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Lake Lucy Aquatic Plant Management Plan

Prepared for:

RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT
CITY OF CHANHASSEN

Prepared by:

WENCK ASSOCIATES, INC.
1800 Pioneer Creek Center
P.O. Box 249
Maple Plain, Minnesota 55359-0249
(763) 479-4200

1-800-472-2232 Corporate Headquarters: 1800 Pioneer Creek Center, PO Box 249, Maple Plain, MN 55359 www.wenck.com

Maple Plain, MN	Woodbury, MN	Windom, MN	Roswell, GA	Fargo, ND	Mandan, ND	Minot, ND	Cheyenne, WY	Buffalo, WY
763-479-4200	651-294-4580	507-831-2703	678-987-5840	701-297-9600	701-751-3370	701-858-9999	307-634-7848	307-684-7953

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1.0 Introduction

The Riley Purgatory Bluff Creek Watershed District (RPBCWD) and the City of Chanhassen desire an aquatic plant management plan for Lake Lucy that addresses effective long-term management of aquatic plants, especially invasive species. RPBCWD and the City of Chanhassen believe a plan that focuses on long-term management will better address improving water quality, use of the lake for navigation, and improving the health of Lake Lucy. These goals are addressed by this plan through:

- Identifying the current situation in the lake in regard to aquatic plants.
- Specifying quantifiable management goals.
- Recommending specific management action items to improve lake conditions.
- Developing an annual budget for program implementation.

The development of an aquatic plant management plan will also provide a number of other benefits to lakeshore property owners and the surrounding area of around Lake Lucy. Typical benefits of an aquatic plant management plan include but are not limited to:

1. Improved lake access for lakeshore property owners or other property owners sharing a private lake access.
2. Improved opportunities for recreation on the lake for property owners and the surrounding neighborhoods by creating opportunities for fishing, boating, wildlife habitat and swimming.
3. Providing a low cost service for management of aquatic plants; to help improve the navigability of the lake.

Therefore, the purpose of this report is to explain current conditions, discuss alternatives and make recommendations for aquatic plant management activities on Lake Lucy. It is important to note that the focus for the RPBCWD is to manage aquatic invasive species, especially those species that affect water quality (Curlyleaf pondweed) and ecological health.

1.1 MANAGEMENT GOALS

As part of the plan development RPBCWD and the City of Chanhassen hosted 4 public meetings with lake residents in 2013 to discuss the lake issues and the goals that should be established for the lake. Following are the results of the meeting.

Issues

1. Submerged aquatic vegetation is over-abundant in the lake leading to minimal open water recreational areas, nuisance levels of dead plant biomass, and limited bird and water fowl habitat. The overabundance of submerged aquatic vegetation limits lake uses such as:
    a. swimming in areas adjacent to property and in other larger areas of the lake
    b. navigational access to most areas of the lake
    c. fishing opportunities throughout the lake
    d. aesthetics of the lake including water quality and SAV matting
2. Species diversity in Lake Lucy is dominated by coontail and water lily.

Goals

1. Improve and maintain the ecological conditions of the lake including minimizing nuisance algae blooms, invasive species dominance, filamentous algae mats, foul odors, trash, and nuisance aquatic plant abundance.
2. Improve and maintain the recreational uses of the lake including boating, fishing and swimming.
3. Improve and maintain a healthy and balanced fishery that supports reasonable fishing opportunities and local bird populations.
4. Improve and maintain the wildlife habitat of the lakes including birds and mammals through increased plant diversity.
5. Protect the lake from invasive species including, but not limited to, Curly-leaf pondweed, Eurasian water milfoil, purple loosestrife, and zebra mussels.

1.2 SHALLOW LAKE MANAGEMENT

1.2.1 Shallow Lake Ecology

Shallow lakes are ecologically different from deep lakes. Compared to deep lakes, shallow lakes have a greater proportion of sediment area to lake volume, allowing potentially larger sediment contributions to nutrient loads and higher potential sediment resuspension that can decrease water clarity. Biological organisms also play a greater role in maintaining water quality. Rough fish, especially carp, can uproot submerged aquatic vegetation and stir up sediment. Submerged aquatic vegetation stabilizes the sediment, reducing the amount that can be resuspended and cloud water clarity. Submerged aquatic vegetation also provides refugia for zooplankton, a group of small crustaceans that consumes algae.

All of these interactions in shallow lakes occur within a theoretical paradigm of two alternative stable states: a clear water state and a turbid water state (Scheffer 2004). The clear water state is characterized by a robust and diverse submerged aquatic vegetation community, balanced fish community and large daphnia (zooplankton that are very effective at consuming algae). Alternatively, the turbid water state typically lacks submerged aquatic vegetation, is dominated by rough fish, and is characterized by both sediment resuspension and algal productivity. The state in which the lake persists depends on the biological community as well as the nutrient conditions in the lake. Therefore, lake management must focus on the biological community as well as the water quality of the lake.

The following five-step process for restoring shallow lakes (Moss et al. 1996) was developed in Europe but is also applicable here in the United States:

1. Forward “switch” detection and removal
2. External and internal nutrient control
3. Biomanipulation (reverse “switch”)
4. Plant establishment
5. Stabilizing and managing restored system

The first step refers to identifying and eliminating those factors, also known as “switches,” that are driving the lake into a turbid water state. These can include high nutrient loads, invasive species such as carp and Curly-leaf pondweed, altered hydrology, and direct physical impacts such as plant removal. Once the switches have been eliminated, an acceptable nutrient load must be established. After the first two steps, the lake is likely to remain in the turbid water state even though conditions have improved, and it must be forced back into the clear lake state by manipulating its biology (also known as biomanipulation). Biomanipulation typically includes whole lake drawdown and fish removal. Once the submerged aquatic vegetation has been established, management will focus on stabilizing the lake in the clear lake state (steps 4 and 5).

