rehabilitation techniques will be limited. A steel or vinyl seawall may be the only viable option.

Cost-share and technical assistance for the protection, restoration, and enhancement of aquatic resources with secondary benefits to wildlife habitats in the Fox River Watershed is available from the Lake County Soil and Water Conservation District (847-223-1056). Cost-share payments for all eligible practices are at a rate of 75%. Two deadline dates, March 15 and August 15, 2001 currently exist. Rehabilitating the northwestern shoreline may not qualify under this program, but other areas of the lake (particularly the far shoreline adjacent to the golf course and the area of severe erosion along the southwestern shoreline) may qualify.

Option 1: No Action

Pros

There are no short-term costs to this option. However, extended periods of erosion may result in substantially higher costs to repair the shoreline in the future.

Eroding banks on steep slopes can provide habitat for wildlife, particularly bird species (e.g. kingfishers and bank swallows) that need to burrow into exposed banks to nest. In addition, certain minerals and salts in the soils are exposed during the erosion process, which are utilized by various wildlife species.

Cons

Taking no action will most likely cause erosion to continue and subsequently may cause poor water quality due to high levels of sediment or nutrients entering a lake. This in turn may retard plant growth and provide additional nutrients for algal growth. A continual loss of shoreline is both aesthetically displeasing and

may potentially reduce property values. Since a shoreline is easier to protect than it is to rehabilitate, it is in the interest of the property owner to address the erosion issue immediately.

Costs

In the short-term, cost of this option is zero. However, long-term implications can be severe since prolonged erosion problems may be more costly to repair than if the problems were addressed earlier. As mentioned previously, long-term erosion may cause serious damage to shoreline property and in some cases lower property values.

Option 2: Install a Steel or Vinyl Seawall

Seawalls are designed to prevent shoreline erosion on lakes in a similar manner they are used along coastlines to prevent beach erosion or harbor siltation. Today, seawalls are generally constructed of steel, although in the past seawalls were made of concrete or wood (frequently old railroad ties). Concrete seawalls cracked or were undercut by wave action requiring routine maintenance. Wooden seawalls made of old railroad ties are not used anymore since the chemicals that made the ties rot-resistant could be harmful to aquatic organisms. A new type of construction material being used is vinyl or PVC. Vinyl seawalls are constructed of a lighter, more flexible material as compared to steel. Also, vinyl seawalls will not rust over time as steel will.

Pros

If installed properly and in the appropriate areas (i.e. shorelines with severe erosion) seawalls provide effective erosion control. Seawalls are made to last numerous years and have relatively low maintenance. On Leisure Lake, a seawall may be the only option for the northwest shoreline, considering the minimal shoreline remaining that is owned by Leisure Village.

Cons

Seawalls are disadvantageous for several reasons. One of the main disadvantages is that they are expensive, since a professional contractor and heavy equipment are needed for installation. Any repair costs tend to be expensive as well. If any fill material is placed in the floodplain along the shoreline, compensatory storage may also be needed. Compensatory storage is the process of excavating in a portion of a property or floodplain to compensate for the filling in of another portion of the floodplain. Permits and surveys are needed whether replacing and old seawall or installing a new one (see costs below).

Wave deflection is another disadvantage to seawalls. Wave energy not absorbed by the shoreline is deflected back into the lake, potentially causing sediment disturbance and resuspension, which in turn may cause poor water clarity and

problems with nuisance algae, which use the resuspended nutrients for growth. If seawalls are installed in areas near channels, velocity of run-off water or channel flow may be accelerated. This may lead to flooding during times of high rainfall and run-off, shoreline erosion in other areas of the lake, or a resuspension of sediment due to the agitation of the increased wave action or channel flow, all of which may contribute to poor water quality conditions throughout the lake. Plant growth may be limited due to poor water clarity, since the photosynthetic zone where light can penetrate, and thus utilized by plants, is reduced. Healthy plants are important to the lake's overall water clarity since they can help filter some of the incoming sediment, prevent resuspension of bottom sediment, and compete with algae for nutrients. However, excessive sediment in the water and high turbidity may overwhelm these benefits.

Finally, seawalls provide no habitat for fish or wildlife. Because there is no structure for fish, wildlife, or their prey, few animals use shorelines with seawalls. In addition, poor water clarity that may be caused by resuspension of sediment from deflected wave action contributes to poor fish and wildlife habitat, since sight feeding fish and birds (i.e. bass, herons, and kingfishers) are less successful at catching prey. This may contribute to a lake's poor fishery (i.e. stunted fish populations).

Costs

Depending on factors such as slope and shoreline access, cost of seawall installation ranges from \$65-80 per linear foot for steel and \$70-100 per linear foot for vinyl. A licensed contractor installs both types of seawall. Additional costs may occur if the shoreline needs to be graded and backfilled, has a steep slope, or poor accessibility. Price does not include the necessary permits required. Additional costs will be incurred if compensatory storage is needed. Prior to the initiation of work, permits and/or surveys from the appropriate government agencies need to be obtained. For seawalls, a site development permit and a building permit are needed. Costs for permits and surveys can be \$1,000-2,000 for installation of a seawall. Contact the Army Corps of Engineers, local municipality, or the Lake County Planning and Development Department.

The cost of installing a steel seawall on the 540 feet of shoreline that is severely eroding on Leisure Lake would be \$35,100 – 43,200 and \$45,000- 56,000 for the 700 feet of the northwest shoreline. This does not include the necessary permits and surveys that are needed prior to installation.

Option 3: Install Rock Rip-Rap or Gabions

Rip-rap is the term for using rocks to stabilize shorelines. Size of the rock depends on the severity of the erosion, distance to rock source, and aesthetic preferences. Generally, four to eight inch diameter rocks are used. Gabions are wire cages or baskets filled with rock. They provide similar protection as rip-rap, but are less prone to displacement. They can

be stacked, like blocks, to provide erosion control for extremely steep slopes. Both rip-rap and gabions can be incorporated with other erosion control techniques such as plant buffer strips. If any plants will be growing on top of the rip-rap or gabions, fill will probably be needed to cover the rocks and provide an acceptable medium for plants to grow on. Prior to the initiation of work, permits and/or surveys from the appropriate government agencies need to be obtained (see costs below).

Pros

Rip-rap and gabions can provide good shoreline erosion control. Rocks can absorb some of the wave energy while providing a more aesthetically pleasing appearance than seawalls. If installed properly, rip-rap and gabions will last for many years. Maintenance is relatively low, however, undercutting of the bank can cause sloughing of the rip-rap and subsequent shoreline. Areas with severe erosion problems may benefit from using rip-rap or gabions. In all cases, a filter fabric should be installed under the rocks to maximize its effectiveness.

Fish and wildlife habitat can be provided if large boulders are used. Crevices and spaces between the rocks can be used by a variety of animals and their prey. Small mammals, like shrews can inhabit these spaces and prey upon many invertebrate species, including many harmful garden and lawn pests. Also, small fish may utilize the structure created by large boulders for foraging and hiding from predators.

Cons

A major disadvantage of rip-rap is the initial expense of installation and associated permits. Installation is expensive since a licensed contractor and heavy equipment are generally needed to conduct the work. Permits are required if replacing existing or installing new rip-rap or gabions and must be acquired prior to work beginning. If any fill material is placed in the floodplain along the shoreline, compensatory storage may also be needed. Compensatory storage is the process of excavating in a portion of a property or floodplain to compensate for the filling in of another portion of the floodplain.

While rip-rap and gabions absorb wave energy more effectively than seawalls, there is still some wave deflection that may cause resuspension of sediment and nutrients into the water column.

Small rock rip-rap is poor habitat for many fish and wildlife species, since it provides limited structure for fish and cover for wildlife. As noted earlier, some small fish and other animals will inhabit the rocks if boulders are used. Smaller rip-rap is more likely to wash away due to rising water levels or wave action. On the other hand, larger boulders are more expensive to haul in and install.

Rip-rap may be a concern in areas of high public usage since it is difficult and possibly dangerous to walk on due to the jagged and uneven rock edges. This may be a liability concern to property owners.

Costs

Cost and type of rip-rap used depend on several factors, but average cost for installation (rocks and filter fabric) is approximately \$30-45 per linear foot. Costs for gabions are approximately \$20-30 per linear foot, and approximately \$60-100 per linear foot when filled with rocks. The steeper the slope and severity of erosion, the larger the boulders that will need to be used and thus, higher installation costs. In addition, costs will increase with poor shoreline accessibility and increased distance to rock source. Costs for permits and surveys can be \$1,000-2,000 for installation of rip-rap or gabions, depending on the circumstances. Additional costs will be incurred if compensatory storage is needed. Contact the Army Corps of Engineers, local municipalities, and the Lake County Planning and Development Department.

The cost of installing rip-rap on the 540 feet of shoreline that is eroding on Leisure Lake would be \$16,200 – 24,300. This does not include the necessary permits and surveys that are needed prior to installation. The cost to rip-rap the entire shoreline of Leisure Lake would be \$140,000-200,000. If rip-rap is used to repair the shoreline, a rock size larger than the size currently found around the lake is recommended. Due to the narrow width of the northwestern shoreline owned by Leisure Village, this option is probably not viable.

Option 4: Create a Buffer Strip

Another effective method of controlling shoreline erosion is to create a buffer strip with existing or native vegetation. Native plants have deeper root systems than turfgrass and thus hold soil more effectively. Native plants also provide positive aesthetics and good wildlife habitat. Cost of creating a buffer strip is quite variable, depending on the current state of the vegetation and shoreline and whether vegetation is allowed to become established naturally or if the area needs to be graded and replanted. Allowing vegetation to naturally propagate the shoreline would be the most cost effective, depending on the severity of erosion and the composition of the current vegetation. Non-native plants or noxious weedy species may be present and should be controlled or eliminated.