The biological conditions (fish, plants, zooplankton, and invertebrates) in shallow lakes play a critical role in maintaining water quality. The balance between top predators and their prey (panfish, minnows) can have a large effect on the size of the cladoceran population, an effective algae grazer. Likewise, the amount and type of vegetation can affect the fish and zooplankton balance, ultimately affecting the cladocerans population. Because all the lakes are highly dependent on biological conditions, management of the vegetation community must be approached with caution.

1.2.2 Managing Vegetation in Shallow Lakes

Aquatic plants are beneficial to lake ecosystems by providing spawning and cover for fish, habitat for macroinvertebrates, refuge for prey, and stabilization of sediments. However, in high abundance and density, they limit recreation activities, such as boating and swimming, and may reduce aesthetic values. Excess nutrients in lakes can lead to non-native, invasive aquatic plants taking over a lake. Some exotics can lead to special problems in lakes. For example, under the right conditions, Eurasian watermilfoil can reduce plant biodiversity in a lake when it grows in great densities and out-competes all the other plants. Ultimately, this can lead to a shift in the fish community because these high densities favor panfish over large game fish. Species such as Curly-leaf pondweed can cause very specific problems by changing the dynamics of internal phosphorus loading. Ultimately, there is a delicate balance within the aquatic plant community in any lake ecosystem.

Invasive Aquatic Vegetation

The two most common invasive species managed in Minnesota lakes are Curly-leaf pondweed and Eurasian watermilfoil. Eurasian watermilfoil can dominate a lake’s vegetation community, limiting native plant growth, thereby limiting the ecological value of the community. Curly-leaf pondweed is an invasive, like Eurasian watermilfoil, that can easily take over a lake's aquatic macrophyte community. It presents a unique problem because it is believed to significantly affect the in-lake availability of phosphorus, contributing to the eutrophication problem. Curly-leaf pondweed begins growing in late fall, continues growing under the ice, and dies back relatively early in summer, releasing nutrients into the water column as it decomposes, possibly contributing to algal blooms. Curly-leaf pondweed can also out-compete desirable native plant species that typically grow in early summer.

Because of these potential impacts, it is important to evaluate the impacts of the invasive species and determine an appropriate management strategy that minimizes their impact on the ecological health of the lake. Lakes that have nuisance populations of either species should consider controlling those populations. Management of aquatic invasive species typically involves the use of herbicides such as endothall or mechanical harvesting. This plan evaluates the cost for using both of these techniques to manage the invasive vegetation in Lake Lucy.

Native Vegetation

Managing native aquatic vegetation in Minnesota lakes is typically focused on providing recreational access to the lakes to support uses such as swimming and boating. There is also a need for long term management to increase the diversity of the plant community. However, managing the native community is difficult and must be approach with care. Many management techniques' outcomes such as whole lake drawdown are difficult to predict and caution is needed to protect the current plant community from harm. Furthermore, the science of managing vegetation for increased native diversity is limited.

Based on this understanding, this plan focuses on techniques that can have some long term positive impacts on the diversity of the native population. The management philosophy employed in this plan recognizes that submerged aquatic vegetation is a critical part of the lake and that some vegetation is better than no vegetation but that ultimately the goal is a healthy, diverse, native dominated plant population (Figure 1.1). The current state of the lake must first be analyzed, then appropriate management actions identified to move toward the next better state.

Figure 1.1. Continuum of lake vegetation conditions from best to worst.

It is fairly well established in the current literature that plant abundance is driven by light, carbon, temperature, nutrient availability, and sediment type. Submerged aquatic vegetation SAV get the majority of their nutrients from the sediments and are likely N limited, so managing native SAV abundance likely requires a focus on N reductions in lake sediments. However, the most abundant plant in the lake is coontail which is not a truly rooted plant, so its response to sediment nutrient reductions is difficult to determine. It is also established in the literature that sediment bulk density is a key factor in controlling SAV abundance although this is very difficult to manage without drastic and expensive measure such as whole lake drawdown or sediment engineering.

Since there are no clear steps to improve the current native plant conditions, there are a few scientific understandings that can be used to guide the management of vegetation in shallow lakes. These approaches recognize the need for long term changes in lake conditions and are based on the best understanding of the physical and chemical factors that control plant communities.

Following is a brief description of these scientific understandings.

1. SAV are likely limited by nitrogen availability in the sediments.

Since it is likely that most SAV are limited by nitrogen, reducing nitrogen loading to the lake will ultimately reduce long term build up in sediments. This can be accomplished through the use of woodchip bioreactors where appropriate to reduce nitrogen loading to the lake and stormwater ponds to reduce TSS and P input into the lake.

2. SAV abundance is likely controlled by sediment bulk density

One of the key factors that determine the species present in a lake is sediment bulk density. However, identifying the target bulk density for the desired condition is difficult and needs further research. There are a number of techniques that can be used to alter sediment bulk density including the addition of sand or engineered soils to the lake. However, this is typically infeasible due to the high cost to treat a large area of the lake and the uncertainty of the outcomes. The most common approach to altering sediment bulk density is whole lake drawdown. Exposing lake sediment to the atmosphere results in sediment drying and consolidation and loss of nitrogen from increased denitrification. The down side for recreational shallow lakes is that the drawdown is typically conducted during the summer recreational season resulting in loss of recreational opportunities. There is also the potential to damage the existing lake vegetation community and shift the lake to a turbid water state.

1.3 CURRENT CONDITION

The Lake Lucy watershed is entirely within the boundaries of the City of Chanhassen boundaries and is approximately 962 acres (Figure 1.2). The watershed is fully developed and dominated by residential and commercial/industrial land use. Lake Lucy is a 92 acre shallow lake with a maximum depth of approximately 20 feet. The majority of the lake area is expected to support submerged aquatic vegetation.

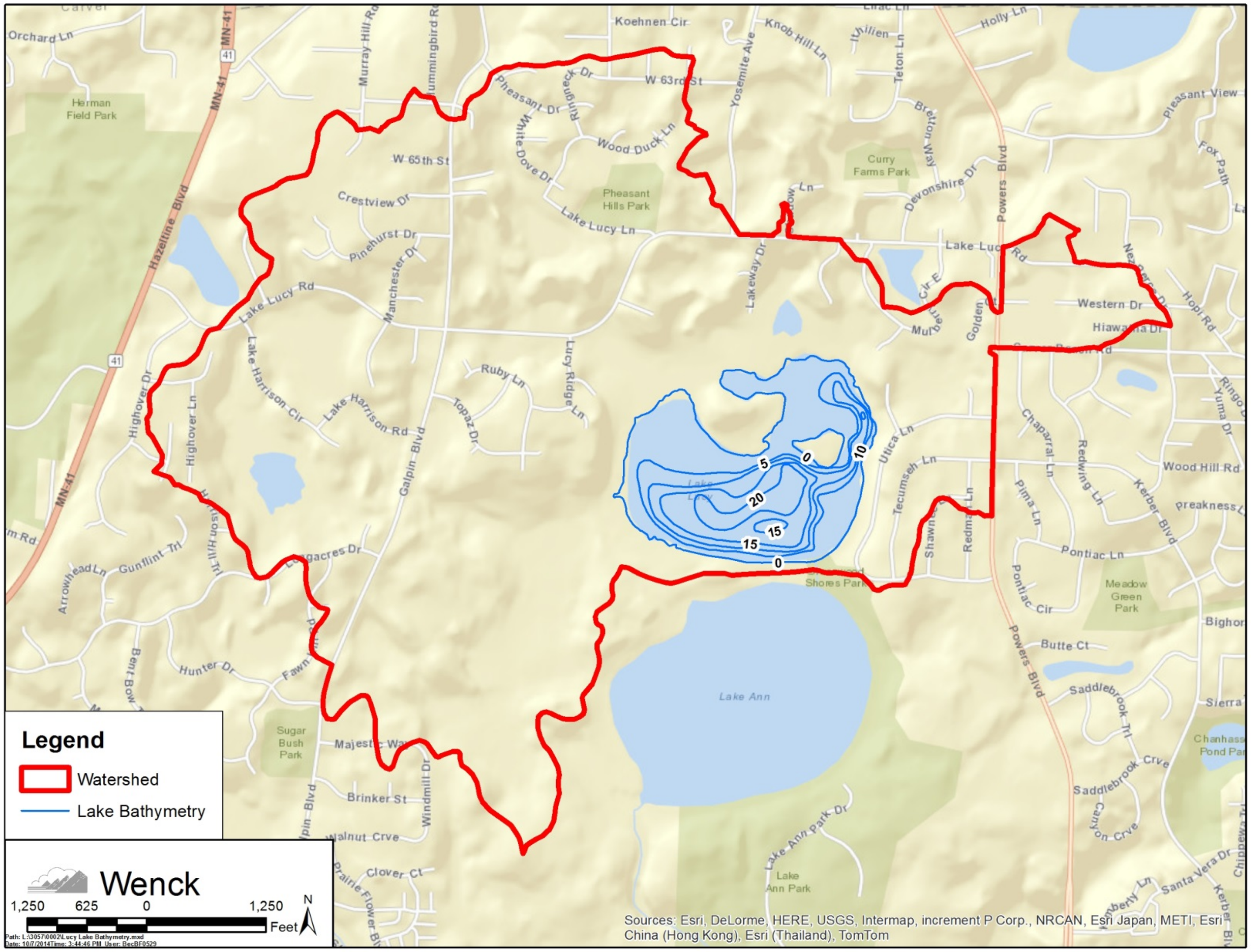


Figure 1.1.2. Lake Lucy Watershed

1.3.1 Water Quality

Water quality in Lake Lucy is relatively good for an urban, shallow lake especially in recent years. Following is a description of water quality conditions in Lake Lucy.

Total Phosphorus

Algal growth (measured as total chlorophyll-*a*) is typically limited by the amount of phosphorus in the water column in most Minnesota lakes. Therefore, total phosphorus is considered the causative factor for algal growth. Summer average total phosphorus concentrations ranged from 44.3 to 68.6 µg/L, and meeting the state shallow lake standards for the North Central Hardwood Forest Eco region (<60 µg/L) in 3 of the last 5 monitored years (Figure 1.3).

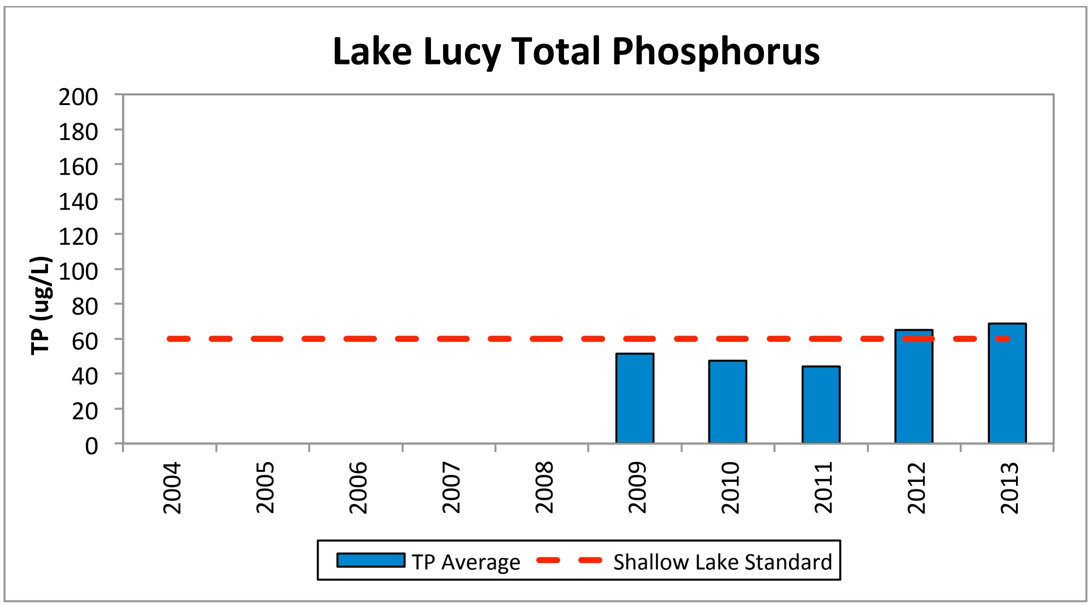


Figure 1.1.3. Average Total Phosphorus for Lake Lucy (June 1 – September 30). The red line indicates the State of Minnesota's standard for shallow lakes in the North Central Hardwood Forest Eco region. Only data with 4 or more summer samples are shown on the graph.