Stabilizing the shoreline with vegetation is most effective on slopes no less than 2:1 to 3:1, horizontal to vertical, or flatter. Usually a buffer strip of at least 25 feet is recommended, however, wider strips (50 or even 100 feet) are recommended on steeper slopes or areas with severe erosion problems. Areas where erosion is severe or where slopes are greater than 3:1, additional erosion control techniques may have to be incorporated such as biologs, A-Jacks®, or rip-rap.

Buffer strips can be constructed in a variety of ways with various plant species. Generally, buffer strip vegetation consists of native terrestrial (land) species and emergent (at the land and water interface) species. Terrestrial vegetation such as native grasses and wildflowers can be used to create a buffer strip along lake shorelines. Table 5 gives some examples, seeding rates and costs of grasses and seed mixes that can be used to create buffer strips. Native plants and seeds can be purchased at regional nurseries or from catalogs. When purchasing seed mixes, care should be taken that native plant seeds are used. Some commercial seed mixes contain non-native or weedy species or may contain annual wildflowers that will have to be reseeded every year. If purchasing plants from a nursery or if a licensed contractor is installing plants, inquire about any guarantees they may have on plant survival. Finally, new plants should be protected from herbivory (e.g., muskrats) by placing a wire cage over the plants for at least one year.

A technique that is sometimes implemented along shorelines is the use of willow posts, or live stakes, which are harvested cuttings from live willows (*Salix* spp.). They can be planted along the shoreline along with a cover crop or native seed mix. The willows will sprout and begin establishing a deep root structure that secures the soil. If the shoreline is highly erodible, willow posts may have to be used in conjunction with another erosion control technique such as biologs, A-Jacks ®, or rip-rap.

Emergent vegetation, or those plants that grow in shallow water and wet areas, can be used to control erosion more naturally than seawalls or rip-rap. Native emergent vegetation can be either hand planted or allowed to become established on its own over time. Some plants, such as native cattails (*Typha* sp.), quickly spread and help stabilize shorelines, however they can be aggressive and may pose a problem later. Other species, such as those listed in Table 5 should be considered for native plantings.

Pros

Buffer strips can be one of the least expensive means to stabilize shorelines. If no permits or heavy equipment are needed (i.e. no significant earthmoving or filling is planned), the property owner can complete the work without the need of professional contractors. Once established (typically within 3 years), a buffer strip of native vegetation will require little maintenance and may actually reduce the overall maintenance of the property, since the buffer strip will not have to be continuously mowed, watered, or fertilized. Occasional high mowing (1-2 times per year) for specific plants or physically removing other weedy species may be needed.

The buffer strip will stabilize the soil with its deep root structure and help filter run-off from lawns and agricultural fields by trapping nutrients, pollutants, and sediment that would otherwise drain into the lake. This may have a positive impact on the lake's water quality since there will be less "food" for nuisance algae and "weedy" aquatic plants. Buffer strips can filter as much as 70-95% of sediment and 25-60% of nutrients and other pollutants from runoff.

Another benefit of a buffer strip is potential flood control protection. Buffer strips may slow the velocity of flood waters, thus preventing shoreline erosion. Native plants also can withstand fluctuating water levels more effectively than commercial turfgrass. Many plants can survive after being under water for several days, even weeks, while turfgrass is intolerant of wet conditions and usually dies after several days under water. This contributes to increased maintenance costs, since the turfgrass has to be either replanted or replaced with sod. Emergent vegetation can provide additional help in preserving shorelines and improving water quality by absorbing wave energy that might otherwise batter the shoreline. Calmer wave action will result in less shoreline erosion and resuspension of bottom sediment, which may result in potential improvements in water quality.

Many fish and wildlife species prefer the native shoreline vegetation habitat. This habitat is an asset to the lake's fishery since the emergent vegetation cover may be used for spawning, foraging, and hiding. Various wildlife species are even dependent upon shoreline vegetation for their existence. Certain birds, such as marsh wrens (*Cistothorus palustris*) and endangered yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) nest exclusively in emergent vegetation like cattails and bulrushes. Hosts of other wildlife like waterfowl, rails, herons, mink, and frogs to mention just a few, benefit from healthy stands of shoreline vegetation. Dragonflies, damselflies, and other beneficial invertebrates can be found thriving in vegetation along the shoreline as well. Two invertebrates of particular importance for lake management, the water-milfoil weevils (*Euhrychiopsis lecontei* and *Phytobius leucogaster*), which have been shown to naturally reduce stands of exotic Eurasian water-milfoil (*Myriophyllum spicatum*). Weevils need proper over wintering habitat such as leaf litter and mud which are typically found on naturalized shorelines or shores with good buffer strips. Many species of amphibians, birds, fish, mammals, reptiles, and invertebrates have suffered precipitous declines in recent years primarily due to habitat loss. Buffer strips may help many of these species and preserve the important diversity of life in and around lakes.

In addition to the benefits of increased fish and wildlife use, a buffer strip planted with a variety of native plants may provide a season long show of various colors from flowers, leaves, seeds, and stems. This is not only aesthetically pleasing to people, but also benefits wildlife and the overall health of the lake's ecosystem.

Cons

There are few disadvantages to native shoreline vegetation. Certain species (i.e. cattails) can be aggressive and may need to be controlled occasionally. If stands of shoreline vegetation become dense enough, access and visibility to the lake may be compromised to some degree. However, small paths could be cleared to provide lake access or smaller plants could be planted in these areas.

Costs

If minimal amount of site preparation is needed, costs can be approximately \$10 per linear foot, plus labor. Cost of installing willow posts is approximately \$15-20 per linear foot. The labor that is needed can be completed by the property owner in most cases, although consultants can be used to provide technical advice where needed. This cost will be higher if the area needs to be graded. If grading is necessary, appropriate permits and surveys are needed. If filling is required, additional costs will be incurred if compensatory storage is needed. The permitting process is costly, running as high as \$1,000-2,000 depending on the types of permits needed.

The cost of installing a buffer strip on the 540 feet of shoreline that is eroding on Leisure Lake would be at least \$5,400. To install a buffer strip along the entire shoreline of Leisure Lake would cost approximately \$46,000. Due to the steep nature of the lake bottom, significant grading would be necessary to properly prepare the shoreline for planting. This grading would increase the overall cost. If the slope was reduced in pitch by filling in part of the lake near the shoreline, compensatory storage would need to be remedied. Compensatory storage would also increase the overall cost. These costs do not include the necessary permits and surveys that are needed prior to installation. Due to the narrow width of the northwestern shoreline owned by Leisure Village, this option is probably not viable.

Option 5: Install A-Jacks®

A-Jacks® are made of two pieces of pre-cast concrete when fitted together resemble a child's playing jacks. These structures are installed along the shoreline and covered with soil and/or an erosion control product. Native vegetation is then planted on the backfilled area. They can be used in areas where severe erosion does not justify a buffer strip alone.

Pros

The advantage to A-Jacks® is that they are quite strong and require low maintenance once installed. In addition, once native vegetation becomes established the A-Jacks® can not be seen. They provide many of the advantages that both rip-rap and buffer strips have. Specifically, they absorb some of the wave energy and protect the existing shoreline from additional erosion. The added benefit of a buffer strip gives the A-Jacks® a more natural appearance, which may provide wildlife habitat and help filter run-off nutrients, sediment, and pollutants. Less run-off entering a lake may have a positive effect on water quality.

Cons

The disadvantage is that installation cost can be high since labor is intensive and requires some heavy equipment. A-Jacks® need to be pre-made and hauled in from the manufacturing site. These assemblies are not as common as rip-rap, thus only a limited number of contractors may be willing to do the installation.

Costs

The cost of installation is approximately \$40-75 per linear foot, but does not include permits and surveys, which can cost \$1,000-2,000 and must be obtained prior to any work implementation. Additional costs will be incurred if compensatory storage is needed.

The cost of installing A-Jacks® on the 540 feet of shoreline that is eroding on Leisure Lake would be \$21,600 – 40,500. This does not include the necessary permits and surveys that are needed prior to installation.

Option 6: Install Biolog, Fiber Roll, or Straw Blanket with Plantings

These products are long cylinders of compacted synthetic or natural fibers wrapped in mesh. The rolls are staked into shallow water. Once established, a buffer strip of native plants can be planted along side or on top of the roll (depending if rolls are made of synthetic or natural fibers). They are most effective in areas where plantings alone are not effective due to already severe erosion. In areas of severe erosion, other techniques may need to be employed or incorporated with these products.

Pros

Biologs, fiber rolls, and straw blankets provide erosion control that secure the shoreline in the short-term and allow native plants to establish which will eventually provide long-term shoreline stabilization. They are most often made of bio-degradable materials, which break down by the time the natural vegetation becomes established (generally within 3 years). They provide additional strength to the shoreline, absorb wave energy, and effectively filter run-off from terrestrial sources. These factors help improve water quality in the lake by reducing the amount of nutrients available for algae growth and by reducing the sediment that flows into a lake.

Cons

These products may not be as effective on highly erodible shorelines or in areas with steep slopes, as wave action may be severe enough to displace or undercut these products. On steep shorelines grading may be necessary to obtain a 2:1 or

3:1 slope or additional erosion control products may be needed. If grading or filling is needed, the appropriate permits and surveys will have to be obtained.