Chlorophyll-a

Chlorophyll-*a* is a measure of the biomass in a basin at any given time. The greater the algal biomass and corresponding chlorophyll-*a* values, the more green and productive a lake appears with worst case scenarios including algal scum and foul odors. These conditions are considered nuisance algal blooms, and are both aesthetically unpleasing and create detrimental conditions for fish and other aquatic organisms. Summer average chlorophyll-*a* concentrations in Lake Lucy range from 19.4 to 79.0 µg/L (Figure 1.4) with 4 of the 5 monitored years summer averages failing to meet the state water quality standard for shallow lakes in the North Central Hardwood Forest Eco region (<20 µg/L).

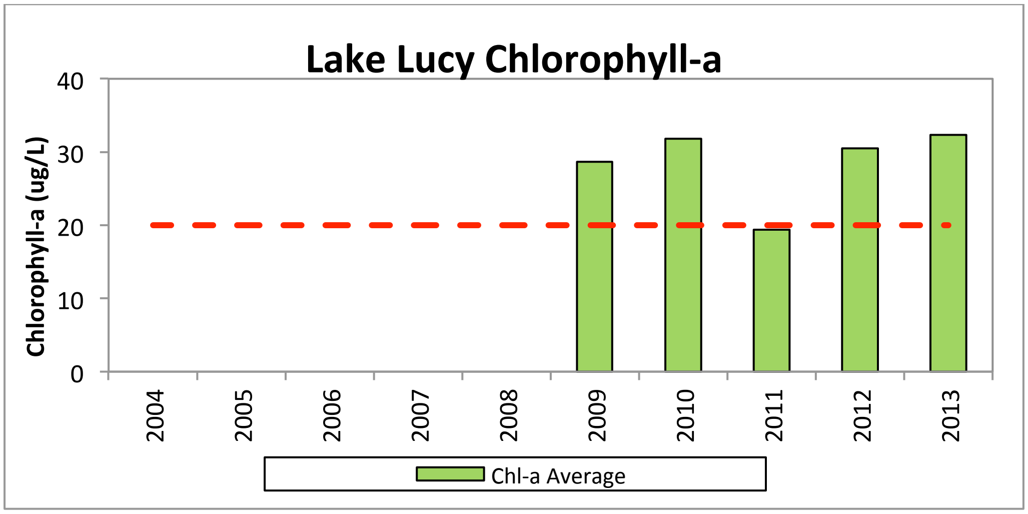


Figure 1.1.4. Average Chlorophyll-a (Chl-a) for Lake Lucy (June 1 – September 30).
The red line indicates the State of Minnesota's standard for shallow lakes in the North Central Hardwood Forest Eco region. Only data with 4 or more summer samples are shown on the graph.

Water Clarity (Secchi Depth)

Water clarity in lakes is typically measured using a Secchi disk, which is a black and white disk that is lowered into the water column until it can no longer be seen. The depth at which the disk disappears is known as the Secchi depth and is considered the depth where 90% of the light is extinguished.

Water clarity in shallow lakes is controlled by several factors including the amount of algae in the water column as well as other suspended particles such as suspended sediment as a result of wind resuspension and bioturbation (such as carp). Lake Lucy meets Secchi depth water quality standards for shallow lakes four of the last ten monitored years (Figure 1.5).

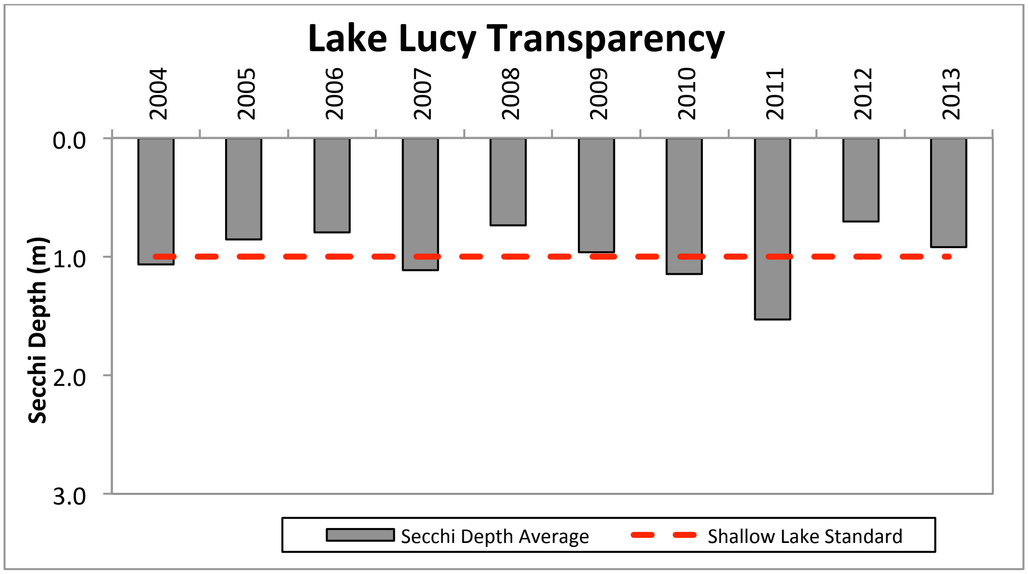


Figure 1.1.5. Average Secchi depth for Lake Lucy Lake (June 1 – September 30). The red line indicates the State of Minnesota's standard for shallow lakes in the North Central Hardwood Forest Eco region. Only data with 4 or more summer samples are shown on the graph.