Costs

Costs range from \$25 to \$35 per linear foot of shoreline, including plantings. This does not include the necessary permits and surveys, which may cost \$1,000 – 2,000 depending on the type of earthmoving that is being done. Additional costs may be incurred if compensatory storage is needed.

The cost of installing these products on the 540 feet of shoreline that is eroding on Leisure Lake would be \$13,500 – 18,900. This does not include the necessary permits and surveys that are needed prior to installation. Due to the narrow width of the northwestern shoreline owned by Leisure Village, this option is probably not viable.

Objective IV: Exotic Plant Species Control

Numerous exotic plant species have been introduced into our local ecosystems. Some of these plants are aggressive, quickly out-competing native vegetation and flourishing in an environment where few natural predators exist. Plants such as purple loosestrife (*Lythrum salicaria*), buckthorn (*Rhamnus thartica*), and reed canary grass (*Phalaris arundinacea*) are three examples. The outcome is a loss of plant and animal diversity. This section will address terrestrial shoreline exotic species.

Purple loosestrife is responsible for the “sea of purple” seen along roadsides and in wetlands during summer. It can quickly dominate a wetland or shoreline. Due in part to an extensive root system, large seed production (estimates range from 100,000 to 2.7 million per plant), and high seed germination rate, purple loosestrife spreads quickly. Buckthorn is an aggressive shrub species that grows along lake shorelines as well as most upland habitats. It shades out other plants and is quick to become established on disturbed soils. Reed canary grass is an aggressive plant that if left unchecked will dominate an area, particularly a wetland or shoreline, in a short period of time. Since it begins growing early in the spring, it quickly out-competes native vegetation that begins growth later in the year. Control of purple loosestrife, buckthorn, and reed canary grass are discussed below. However, these control measures can be similarly applied to other exotic species such as garlic mustard (*Allilaria officianalis*) or honeysuckle (*Lonicera* spp.) as well as some aggressive native species, such as box elder (*Acer negundo*).

Presence of exotic species along a lakeshore is by no means a death sentence for the lake or other plant and animal life. If controlled, many exotic species can perform many of the original functions that they were brought here for. For example, reed canary grass was imported for its erosion control properties. It still contributes to this objective (offering better erosion control than commercial turfgrass), but needs to be isolated and kept in control. Many exotics are the result of garden or ornamental plants escaping into the wild. One isolated plant along a shoreline will probably not create a problem by itself. However, problems arise when plants are left to spread, many times to the point where treatment is difficult or cost prohibitive. A monitoring program should be established, problem areas identified, and control measures taken when appropriate. This is particularly important in remote areas of lake shorelines where the spread of exotic species may go unnoticed for some time.

Option 1: No Action

No control will likely result in the expansion of the exotic species and the decline of native species. This option is not recommended if possible.

Pros

There are few advantages with this option. Some of the reasons exotics were brought into this country are no longer used or have limited use. However, in some cases having an exotic species growing along a shoreline may actually be

preferable if the alternative plant is commercial turfgrass. Since turfgrass has shallow roots and is prone to erosion along shorelines, exotics like reed canary grass or common reed (*Phragmites australis*) will control erosion more effectively. Native plants should take precedent over exotics when possible. Table 5 lists several native plants that can be planted along shorelines.

Cons

Native plant and wildlife diversity will be lost as stands of exotic species expand. Exotic species are not under the same stresses (particularly diseases and predators) as native plants and thus can out-compete the natives for nutrients, space, and light. Few wildlife species use areas where exotic plants dominate. This happens because many wildlife species either have not adapted with the plants and do not view them as a food resource, the plants are not digestible to the animal, or their primary food supply (i.e., insects) are not attracted to the plants. The result is a monoculture of exotic plants with limited biodiversity.

Recreational activities, especially wildlife viewing, may be hampered by such monocultures. Access to lake shorelines may be impaired due to dense stands of non-native plants. Other recreational activities, such as swimming and boating, may not be effected.

Costs

Costs with this option are zero initially, however, when control is eventually needed, costs will be substantially more than if action was taken immediately. Additionally, the eventual loss of ecological diversity is difficult to calculate financially.

Option 2: Control by Hand

Controlling exotic plants by hand removal is most effective on small areas (< 1 acre) and if done prior to heavy infestation. Some exotics, such as purple loosestrife and reed canary grass, can be controlled to some degree by digging, cutting, or mowing if done early and often during the year. Digging may be required to ensure the entire root mass is excavated. Spring or summer is the best time to cut or mow, since late summer and fall is when many of the plant seeds disperse. Proper disposal of excavated plants is important since seeds may persist and germinate even after several years. Once exotic plants are removed, the disturbed ground should be planted with native vegetation and closely monitored. Many exotic species, such as purple loosestrife, buckthorn, and garlic mustard are proficient at colonizing disturbed sites.

On Leisure Lake, this is probably the most viable option since the exotic species present are at manageable densities.

Pros

Removal of exotics by hand eliminates the need for chemical treatments. Costs are low if stands of plants are not too large already. Once removed, control is simple with yearly maintenance. Control or elimination of exotics preserves the ecosystem's biodiversity. This will have positive impacts on plant and wildlife presence as well as some recreational activities.

Cons

This option may be labor intensive or prohibitive if the exotic plant is already well established. Costs may be high if large numbers of people are needed to remove plants. Soil disturbance may introduce additional problems such as providing a seedbed for other non-native plants that quickly establish disturbed sites, or cause soil-laden run-off to flow into nearby lakes or streams. In addition, a well-established stand of an exotic like purple loosestrife or reed canary grass may require several years of intense removal to control or eliminate.

Costs

Cost for this option is primarily in tools, labor, and proper plant disposal.

Option 3: Herbicide Treatment

Chemical treatments can be effective at controlling exotic plant species. However, chemical treatment works best on individual plants or small areas already infested with the plant. In some areas where individual spot treatments are prohibitive or unpractical (i.e., large expanses of a wetland or woodland), chemical treatments may not be an option due to the fact that in order to chemically treat the area a broadcast application would be needed. Since many of the herbicides that are used are not selective, meaning they kill all plants they contact; this may be unacceptable if native plants are found in the proposed treatment area.

Herbicides are commonly used to control nuisance shoreline vegetation such as buckthorn and purple loosestrife. Herbicides are applied to green foliage or cut stems. Products are applied by either spraying or wicking (wiping) solution on plant surfaces. Spraying is used when large patches of undesirable vegetation are targeted. Herbicides are sprayed on growing foliage using a hand-held or backpack sprayer. Wicking is used when selected plants are to be removed from a group of plants. The herbicide solution is wiped on foliage, bark, or cut stems using a herbicide soaked device. Trees are normally treated by cutting a ring in the bark (called girdling). Herbicides are applied onto the ring at high concentrations. Other devices inject the herbicide through the bark. It is best to apply herbicides when plants are actively growing, such as in the late spring/early summer, but before formation of seed heads. Herbicides are often used in conjunction with other methods, such as cutting or mowing, to achieve the best results. Proper use of these products is critical to their success. Always read and follow label directions.

On Leisure Lake, the only area that may need a herbicide treatment is the southwestern section where the buckthorn is growing. Herbicide (preferably triclopyr) could be applied to the stumps once the shrubs are cut. Triclopyr (sold as Garlon®) cannot be used near water.

Pros

Herbicides provide a fast and effective way to control or eliminate nuisance vegetation. Unlike other control methods, herbicides kill the root of the plant, which prevents regrowth. If applied properly, herbicides can be selective. This allows for removal of selected plants within a mix of desirable and undesirable plants.

Cons

Since most herbicides are non-selective, they are not suitable for broadcast application. Thus, chemical treatment of large stands of exotic species may not be practical. Native species are likely to be killed inadvertently and replaced by other non-native species. Off target injury/death may result from the improper use of herbicides. If herbicides are applied in windy conditions, chemicals may drift onto desirable vegetation. Care must also be taken when wicking herbicides as not to drip on to non-targeted vegetation such as native grasses and wildflowers. Another drawback to herbicide use relates to their ecological soundness and the public perception of them. Costs may also be prohibitive if plant stands are large. Depending on the device, cost of the application equipment can be high.

Costs

Glyphosate should be applied at a rate of one gallon per acre and costs approximately \$100 / gallon. A Hydrohatchet®, a hatchet that injects herbicide through the bark, is about \$300.00. Another injecting device, E-Z Ject® is \$450.00. Hand-held and backpack sprayers costs from \$25-\$45 and \$80-150, respectively. Wicking devices are \$30-40.

Objective V: Canada Goose Control

Canada geese are migratory waterfowl common throughout North America. Geese in urban areas can be undesirable primarily due to the large amount of feces they leave behind. Recreational activities on lawns and parks are impeded due to goose feces. Large amounts of feces may end up in the water, either directly from geese on the water or rainwater runoff from lawns where feces have accumulated. Goose feces is high in organic phosphorus. High nutrient levels, particularly phosphorus, can contribute to excessive algae growth. This will inhibit other recreational activities such as boating or swimming, as well as creating poor habitat for fish and wildlife, and possibly bad odors when the algae decays.

Geese become problematic for many reasons. They seek locations that have open water, adequate food supplies, and safety from predators. If these factors are present, geese may not migrate. Since geese exhibit a high level of site fidelity, they return to (or stay at) the same area each year. Thus, adults will likely come back to the same area year after year to nest. If conditions remain optimal, one pair of geese can quickly multiply causing additional problems. Increased development in Lake County has inadvertently created ideal habitat for goose populations. Manicured lawns mowed to the edge of lakes and detention ponds provide geese with open areas with ample food and security. Other conditions that encourage goose residency include open water during winter (primarily the result of aerators in lakes and ponds), mild winters, and people feeding birds with bread or similar human food.