1.3.2 Submerged Aquatic Vegetation

Figures 1.6 and 1.7 show the most recent vegetation surveys and species quantification for the lake which is broken up between floating leaf and submerged vegetation (Blue Water Science 2013). Curly-leaf pondweed (*Potamogeton crispus)* was the only invasive aquatic vegetation present (Table 1.1).

The lake is dominated by Curly-leaf pondweed, white water lilies and coontail early in the season with coontail abundance high throughout the season. In 2013, Curly-leaf pondweed covered approximately 10 acres of the 92 acre lake with densities varying from dense to light growth (Figure 1.6; Blue Water Science 2013). Coontail was found at 60% of the sample sites and to a depth of around 11 feet. White water lilies cover approximately 40% of the littoral area in early spring.

In the late summer after Curly-leaf pondweed senescence, coontail remains the dominant species and expands to about 71% of the sites (Table 1.1). Submerged aquatic vegetation covers approximately 48 acres (52%) of the lake (Figure 1.7). There are a number of pondweeds (flatstem, stringy, sago) that are present in the lake, but not very abundant, likely due to the dominance of coontail (Table 1.1). There is also a relatively robust population of Northern watermilfoil in the lake with 27% occurrence in 2009. The population of Northern water milfoil and Whitestem pondweed both declined significantly from 2003 to 2013.

Table 1.1. Lake Lucy aquatic vegetation species occurrence and abundance in the most recent plant survey.

Species	21-Jun-13		6-Sep-13	
	% Occurrence	Average Density	% Occurrence	Average Density
Duckweed	10%	1.4	--	--
Curly-leaf pondweed	20%	1.4	--	--
Elodea	3%	1.3	--	--
Flatstem pondweed	1%	1.0	--	--
Floating-leaf pondweed	2%	1.0	--	--
Whitestem pondweed	1%	1.0	--	--
Filamentous Algae	10%	1.9	--	--
Coontail	54%	2.2	73%	2.4
White lilies	35%	1.7	50%	3.0
Bladderwort	2%	1.0	19%	1.1
Star duckweed	13%	1.0	19%	1.0
Spatterdock	6%	2.2	8%	2.9
Chara	17%	2.6	7%	2.7
Northern watermilfoil	3%	1.0	2%	1.0
Sago pondweed	2%	1.0	2%	1.0

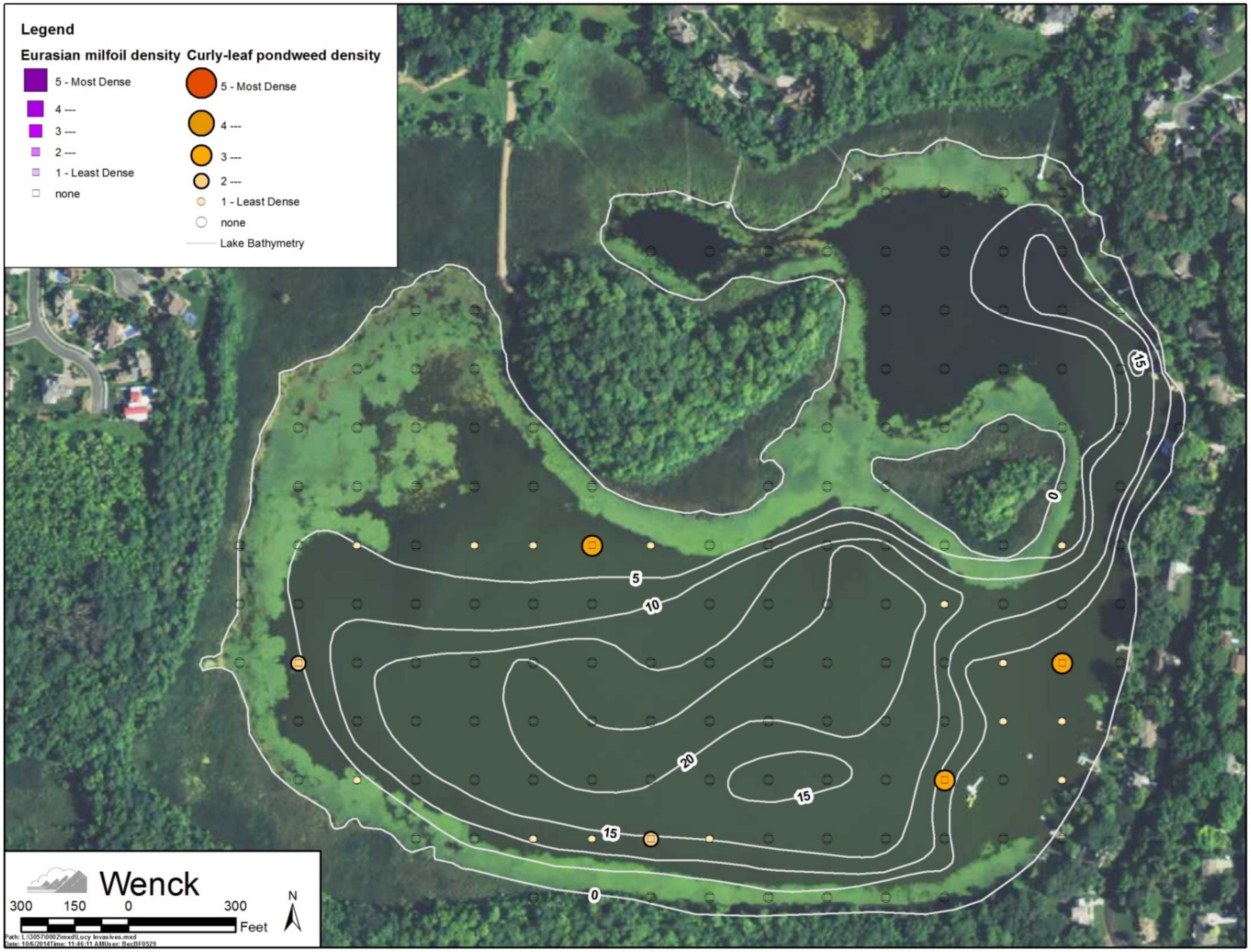


Figure 1.1.6. Lake Lucy invasive species map – 2013.