Large populations of geese pose a potential disease threat both to resident and wild populations of waterfowl. This problem may be more serious in residential populations since these birds stay in one area for long periods of time are more likely to transmit any disease to neighboring groups of geese. There is no threat of disease transmission to humans or domestic dogs and cats since most of the diseases are specific to birds.

Option 1: No Action

Pros

This option has no costs, however, increasing numbers of geese will most likely exacerbate existing problems and probably create new ones, which in the future may cost more than if the problems are addressed immediately.

Cons

If current conditions continue and no action is taken, numbers of Canada Geese and problems associated with them will likely increase. An increase of goose feces washed into a lake will increase the lake's nutrient load and eventually may have a detrimental impact on water quality through excessive algae growth. One study (Manny et al. 1975) documented that each goose excretes 0.072 lbs of feces per day. This may not seem like a significant amount, but if 100 geese are present

(many lakes in the county can experience 1,000 or more at a time) that equates to over 7 lbs of feces per day! Algae blooms may negatively impact recreational uses such as swimming, boating, and fishing. In addition, when algae dies, odor problems and depleted oxygen levels in the water occur. Increased numbers of geese may also result in overgrazed areas of grass.

Costs

There are a few short-term financial costs with this option. Costs of cleaning feces off lawns or piers are probably more psychological or physical than financial. Long-term costs may be more indirect, including increased nutrient deposition into lakes which may promote excessive algae and plants. Costs incurred may include money needed to control algae with algaecides.

Reference:

Manny, B. A., R. G. Wetzel, and W. C. Johnson. 1975. Annual contribution of carbon, nitrogen, and phosphorus by migrant Canada geese to a hardwater lake. *Verh. Internat. Verein. Limnol.* 19:949-951.

Option 2: Removal

Since Canada Geese are considered migratory waterfowl, both state and federal laws restrict taking or harassing geese. Under the federal Migratory Bird Treaty Act, it is illegal to kill or capture geese outside a legal hunting season or to harass their nests without a permit. If removal of problematic geese is warranted or if nest and egg destruction is an option, permits need to be obtained from the Illinois Department of Natural Resources (217-782-6384) and the U.S. Fish and Wildlife Service (217-241-6700).

Hunting is one of the most effective techniques used in goose management. However, since many municipalities have ordinances prohibiting the discharge of firearms, reduction of goose numbers by hunting in urban areas (i.e., lakes, ponds, and parks) may not be an option. Hunting does occur on many lakes in the county, but certain regulations apply (e.g., 100 yard minimum distance from any residential property). Contact the Illinois Department of Natural Resources for dates and regulations regarding the waterfowl hunting seasons. Also, contact local and county law enforcement agencies regarding any ordinances concerning hunting within municipal boundaries.

Egg addling, or destroying the egg by shaking, piercing, or freezing, can be used to reduce or eliminate a successful clutch. Eggs should be returned to the nest so the hen goose does not re-lay another clutch. However, if no eggs hatch, she may still lay another clutch. Leaving one or two eggs unaltered and allowing them to hatch may prevent another clutch from being laid and reduces the total year's reproduction. Egg addling requires a state and federal permit.

The capture and relocation of geese is no longer a desirable option. First, relocated geese can return to the same location where they were captured. Second, there is a concern over potential disease transmission from relocated geese to other goose populations. Finally, since goose numbers in Illinois are already high there is no need to supplement other populations in the area.

Pros

Removing a significant portion of a problem goose population can have a positive effect on the overall health of a lake. Reduction of feces on lawns and parks is beneficial to recreation users of all types. Less feces in the water means less phosphorus available for nuisance plant and algae growth. Thus, the overall water quality of the lake may be improved by this reduction in phosphorus.

Cons

If the habitat conditions still exist, more geese will likely replace any that were removed. Thus, money and time used removing geese may not be well spent unless there is a change in habitat conditions.

Costs

An Illinois residential waterfowl hunting license (including state and federal waterfowl stamps) is \$33.00 for the 2000-2001 hunting season. For depredation permits, there is a \$25 fee for the federal permit. Once the federal permit is issued the state permit can be obtained at no charge.

Option 3: Dispersal/Repellent Techniques

Several techniques and products are on the market that claim to disperse or deter geese from using an area. These techniques can be divided into two categories: harassment and chemical. With both types of techniques it is important to implement any action early in the season, before geese establish territories and begin nesting. Once established, the dispersal/repellant techniques may be less effective and geese more difficult to coerce into leaving.

The goal with harassment techniques is to frighten geese from an area using sounds or objects. Various products are available that simulate natural predators (i.e., plastic hawks and owls) or otherwise make geese nervous (i.e., balloons, shiny tape, and flags). Other products emit noises, such as propane cannons, which can be set on a timer to go off at programmed intervals (e.g., every 20-30 seconds), or recorded goose distress calls which can be played back over a loudspeaker or tape player. Over time these techniques may be ineffective, since geese become acclimated to these devices. Most of these products are more effective when used in combination with other techniques.

Another technique that has become popular is using dogs or swans to harass geese. Dogs can be used primarily in the spring and fall to keep birds from using an area by herding or chasing geese away from a particular area. Any dogs used for this purpose should be well trained and under the owners control at all times. Professional trainers can be contracted to use their dogs for this purpose. Dogs should not be used during the summer when geese are unable to fly due to molting. Swans are used because they are naturally aggressive in defending their territory, including chasing other waterfowl away from their nesting area. Since wild swans cannot be used for this technique, non-native mute swans are used. However, mute swans are not as aggressive and in some case are permissive of geese. Again, using a combination of techniques would be most effective.

Chemical repellents can be used with some effectiveness. New products are continually coming out that claim to rid an area of nuisance geese. Several products (ReJeX-iT® and GooseChase™) are made from methyl-anthranilate, a natural occurring compound, and can be sprayed on areas where geese are feeding. The spray makes the grass distasteful and forces geese to move elsewhere to feed. Another product, Flight Control™, works similarly, but has the additional benefit of absorbing ultra violet light making the grass appear as if it was not a food source. The sprays need to be reapplied every 14-30 days, depending upon weather conditions or mowing frequency.

Pros

With persistence, harassment and/or use of repellants can result in reduced or minimal usage of an area by geese. Fewer geese may mean less feces and cleaner yards and parks, which may increase recreational uses along shorelines. If large numbers of geese were once present, the reduction of fecal deposits into the lake may help minimize the amount of phosphorus entering the water. Less phosphorus in the water means less “food” available for plant and algae growth, which may have a positive effect of water quality. Finally, any areas overgrazed by geese may have a chance to recover.

Cons

The effectiveness of harassment techniques is reduced over time since geese will adapt to the devices. However, their effectiveness can be extended if the devices are moved to different locations periodically, or used in conjunction with other techniques.

Use of dogs can be time consuming, since the dog must be trained and taken care of. Dogs must also be used frequently in the beginning of the season to be effective at deterring geese. This requires time of the dog owner as well. Dogs (frequently herding dogs, like border collies) that are effective at harassing or herding geese are typically not for the average homeowner. They are bred as working dogs and consequently have high levels of energy that requires the owner’s attention.

Repelling or chasing away geese from an area only solves the goose problem for that area and most likely moves the geese (and the problem) to another area. As long as there is suitable habitat nearby, the geese will not wander very far.

Costs

Costs for the propane cannons are approximately \$660 (\$360 for the cannon, \$300 for a timer), not including the propane tank. The cost of ReJeX-iT® is \$70/gallon, GooseChase™ is \$92/gallon, and Flight Control™ costs \$200/gallon. One gallon covers one acre of turf using ReJeX-iT® and, GooseChase™, and two acres using Flight Control™.

Option 4: Exclusion

Erecting a barrier to exclude geese is another option. In addition to a traditional wood or wire fence, an effective exclusion control is to suspend netting over the area where geese are unwanted. Geese are reluctant to fly or walk into the area. A similar deterrent that is often used is a single string or wire suspended a foot or so above the ground along the length of the shoreline.

Pros

Depending on the type of barrier used, areas of exclusion will have less fecal mess and may have higher recreational uses. Vegetation that was overgrazed by geese may also be able to recover.

Cons

This technique will not be very effective if the geese are using a large area. Also, use of the area by people is severely limited if netting is installed. Fences can also limit recreational uses. The single string or wire method may be effective at first, but geese often learn to go around, over, or under the string after a short period of time. Finally, excluding geese from one area will force them to another area on a different part of the same lake or another nearby lake. While this solves one property owners problem, it creates one (or makes one worse) for another. Also, problems associated with excess feces entering the lake (i.e., increased phosphorus levels) will continue.

Costs

The costs of these techniques are minimal, unless a wood or wire fence is constructed. String, wire, or netting can be purchased or made from materials at local stores.

Option 5: Habitat Alteration

One of the best methods to deter geese from using an area is through habitat alteration. Habitats that consist of mowed turfgrass to the edge of the shoreline are ideal for geese. Low vegetation near the water allows geese to feed and provides a wide view with which to see potential predators. In general, geese do not favor habitats with tall vegetation. To achieve this, create a buffer strip (approximately 10-20 feet wide) between the shoreline and any mowed lawn. Planting natural shoreline vegetation (i.e., bulrushes, cattails, rushes, grasses, shrubs, and trees, etc.) or allowing the vegetation to establish naturally can create buffer strips. Table 5 has a list of native plants, seeding rates, and approximate costs that can be used when creating buffer strips.