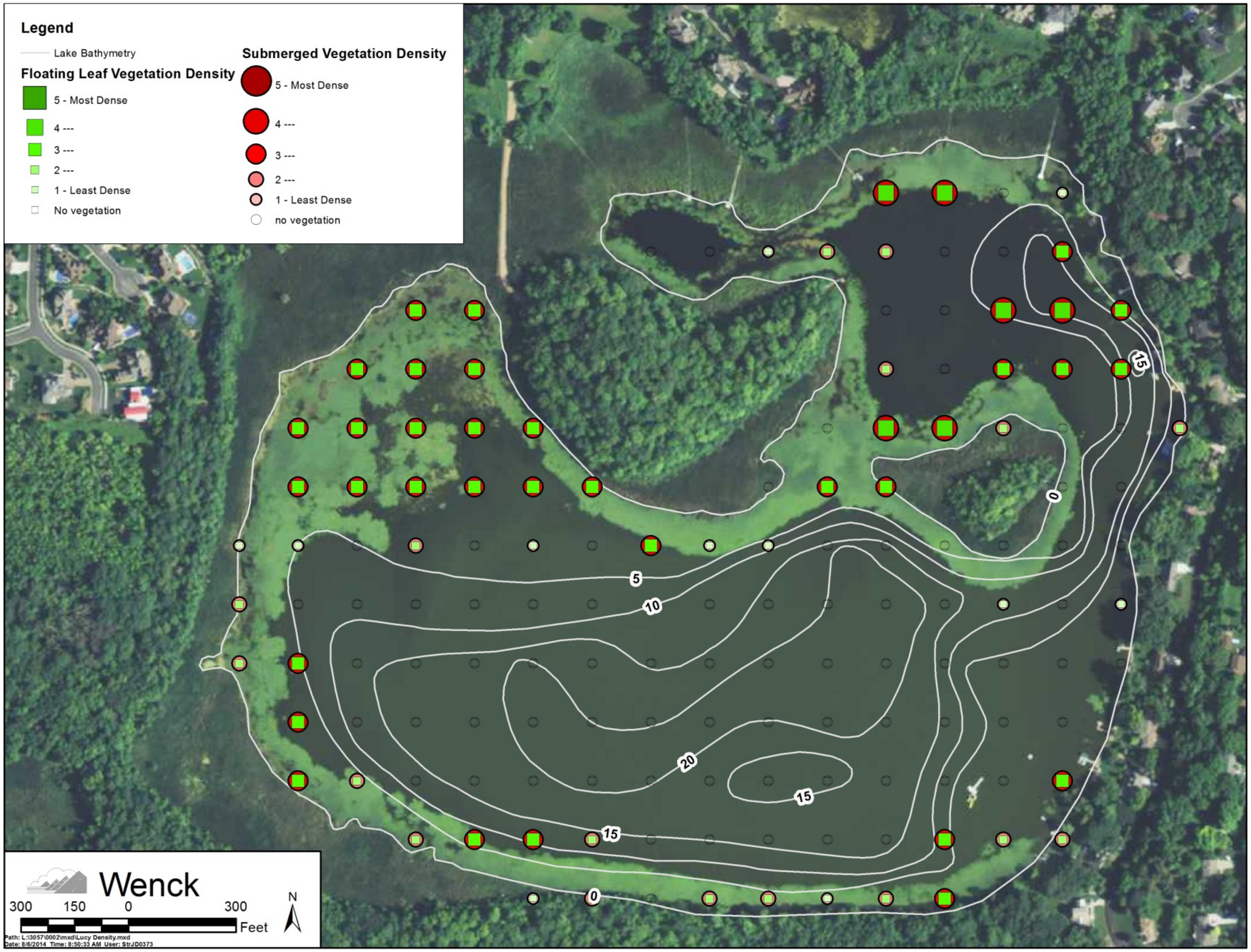
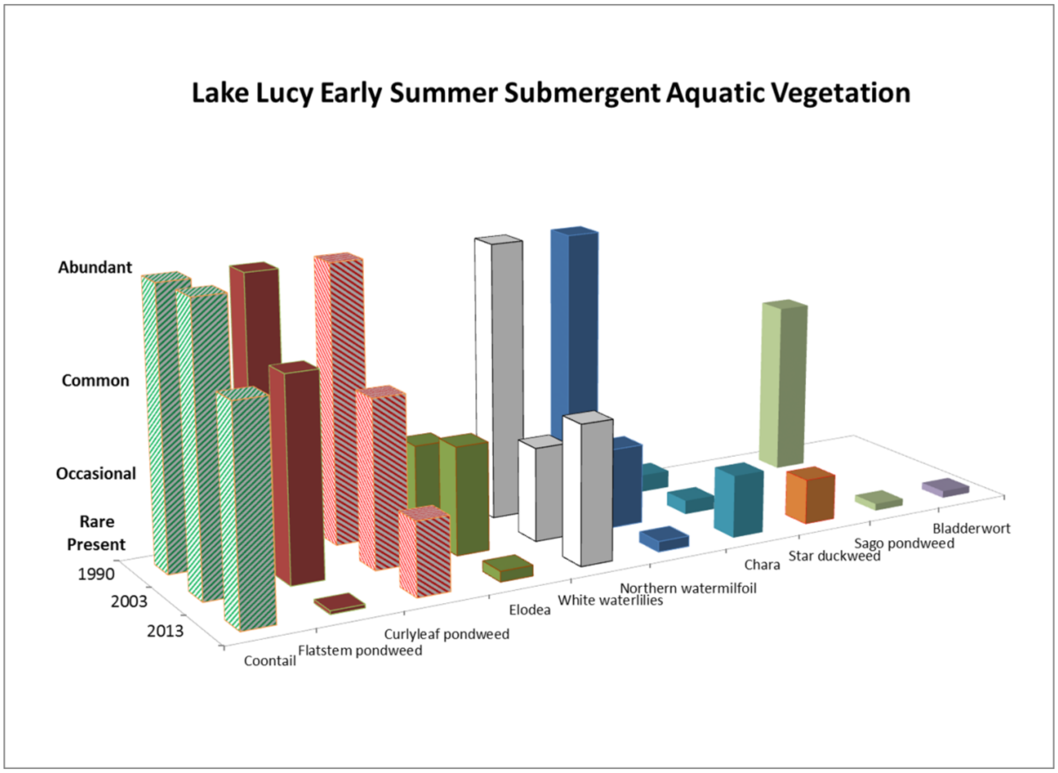