Geese prefer ponds and lakes that have shorelines with gentle slopes to ones with steep slopes. While this alone will not prevent geese from using an area, steeper slopes used along with other techniques will be more effective. This option may not be practical for existing lake shorelines since any grading and/or filling would require permits and surveys, which would drive up the costs of redoing the shoreline considerably.

Aeration systems that run into the fall and winter prevent the lake from freezing, thus not forcing geese to migrate elsewhere. To alleviate this problem, turn aerators off during fall and early winter. Once the lake freezes over and the geese have left, wait a few weeks before turning the aerators on again if needed.

Pros

Altering the habitat in an area can not only make the habitat less desirable for geese, but may be more desirable for many other species of wildlife (see **Objective VI: Enhance Wildlife Habitat Conditions**). A buffer strip has additional benefits by filtering run-off of nutrients, sediments, and pollutants and protecting the shoreline from erosion from wind, wave, or ice action (see **Objective III: Shoreline Erosion Control**). Finally, the more of the area that is in natural vegetation, the less turfgrass that needs to be constantly manicured and maintained.

Cons

Converting a portion or all of an area to tall grass or shrub habitat may reduce the lake access or visibility. However, if this occurs, a small path can be made to the lake or shorter plants may be used at the access location in the buffer strip.

Costs

If minimal amount of site preparation is needed to create a buffer strip, costs can be approximately \$10 per linear foot, plus labor. The labor that is needed can be

completed by the property owner in most cases, although consultants can be used to provide technical advice where needed. This cost will be higher if the area needs to be graded. If grading is necessary, appropriate permits and surveys are needed. If filling is required, additional costs will be incurred if compensatory storage is needed. Compensatory storage is the process of excavating in a portion of a property or floodplain to compensate for the filling in of another portion of the floodplain. The permitting process is costly, running as high as \$1,000-2,000 depending on the types of permits needed.

Once established, a buffer strip of native plants needs little maintenance. If aerators are not run for several months, there will be a reduction in electrical costs.

Option 6: Do Not Feed Waterfowl!

There are few “good things”, if any, that come from feeding waterfowl. Birds become dependent on handouts, become semi-domesticated, and do not migrate. This causes populations to increase and concentrate, which may create additional problems such as diseases within waterfowl populations. The nutritional value in many of the “foods” (i.e., white bread) given to geese and other waterfowl are quite low. Since geese are physiologically adapted to eat a variety of foods, they can actually be harmed by filling-up on human food. Geese that are accustomed to hand feeding may become aggressive toward other geese or even the people feeding the geese.

Costs

There are no costs to this option, except the public education that is needed to encourage people not to feed waterfowl. In some cases, signs could be posted to discourage waterfowl feeding.

Objective VI: Enhance Wildlife Habitat Conditions

The key to increasing wildlife species in and around a lake can be summed up in one word: habitat. Wildlife need the same four things all living creatures need: food, water, shelter, and a place to raise their young. Since each wildlife species has specific habitat requirements, which fulfill these four basic needs, providing a variety of habitats will increase the chance that wildlife species may use an area. Groups of wildlife are often associated with the types of habitats they use. For example, grassland habitats may attract wildlife such as northern harriers, bobolinks, meadowlarks, meadow voles, and leopard frogs. Marsh habitats may attract yellow-headed blackbirds and sora rails, while manicured residential lawns attract house sparrows and gray squirrels. Thus, in order to attract a variety of wildlife, a variety of habitats are needed. In most cases quality is more important than quantity (i.e., five 0.1-acre plots of different habitats may not attract as many wildlife species than one 0.5 acre of one habitat type).

It is important to understand that the natural world is constantly changing. Habitats change or naturally succeed to other types of habitats. For example, grasses may be succeeded by shrub or shade intolerant tree species (e.g., willows, locust, and cottonwood). The point at which one habitat changes to another is rarely clear, since these changes usually occur over long periods of time, except in the case of dramatic events such as fire or flood.

In all cases, the best wildlife habitats are ones consisting of native plants. Unfortunately, non-native plants dominate many of the lake shorelines, including Lake Charles. Many of them escaped from gardens and landscaped yards (i.e., purple loosestrife) while others were introduced at some point to solve a problem (i.e., reed canary grass for erosion control). Wildlife species prefer native plants for food, shelter, and raising their young. In fact, one study showed that plant and animal diversity was 500% higher along naturalized shorelines compared to shorelines with conventional lawns (University of Wisconsin – Extension, 1999). More information about non-native (exotic) plants can be found in the section **Objective IV: Exotic Plant Species Control**.

Cost-share and technical assistance for the protection, restoration, and enhancement of aquatic resources with secondary benefits to wildlife habitats in the Fox River Watershed is available from the Lake County Soil and Water Conservation District (847-223-1056). Cost-share payments for all eligible practices are at a rate of 75%. Two deadline dates, March 15 and August 15, 2001 currently exist.

Option 1: No Action

This option means that the current land use activities will continue. No additional techniques will be implemented. Allowing a field to go fallow or not mowing a manicured lawn would be considered an action.

Pros

Taking no action may maintain the current habitat conditions and wildlife species present, depending on environmental conditions and pending land use actions. If all things remain constant there will be little to no effect on lake water quality and other lake uses.

Cons

If environmental conditions change or substantial land use actions occur (i.e., development) wildlife use of the area may change. For example, if a new housing development with manicured lawns and roads is built next to an undeveloped property, there will probably be a change in wildlife present.

Conditions in the lake (i.e., siltation or nutrient loading) may also change the composition of aquatic plant and invertebrate communities and thus influence biodiversity. Siltation and nutrient loading will likely decrease water clarity, increase turbidity, increase algal growth (due to nutrient availability), and decrease habitat for fish and wildlife.

Costs

The financial cost of this option is zero. However, due to continual loss of habitats many wildlife species have suffered drastic declines in recent years. The loss of habitat effects the overall health and biodiversity of the lake's ecosystems.

Option 2: Increase Habitat Cover

This option can be incorporated with Option 3 (see below). One of the best ways to increase habitat cover is to leave a minimum 25-foot buffer between the edge of the water and any mowed grass. Allow native plants to grow or plant native vegetation along shorelines, including emergent vegetation such as cattails, rushes, and bulrushes (see Table 5 for costs and seeding rates). This will provide cover from predators and provide nesting structure for many wildlife species and their prey. It is important to control or eliminate non-native plants such as buckthorn, purple loosestrife, garlic mustard, and reed canary grass, since these species out-compete native plants and provide little value for wildlife.

Occasionally high mowing (with the mower set at its highest setting) may have to be done for specific plants, particularly if the area is newly established, since competition from weedy and exotic species is highest in the first couple years. If mowing, do not mow the buffer strip until after July 15 of each year. This will allow nesting birds to complete their breeding cycle.

Brush piles make excellent wildlife habitat. They provide cover as well as food resources for many species. Brush piles are easy to create and will last for several years. They

should be placed at least 10 feet away from the shoreline to prevent any debris from washing into the lake.

Trees that have fallen on the ground or into the water are beneficial by harboring food and providing cover for many wildlife species. In a lake, fallen trees provide excellent cover for fish, basking sites for turtles, and perches for herons and egrets.

Increasing habitat cover should not be limited to the terrestrial environment. Native aquatic vegetation, particularly along the shoreline, can provide cover for fish and other wildlife.

Pros

Increased cover will lead to increased use by wildlife. Since cover is one of the most important elements required by most species, providing cover will increase the chances of wildlife using the shoreline. Once cover is established, wildlife usually has little problem finding food, since many of the same plants that provide cover also supply the food the wildlife eat, either directly (seeds, fruit, roots, or leaves) or indirectly (prey attracted to the plants).

Additional benefits of leaving a buffer include: stabilizing shorelines, reducing runoff which may lead to better water quality, and deterring nuisance Canada geese. Shorelines with erosion problems can benefit from a buffer zone because native plants have deeper root structures and hold the soil more effectively than conventional turfgrass. Buffers also absorb much of the wave energy that batters the shoreline. Water quality may be improved by the filtering of nutrients, sediment, and pollutants in run-off. This has a “domino effect” since less run-off flowing into a lake means less nutrient availability for nuisance algae, and less sediment means less turbidity, which leads to better water quality. All this is beneficial for fish and wildlife, such as sight-feeders like bass and herons, as well as people who use the lake for recreation. Finally, a buffer strip along the shoreline can serve as a deterrent to Canada geese from using a shoreline. Canada geese like flat, open areas with a wide field of vision. Ideal habitats for them are areas that have short grass up to the edge of the lake. If a buffer is allowed to grow tall, geese may choose to move elsewhere.

Cons

There are few disadvantages to this option. However, if vegetation is allowed to grow, lake access and visibility may be limited. If this occurs, a small path can be made to the shoreline. Composition and density of aquatic and shoreline vegetation are important. If vegetation consists of non-native species such as Eurasian water milfoil or purple loosestrife, or in excess amounts, undesirable conditions may result. A shoreline with excess exotic plant growth may result in a poor fishery (exhibited by stunted fish) and poor recreation opportunities (i.e., boating, swimming, or wildlife viewing).

Costs

The cost of this option would be minimal. The purchase of native plants can vary depending upon species and quantity. Based upon 100 feet of shoreline, a 25-foot buffer planted with a native forb and grass seed mix would cost between \$165-270 (2500 sq. ft. would require 2.5, 1000 sq. ft. seed mix packages at \$66-108 per package). This does not include labor that would be needed to prepare the site for planting and follow-up maintenance. This cost can be reduced or minimized if native plants are allowed to grow. However, additional time and labor may be needed to insure other exotic species, such as buckthorn, reed canary grass, and purple loosestrife, do not become established.

Option 3: Increase Natural Food Supply

This can be accomplished in conjunction with Option 2. Habitats with a diversity of native plants will provide an ample food supply for wildlife. Food comes in a variety of forms, from seeds to leaves or roots to invertebrates that live on or are attracted to the plants. Plants found in Table 5 should be planted or allowed to grow. In addition, encourage native aquatic vegetation, such as water lily, sago pondweed, largeleaf pondweed, and wild celery to grow. Aquatic plants such as these are particularly important to waterfowl in the spring and fall, as they replenish energy reserves lost during migration.

Providing a natural food source in and around a lake starts with good water quality. Water quality is important to all life forms in a lake. If there is good water quality, the fishery benefits and subsequently so does the wildlife (and people) who prey on the fish. Insect populations in the area, including beneficial predatory insects, such as dragonflies, thrive in lakes with good water quality.

Dead or dying plant material can be a source of food for wildlife. A dead standing or fallen tree will harbor good populations of insects for woodpeckers, while a pile of brush may provide insects for several species of songbirds such as warblers and flycatchers.

Supplying natural foods artificially (i.e., birdfeeders, nectar feeders, corn cobs, etc.) will attract wildlife and in most cases does not harm the animals. However, “people food” such as bread should be avoided. Care should be given to maintain clean feeders and birdbaths to minimize disease outbreaks.

Pros

Providing food for wildlife will increase the likelihood they will use the area. Providing wildlife with natural food sources has many benefits. Wildlife attracted to a lake can serve the lake and its residents well, since many wildlife species (i.e., many birds, bats, and other insects) are predators of nuisance insects such as mosquitoes, biting flies, and garden and yard pests (such as certain moths and

beetles). Effective natural insect control eliminates the need for chemical treatments or use of electrical “bug zappers” that have limited effect on nuisance insects.

Migrating wildlife can be attracted with a natural food supply, primarily from seeds, but also from insects, aquatic plants or small fish. In fact, most migrating birds are dependent on food sources along their migration routes to replenish lost energy reserves. This may present an opportunity to view various species that would otherwise not be seen during the summer or winter.

Cons

Feeding wildlife can have adverse consequences if populations become dependent on hand-outs or populations of wildlife exceed healthy numbers. This frequently happens when people feed waterfowl like Canada geese or mallard ducks. Feeding these waterfowl can lead to a domestication of these animals. As a result, these birds do not migrate and can contribute to numerous problems, such as excess feces, which is both a nuisance to property owners and a significant contribution to the lake’s nutrient load. Waterfowl feces are particularly high in phosphorus. Since phosphorus is generally the limiting factor for nuisance algae growth in many lakes in the Midwest, the addition of large amounts of this nutrient from waterfowl may exacerbate a lake’s excessive algae problem. In addition, high populations of birds in an area can increase the risk of disease for not only the resident birds, but also wild bird populations that visit the area.

Finally, tall plants along the shoreline may limit lake access or visibility for property owners. If this occurs, a path leading to the lake could be created or shorter plants may be used in the viewing area.

Costs

The costs of this option are minimal. The purchase of native plants and food and the time and labor required to plant and maintain would be the limit of the expense.

Option 4: Increase Nest Availability

Wildlife are attracted by habitats that serve as a place to raise their young. Habitats can vary from open grasslands to closed woodlands (similar to Options 2 and 3).

Standing dead or dying trees provide excellent habitat for a variety of wildlife species. Birds such as swallows, woodpeckers, and some waterfowl need dead trees to nest in. Generally, a cavity created and used by a woodpecker (e.g., red-headed or downy woodpecker, or common flicker) in one year, will in subsequent years be used by species like tree swallows or chickadees. Over time, older cavities may be large enough for waterfowl, like wood ducks, or mammals (e.g., flying squirrels) to use. Standing dead

trees are also favored habitat for nesting wading birds, such as great blue herons, night herons, and double-crested cormorants, which build stick nests on limbs. For these birds, dead trees in groups or clumps are preferred as most herons and cormorants are colonial nesters.

In addition to allowing dead and dying trees to remain, erecting bird boxes will increase nesting sites for many bird species. Box sizes should vary to accommodate various species. Swallows, bluebirds, and other cavity nesting birds can be attracted to the area using small artificial nest boxes. Larger boxes will attract species such as wood ducks, flickers, and owls. A colony of purple martins can be attracted with a purple martin house, which has multiple cavity holes, placed in an open area near water.

Bat houses are also recommended for any area close to water. Bats are voracious predators of insects and are naturally attracted to bodies of water. They can be enticed into roosting in the area by the placement of bat boxes. Boxes should be constructed of rough non-treated lumber and placed >10 feet high in a sunny location.

Pros

Providing places where wildlife can rear their young has many benefits. Watching wildlife raise their young can be an excellent educational tool for both young and old.

The presence of certain wildlife species can help in controlling nuisance insects like mosquitoes, biting flies, and garden and yard pests. This eliminates the need for chemical treatments or electric “bug zappers” for pest control.

Various wildlife species populations have dramatically declined in recent years. Since, the overall health of ecosystems depend, in part, on the role of many of these species, providing sites for wildlife to raise their young will benefit not only the animals themselves, but the entire lake ecosystem.

Cons

Providing sites for wildlife to raise their young have few disadvantages. Safety precautions should be taken with leaving dead and dying trees due to the potential of falling limbs. Safety is also important when around wildlife with young, since many animals are protective of their young. Most actions by adult animals are simply threats and are rarely carried out as attacks.

Parental wildlife may chase off other animals of its own species or even other species. This may limit the number of animals in the area for the duration of the breeding season.

Costs

The costs of leaving dead and dying trees are minimal. The costs of installing the bird and bat boxes vary. Bird boxes can range in price from \$10-100.00. Purple martin houses can cost \$50-150. Bat boxes range in price from \$15-50.00. These prices do not include mounting poles or installation.

Cost-share and technical assistance for the protection, restoration, and enhancement of aquatic resources with secondary benefits to wildlife habitats in the Fox River Watershed is available from the Lake County Soil and Water Conservation District (847-223-1056). Cost-share payments for all eligible practices are at a rate of 75%. Two deadline dates, March 15 and August 15, 2001 currently exist.

Objective VII: Carp Eradication

A frequent problem that plagues many of the lakes in the County is the presence of common carp (*Cyprinus carpio*). Common carp were first introduced into the United States from Europe in the early 1870's, and were first introduced into Illinois river systems in 1885 to improve commercial fishing. The carp eventually made their way into many inland lakes and are now so wide spread that many people do not realize that they are not native to the U.S.

Carp prefer warm waters in lakes, streams, ponds, and sloughs that contain high levels of organic matter. This is indicative of many lakes in Lake County. Carp feed on insect larvae, crustaceans, mollusks, and even small fish by rooting through the sediments. Immature carp feed mainly on small crustaceans. Because their feeding habits cause a variety of water quality problems. Carp are very undesirable in lakes. Rooting around for food causes resuspension of sediments and nutrients, which can both lead to increased turbidity. Additionally, spawning, which occurs near shore in shallow water, can occur from late April until June. The spawning activities of carp can be violent further contributing to turbidity problems. Adult carp can lay between 100,000 –500,000 eggs, and hatch in 5-8 days. Initial growth is rapid with young growing 4 ¾" to 5" in the first year. Adults normally range in size from 1-10 lbs., with some as large as 60 lbs. Average carp lifespan is 7-10 years, but they may live up to 15 years.

There are several techniques to remove carp. However, rarely does any technique eradicate carp from a lake. Commonly, once a lake has carp, it has carp forever. However, it is up to the management entity to dictate how big the problem is allowed to become. Rotenone is the only reliable piscicide (fish poison) on the market at this time, but it kills all fish that is comes into contact with. Currently, there is a rotenone laced baiting system that can selectively remove carp. While the process is a step in the right direction, several factors still need to be worked out in order for it to be a viable alternative to the whole lake treatment. Until this baiting technique is further developed and produces consistent results, it is not recommended.

Option 1: No Action

By following a no action management approach, nothing would be done to control the carp population of the lake. Populations will continue to expand and reach epidemic proportions if they do not already exist.

Pros

There are very few positive aspects to following a no action management plan for excessive carp populations. The only real advantage would be the money saved by taking no action.

Cons

There are many negative aspects to a no action management plan for carp management. The feeding habits of carp cause most of the associated problems. As carp feed they root around in the lake sediment. This causes resuspension of sediment and nutrients. Increased nutrient levels can lead to increased algal blooms, which, combined with resuspended sediments, lead to increased turbidity. As a result there is a decrease in light penetration, negatively impacting aquatic plants. Additionally, the rooting action of the carp causes the direct disruption of aquatic plants. Loss of aquatic plants can further aggravate sediment and nutrient loads in the water column due to loss of sediment stabilization provided by the plants. Additionally, the fishery of the lake may decline and/or become stunted due to predation issues related to decreased water clarity and loss of habitat. Other wildlife, such as waterfowl, which commonly forage on aquatic plants and fish, would also be negatively impacted by the decrease in vegetation.

The loss of aquatic plants and an increase in algae will drastically impair recreational use of the lake. Swimming could be adversely affected due to the increased likelihood of algal blooms. Swimmers may become entangled in large mats of filamentous algae, and blooms of planktonic species, such as blue-green algae, can produce harmful toxins and noxious odors. Fishing would also be negatively affected due to the decreased health of the lake's fishery. The overall appearance of the lake would also suffer from an increase in unsightly algal blooms, having an unwanted effect on property values.

Costs

There is no cost associated with the no action option.