Figure 1.1.7. Lake Lucy Vegetation Density Map – September 2013

For the period of 2004 through 2014 there has not been a great amount of change in the vegetation community in Lake Lucy (Figure 1.8). Early season conditions are dominated by Curly-leaf pondweed and coontail with coontail filling in open areas after Curly-leaf pondweed senescence. The number of native species in late season surveys has been fairly constant. However, several of the species demonstrated significant declines in occurrence including Northern watermilfoil and Flatstem pondweed which declined from 27% and 44% occurrence to almost nonexistent respectively. Associated with this decline is a small expansion of white water lilies which increased from 30% to 50% occurrence. These trends point to increased eutrophication of Lake Lucy.



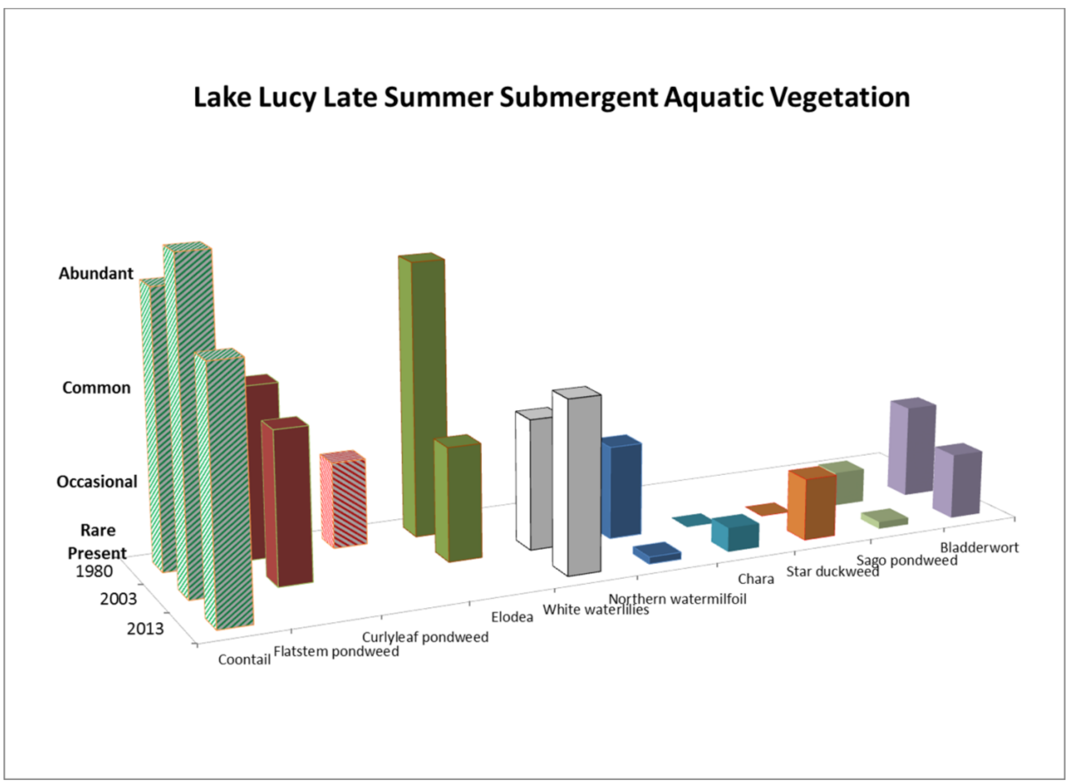


Figure 1.1.8. Lake Lucy Historic Vegetation Surveys.

1.4 AQUATIC PLANT MANAGEMENT PERMIT REQUIREMENTS

1.4.1 Introduction

The management of aquatic plants in Minnesota is regulated by Minnesota Statute, Section 103G.615, Chapter 6280 and is enforced by the Minnesota Department of Natural Resources (DNR). Aquatic plant management activities may or may not require an Aquatic Plant Management (APM) permit, based on the nature of the activity.

APM permits may be issued to provide riparian access, enhance recreational use, control invasive aquatic plants, manage water levels, and protect or improve habitat. Separate permits are required for controlling natives for recreational access and controlling aquatic invasive species. A specific list of criteria is considered to determine if a permit should be granted. A permit will not be issued to improve the appearance of undeveloped shoreline or for aesthetic reasons alone. A permit also cannot be issued in areas given special designations, such as Scientific and Natural Areas or in areas posted as protected fish spawning areas. Permits are required for the control of invasive species and recreational access.