Option 2: Rotenone

Rotenone is a piscicide that is naturally derived from the stems and roots of several tropical plants. Rotenone is approved for use as a piscicide by the USEPA and has been used in the U.S. since the 1930's. It is biodegradable (breaks down into CO₂ and H₂O) and there is no bioaccumulation. Because rotenone kills fish by chemically inhibiting the use of oxygen in biochemical pathways, adult fish are much more susceptible than fish eggs (carp eggs are 50 times more resistant). Other aquatic organisms are less sensitive to rotenone. However, some organisms are effected enough to reduce populations for several months. In the aquatic environment, fish come into contact with the rotenone by a different method than other organisms. With fish, the rotenone comes into direct contact with the exposed respiratory surfaces (gills), which is the route of entry. In other organisms this type of contact is minimal. More sensitive nonfish species include frogs and mollusks but these organisms typically recover to pretreatment levels within a few months. Rotenone has low mammalian and avian toxicity. For example, if a human consumed fish treated with normal concentrations of rotenone, approximately 8,816 lbs.

of fish would need to be eaten at one sitting in order to produce toxic effects in humans. Furthermore, due to its unstable nature, it is unlikely that the rotenone would still be active at the time of consumption, and warm-blooded mammals have natural enzymes that would break down the toxin before it had any effects.

Rotenone is available in 5% and 2.5% concentrations. Both concentrations are available as synergized formulations. The synergist (piperonal butoxide) is an additive that inhibits fish detoxification of rotenone, making the rotenone more effective. Rotenone has varying levels of toxicity on different fish species. Some species of fish can detoxify rotenone quicker than it can build up in their systems. Unfortunately, concentrations to remove undesirable fish, such as carp, bullhead and green sunfish, are high enough to kill more desirable species such as bass, bluegill, crappie, walleye, and northern pike. Therefore, it is difficult to selectively remove undesirable fish while leaving desirable ones. Typically, rotenone is used at concentrations from 2 ppm (parts per million) – 12 ppm. For removal of undesirable fish (carp, bullhead and green sunfish) in lakes with alkalinities in the range found in Lake County, the target concentration should be 6 ppm. Sometimes concentration will need to be increased based on high alkalinity and/or high turbidity. Rotenone is most effectively used when waters are cooling down (fall) not warming up (spring) and is most effective when water temperatures are <50°F. Under these conditions, rotenone is not as toxic as in warmer waters but it breaks down slower and provides a longer exposure time. If treatments are done in warmer weather they should be done before spawn or after hatch as fish eggs are highly tolerant to rotenone.

Rotenone rarely kills every fish (normally 99-100% effective). Some fish can escape removal and rotenone retreatment needs to occur about every 10 years. At this point in time, carp populations will have become reestablished due to reintroduction and reproduction by fish that were not removed during previous treatment. To ensure the best results, precautions can be taken to assure a higher longevity. These precautions include banning live bait fishing (minnows bought from bait stores can contain carp minnows) and making sure every part of the lake is treated (i.e., cattails, inlets, and harbored shallow areas). Restocking of desirable fish species may occur about 30-50 days after treatment when the rotenone concentrations have dropped to sub-lethal levels. Since it is best to treat in the fall, restocking may not be possible until the following spring. To use rotenone in a body of water over 6 acres a *Permit to Remove Undesirable Fish* must be obtained from the Illinois Department of Natural Resources (IDNR), Natural Heritage Division, Endangered and Threatened Species Program. Furthermore, only an IDNR fisheries biologist licensed to apply aquatic pesticides can apply rotenone in the state of Illinois as it is a restricted use pesticide.

Pros

Rotenone is one of the only ways to effectively remove undesirable fish species. This allows for rehabilitation of the lake's fishery, which will allow for improvement of the aquatic plant community, and overall water quality. By removing carp, sediment will be left largely undisturbed. This will allow aquatic plants to grow and help further stabilize the sediment. As a result of decreased

carp activity and increased aquatic plant coverage, fewer nutrients will be resuspended, greatly reducing the likelihood of nuisance algae blooms. Additionally, reestablishment of aquatic plants will have other positive effects on lake health and water quality, increases in fish habitat and food source availability for wildlife such as waterfowl.

Cons

There are no negative impacts associated with removing excessive numbers of carp from a lake. However, in the process of removing carp with rotenone, other desirable fish species will also be removed. The fishery can be replenished with restocking and quality sport fishing normally returns within 2-3 years. Other aquatic organisms, such as mollusks, frogs, and invertebrates (insects, zooplankton, etc.), are also negatively impacted. However, this disruption is temporary and studies show that recovery occurs within a few months. Furthermore, the IDNR will not approve application of rotenone to waters known to contain threatened and endangered fish species. Another drawback to rotenone is the cost. Since the whole lake is treated and costs per gallon range from \$50.00 - \$75.00, total costs can quickly add up. This can be off-set with lake draw down to reduce treatment volume. Unfortunately, draw down is not an option on all lakes.

Costs

As with most intensive lake management techniques, a good bathymetric map is needed so that an accurate lake volume can be determined. To achieve a concentration of 6 ppm, which is the rate needed for most total rehabilitation projects (remove carp, bullhead and green sunfish), 2.022 gal/AF is required.

Table 1. Morphometric Features of Leisure Lake ~ Data From the October 2000 Bathymetric Survey, LCHD Lakes Management Unit

Contour (Feet)	Area Enclosed (Acres)	Percent of total acres	Volume (Acre-feet)	Depth Zone (Feet)	Area (Acres)	Percent (Depth zone to total acres)	Percent (Acre-feet to Total Volume)
0	10.45	100%	10.25	0 - 1	0.39	3.7%	15.1%
1	10.06	96.3%	9.90	1 - 2	0.31	3.0%	14.6%
2	9.75	93.3%	9.57	2 - 3	0.35	3.4%	14.1%
3	9.40	90.0%	9.20	3 - 4	0.40	3.8%	13.5%
4	9.00	86.2%	8.75	4 - 5	0.51	4.9%	12.9%
5	8.49	81.3%	7.94	5 - 6	1.09	10.5%	11.7%
6	7.40	70.8%	6.80	6 - 7	1.18	11.3%	10.0%
7	6.22	59.5%	4.39	7 - 8	3.43	32.8%	6.5%
8	2.79	26.7%	1.07	8 - 9	2.74	26.3%	1.6%
9	0.05	0.4%	0.09	9+	0.05	0.4%	0.1%
			67.96		10.45	100%	100%

Area of Lake: 10.45 Acres
 Maximum Depth of Lake: 9+ Feet
 Average Depth of Lake: 7.2 Feet
 Volume of Lake: 67.96 Acre-Feet
 Shoreline Length: 0.89 miles
 Fetch: 0.36 miles

Water Elevation at normal pool
 10/2/00
 Lake County Health Department
 Environmental Health Services
 Lakes Management Unit

Water quality table.

Epilimnion															
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₃ -N	TP	SRP	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
5/17/00	3	192	0.99	<0.1	<0.05	0.026	<0.005	378	3.5	379	137	8.04	0.5396	8.16	7.2
6/21/00	3	179	0.98	<0.1	0.216	0.068	0.007	354	5.9	395	151	5.91	0.4776	8.39	9.8
7/19/00	3	160	0.98	<0.1	0.051	0.074	<0.005	292	17	307	92	2.63	0.4231	8.24	5.6
8/23/00	3	155	1.9	<0.1	<0.05	0.071	0.009	316	16	332	145	1.21	0.4019	8.69	8.9
9/20/00	3	173	2.42	<0.1	<0.05	0.085	<0.005	266	15	298	113	1.48	0.4224	8.55	7.1

Average 172 1.45 <0.1^k 0.134^k 0.065 0.008^k 321 11.5 342 128 3.85 0.4529 8.41 7.7

Hypolimnion															
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₃ -N	TP	SRP	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
5/17/00	6.5	194	<0.5	<0.1	0.121	0.026	0.006	374	4	380	124	NA	0.5403	8.16	7.2
6/21/00	6	182	0.93	<0.1	0.231	0.07	0.007	358	6.2	368	116	NA	0.4786	8.35	9.5
7/19/00	6	160	0.93	<0.1	0.052	0.088	<0.005	296	15	303	111	NA	0.4257	8.14	4.9
8/23/00	6	161	1.7	0.151	<0.05	0.095	0.008	294	20	324	134	NA	0.4247	7.68	0.4
9/20/00	6	172	2.33	<0.1	<0.05	0.085	0.005	260	15	302	113	NA	0.4234	8.53	7

Average 174 1.47k 0.151^k 0.135^k 0.073 0.007^k 316 12 335 120 NA 0.4585 8.17 5.8

Glossary
ALK = Alkalinity, mg/L CaCO ₃
TKN = Total Kjeldahl nitrogen, mg/L
NH ₃ -N = Ammonia nitrogen, mg/L
NO ₃ -N = Nitrate nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
TDS = Total dissolved solids, mg/L
TSS = Total suspended solids, mg/L
TS = Total solids, mg/L
TVS = Total volatile solids, mg/L
SECCHI = Secchi Disk Depth, Ft.

COND = Conductivity, milliSiemens/cm
DO = Dissolved oxygen, mg/L

Note: "k" denotes that the actual value is known to be less than the value presented.
NA = Not Applicable

Table 5. Native plants for revegetation of shorelines.

Terrestrial-Dry soil	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Big Bluestem Grass (<i>Andropogon gerardii</i>)	10-25b lbs/acre	\$20/lb	NA	\$4-5
Bluejoint Grass (<i>Calamagrostis canadensis</i>)	2 lbs/acre	\$2-4/oz	NA	\$4-5
Little Bluestem Grass (<i>Andropogon scoparius</i>)	10-25 lbs/acre	\$20/lb	NA	\$4-5
Prairie Cord Grass (<i>Spartina pectinata</i>)	0.25-1.0 lbs/acre	\$2-3/oz	250-500/acre	\$2-4
Switch Grass (<i>Panicum virgatum</i>)	0.5-2.0 lbs./acre	\$6-7/oz	NA	\$1-5
Terrestrial-Wet Soil	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Blue Flag (<i>Iris versicolor</i>)	NA	\$10/oz	1000/acre	\$0.60-1.50
Blue Vervain (<i>Verbena hastata</i>)	NA	\$6/oz	500-1000/acre	\$0.80-1.00
Blunt Spike Rush (<i>Eleocharis obtusa</i>)	NA	\$30/oz	500-1000/acre	\$0.50-1.00
Boneset (<i>Eupatorium perfoliatum</i>)	0.006-0.25 lbs./acre	\$6-7/oz	500-700/acre	\$1.00
Water Horsetail (<i>Equisetum fluviatile</i>)	NA	NA	1000/acre	\$0.50
Joe-Pye-Weed (<i>Eupatorium maculatum</i>)	NA	\$8/oz	500-700/acre	\$0.50-1.00
Sweet Flag (<i>Acorus calamus</i>)	NA	\$10/oz	250/acre	\$0.50-1.00
Wild Rice (<i>Zizania aquatica</i>)	NA	\$5.00/lb	1000/acre	\$0.50-0.20
1'-1.5' Deep	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Arrow Arum (<i>Peltandra virginica</i>)	NA	\$4-5/oz	1000/acre	\$0.40-1.00
Bottle Brush Sedge (<i>Carex comosa</i>)	0.12-0.19 lbs./acre	\$6-8/oz	NA	NA
Chairmakers Rush (<i>Scirpus americanus</i>)	0.06-0.25 lbs/acre	\$8-15/oz	1000/acre	\$0.25-0.85
Common Arrowhead (<i>Sagittaria latifolia</i>)	0.06-0.125 lbs/acre	\$15-16/oz	1000/acre	\$0.60-1.25
Common Burreed (<i>Sparganium euycapum</i>)	0.06-0.25 lbs/acre	\$10-15/oz	1000/acre	\$0.22-0.50
Common Cattail (<i>Typha latifolia</i>)	0.06-0.5 lbs/acre	\$3-15/oz	1000/acre	\$0.40-1.00
Hardstem Bulrush (<i>Scirpus acutus</i>)	0.06-0.25 lbs/acre	\$8-15/oz	1000/acre	\$0.25-0.50
Pennsylvania Smartweed (<i>Polygonum pensylvanicum</i>)	0.06-0.25 lbs/acre	\$5/oz	NA	NA
River Bulrush (<i>Scirpus fluviatilis</i>)	0.06-0.25 lbs/acre	\$5/oz	NA	NA
Soft Rush (<i>Juncus effusus</i>)	0.06-0.125 lbs/acre	\$15-16/oz	\$4-5	\$0.25-0.90
Softstem Bulrush (<i>Scirpus validus</i>)	NA	\$20/oz	1000/acre	\$0.25-0.90
Water Plantain (<i>Alisma subcordatum</i>)	0.06-0.25 lbs/acre	\$10-15/oz	1000/acre	\$0.25-0.85
Water Smartweed (<i>Polygonum fluitans</i>)	0.06-0.5 lbs/acre	\$3-25/oz	1000/acre	\$0.35-0.50
White Water Buttercup (<i>Ranunculus longirostris</i>)	NA	NA	500/acre	\$0.40-0.50
Yellow Water Buttercup (<i>Ranunculus flabellaris</i>)	NA	NA	500/acre	\$0.70-1.51
1.5'-3' Deep	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Watersheid (<i>Brasenia schreberi</i>)	NA	NA	1000/acre	\$0.65-1.49
White Water Lily (<i>Nymphaea tuberosa</i>)	NA	NA	200/acre	\$0.30-0.40
Yellow Water Lily (<i>Nuphar advena</i>)	NA	NA	200/acre	\$3.75
3'-8' Deep	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Elodea (<i>Elodea canadensis</i>)	NA	NA	1000/acre	\$0.25-0.51
Large-leaved Pondweed (<i>Potamogeton amplifolius</i>)	NA	NA	1000/acre	\$0.25-0.51
Richardson's Pondweed (<i>Potamogeton richardsonii</i>)	NA	NA	250lbs/acre	\$2/lb
Sago Pondweed (<i>Potamogeton pectinatus</i>)	NA	NA	1000/acre	\$0.35-0.50
Vallisneria, Eel Grass (<i>Vallisneria americana</i>)	NA	NA	1000/acre	\$0.40-0.75
Water Stargrass (<i>Zosterella dubia</i>)	NA	\$4.00/lb	1000/acre	\$0.25-0.50
Trees and Shrubs	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Bur Oak (<i>Quercus macrocarpa</i>)	NA	NA	NA	\$5-6
Buttonbush (<i>Cephalanthus occidentalis</i>)	NA	NA	NA	\$6-7
Red Osier Dogwood (<i>Cornus stolonifera</i>)	NA	\$9/oz	NA	\$2-5
White Oak (<i>Quercus alba</i>)	NA	\$5-8/oz	NA	\$6-7
Seed Mixes	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Forb and Grass Seed Mix	500 square ft	\$20-60	NA	NA
Forb and Grass Seed Mix	1000 square ft	\$66-108	NA	NA

FIGURE 1

FIGURE 2

FIGURE 3

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 generally at the deepest point in the lake (see sample site map), three feet below the surface, and approximately two feet off the bottom. Samples were collected with a horizontal or vertical 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. TestAmerica Incorporated, an environmental services lab, analyzed samples collected for total Kjeldahl nitrogen (TKN). The Health Department lab analyzed all other samples. 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. Total Kjeldahl nitrogen was analyzed by method 351.2 from the Methods for Chemical Analyses of Water and Wastes (EPA 600 Series). 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 foot until reaching the bottom in lakes ≤ 15 feet deep, and every two feet in lakes >15 feet.

Plant Sampling

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 random locations in the littoral zone, 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, any plants on the rake were identified and recorded. Plants that were not found on the rake but were ocularly 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. Approximate locations of each point were drawn on an aerial photo of the lake. Locations of the plant edge were also identified and marked on the aerial photo. The plant edge was defined as the area where aquatic plants presence dissipated, typically toward the deeper portions of the lake. The number of sample locations was contingent upon lake surface area, area of littoral zone, and presence and distribution of plants.

Shoreline Assessment

To assess the current condition of each lake's shoreline, a shoreline assessment was completed in 2000. This survey was conducted with the use of a boat, aerial photos, and county parcel maps. The shoreline along the land/water interface on each parcel was observed from a boat and various parameters were assessed (Table A2). Shorelines were first identified as developed or undeveloped. The type of shoreline was then determined and length of each type was recorded based on the parcel map or was ocularly estimated. In addition, several other parameters were measured including: the extent of shoreline vegetation, the degree of slope and erosion, and the presence of inlets, recreational structures (including boats, canoes, jetskis, boat ramps, piers, boat lifts, swimming platforms, etc.), aerators, irrigation pumps, water control structures, invasive vegetation, beaver activity, and deadfall (trees or shrubs lying in the water).

Frequently a parcel consisted of several shoreline types. For example, a parcel may have a beach, a steel seawall, and rip-rap along the its shore. In this case, the parcel was subdivided into three separate sections.

Data was entered and analyzed in ArcView 3.2[®] Geographic Information System (GIS) software. Total shoreline lengths and percentages for each category were determined using Excel software.

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
Dissolved oxygen	Hydrolab DataSonde ®4a
Nitrate nitrogen	Brucine method
Ammonia nitrogen	Electrode method, #4500F
Total Kjeldahl nitrogen	EPA 600 Series, Method 351.2
pH	Hydrolab DataSonde® 4a, Electrometric method
Total solids	Method #2540B
Total suspended solids	Method #2540D
Total dissolved solids	Method #2540C
Total volatile solids	Method #2540E, from total solids
Alkalinity	Method #2320B, titration method
Conductivity	Hydrolab DataSonde® 4a
Total phosphorus	Methods #4500-P B 5 and #4500-P E
Soluble reactive phosphorus	Methods #4500- P E and #4500-P B1
Clarity	Secchi disk
Color	Illinois EPA Volunteer Lake Monitoring Color Chart
Photosynthetic Active Radiation (PAR)	Hydrolab DataSonde® 4a, LI-COR® 192 Spherical Sensor

Table A2. Shoreline Type Categories and Assessment.

<i>Category</i>	<i>Assessment</i>
Developed	Yes, No
Inlets	None, Culvert, Creek, Farm Tiles, Storm Water Outlet, Swale, Sump
Shoreline Vegetation	None, Light, Moderate, Heavy
Type	Prairie, Shrub, Wetland, Woodland, Beach, Buffer, Canopy, Lawn, Rip-rap, Seawall, Vacant
Slope	Flat, Gentle, Steep
Erosion	None, Slight, Moderate, Severe
Water Control Structures	None, Culvert, Dam, Spillway
Recreational Structures	Yes, No
Irrigation Present	Yes, No
Aerator Present	Yes, No
Invasive Vegetation	Yes, No
Beaver Activity	Yes, No
Deadfall	Yes, No

Figure 2. Secchi disk transparency (feet) and the 1 % light level (feet) versus Total Suspended Solids (TSS; mg/L) for Leisure Lake, May – September 2000.