There are a number of permit fees associated with the control of vegetation in Minnesota lakes. For recreational access, the fee for offshore (>150 feet from shore) mechanical control of submerged aquatic vegetation is $35.00 for the first acre, plus $2.00 for each additional acre up to a maximum fee of $2,500.00. The fee for offshore mechanical control of rooted vegetation on lakes 20 acres or less in size is $17.50 for the first acre plus $1.00 per acres for each additional acre. To control rooted aquatic vegetation with pesticides, the fee is $35 for each contiguous parcel of shoreline up to a maximum of $2,500. If multiple methods are used, only the larger of the fees applies. There is typically no fee for a permit to control aquatic invasive species.

1.4.2 Activities not Requiring a Permit

Chapter 6280.0250 allows certain activities without an Aquatic Plant Management (APM) permit. Specifically, mechanical control of submersed aquatic plants is allowed by individual property owners in an area not to extend along more than 50 feet or one-half the length of the owner's total shoreline, whichever is less, and not to exceed 2,500 sq. ft. plus the area needed to extend a channel no wider than 15 feet to open water.

These rules also allow for the mechanical control of floating-leaf aquatic plants to obtain a channel extending to open water with the provisions that the channel is no more than 15 feet wide and follows the most direct route to open water, the channel is maintained by cutting or pulling, and the channel remains in the same location from year to year.

The skimming of duckweed or filamentous algae off of the surface of a water body is also allowed without a permit.

1.4.3 Activities Requiring a Permit

An APM permit is required for all other activities below the Ordinary High Water (OHW) level not mentioned above, including all herbicide control of aquatic plants, relocating or removing bogs, and installing or operating an automated aquatic plant control device (weed harvester).

1.4.4 Types of Aquatic Plant Management Control

Herbicide Control

A permit is required for all chemical control of aquatic plants. Herbicide control of aquatic plants is limited to an area that does not exceed 15% of the littoral area of a lake (12 acres on Lake Lucy). Only specific pesticides that are labeled for use in aquatic sites can be used, and they must be applied according to the label instructions. Removal can occur as frequently as the applicant desires, however the frequency must be approved by the DNR.

Permit Requirements

A riparian lakeshore owner, lake association, or government agency may apply for an APM permit. Before the permit is issued, it is necessary to obtain the permission and signature of all landowners whose shorelines will be treated.

Applications for permits must be submitted by August 1 of each year. An APM permit is valid for one growing season and expires on December 31 of the year that it is issued.

1.5 PAST MANAGEMENT ACTIVITIES

In 2013, the RPBCWD updated the Lake Lucy and Lake Ann UAA to develop a long term plan to improve and protect water quality in Lake Lucy. The District previously conducted plant surveys in Lake Lucy to characterize the plant community and any changes that may be occurring. The City of Chanhassen has previously hired Blue Water Science to conduct plant surveys in Lake Lucy (2003, 2013).

2.0 Alternatives

Current conditions in Lake Lucy suggest that an aquatic plant management plan would be beneficial for Lake Lucy due to the presence of invasive species, late season dominance by coontail, and an abundance of submerged aquatic vegetation in many areas. However, due to the lake's bathymetry, a large plant free area remains in the lake which supports recreational uses. Furthermore, Curly-leaf pondweed is in low abundance and does not require management at this point. To identify the optimum amount of management, the following assessment was completed.

- Descriptions and assessments of alternatives for aquatic plant management:
    - Targeted Alternatives (harvesting and herbicide treatment)
- An assessment of management impacts to fisheries, fish habitat, and water quality due to proposed management alternatives
- Identification of other considerations for management actions

2.1 DESCRIPTION OF ALTERNATIVES

Proposed alternatives were developed to be in line with goals identified in Section 1. Each of the alternatives assumes that one of the Local Governing Units (LGU) would take the lead, but does not identify who the LGU is at this time. LGU's that can take the lead include:

- RPBCWD,
- City of Chanhassen, or the
- Lake Lucy Association.

Scenarios were developed separately for managing invasive species and for managing natives for recreational access.

Two targeted alternatives were assessed for invasive species management that are within state permit guidelines as part of this plan. Mechanical harvesting was not considered viable for Lake Lucy to difficulties in obtaining access to the lake and the small areas where harvesting would occur. Following are detailed descriptions of the evaluated alternatives.

2.1.1 Targeted Invasive Species Alternative #1 - Herbicide Treatment (4.5 acres)

The lead LGU would contract to have 4.5 acres treated with an endothall herbicide (likely Aquathol K) once a year (Figure 2.1). Aquathol K is a contact herbicide and is an industry standard for controlling curly leaf pondweed. The targeted area in to be treated is 4.5 acres, which does not exceed the maximum area that can be treated with herbicide (12 acres). The use of the herbicide will not significantly reduce seed banks or the ability of the vegetation to grow back requiring the treatments to occur annually. As with all chemical treatments, this alternative would require a permit from the DNR.

The following assumptions have been made for this alternative:

- A Minnesota licensed herbicide applicator would be hired to provide the treatment service at a cost of approximately $500/acre in 2014 dollars.
- Monitoring would be completed by the City, Watershed District, or by hired professionals every year to confirm effectiveness of treatment options.

2.1.2 Targeted Recreational Access Alternative #2 – Contract Herbicide (0.8 acres).

Herbicide application (likely diquat) would be conducted by a contractor twice per year focused on maintain a 15 foot wide channel from the deep part of the lake to the northern bay(Figure 2.2). The area to be treated totals approximately 0.8 acres. A contractor would be selected by the lead LGU from the Minnesota DNR “Commercial Aquatic Pesticide Applicators” list to complete the herbicide application. Contractors would be selected early in the year and will be selected on an annual basis.

Lakeshore residents could hire the Contractor selected by the LGU to spray herbicide near their docks if desired. The herbicide application area associated with these access paths was not incorporated in this plan, but the addition of these paths would not exceed the DNR permit limit of 15% of the littoral zone (12 acres). The primary goal of this alternative is to increase the recreational benefits of Lake Lucy.

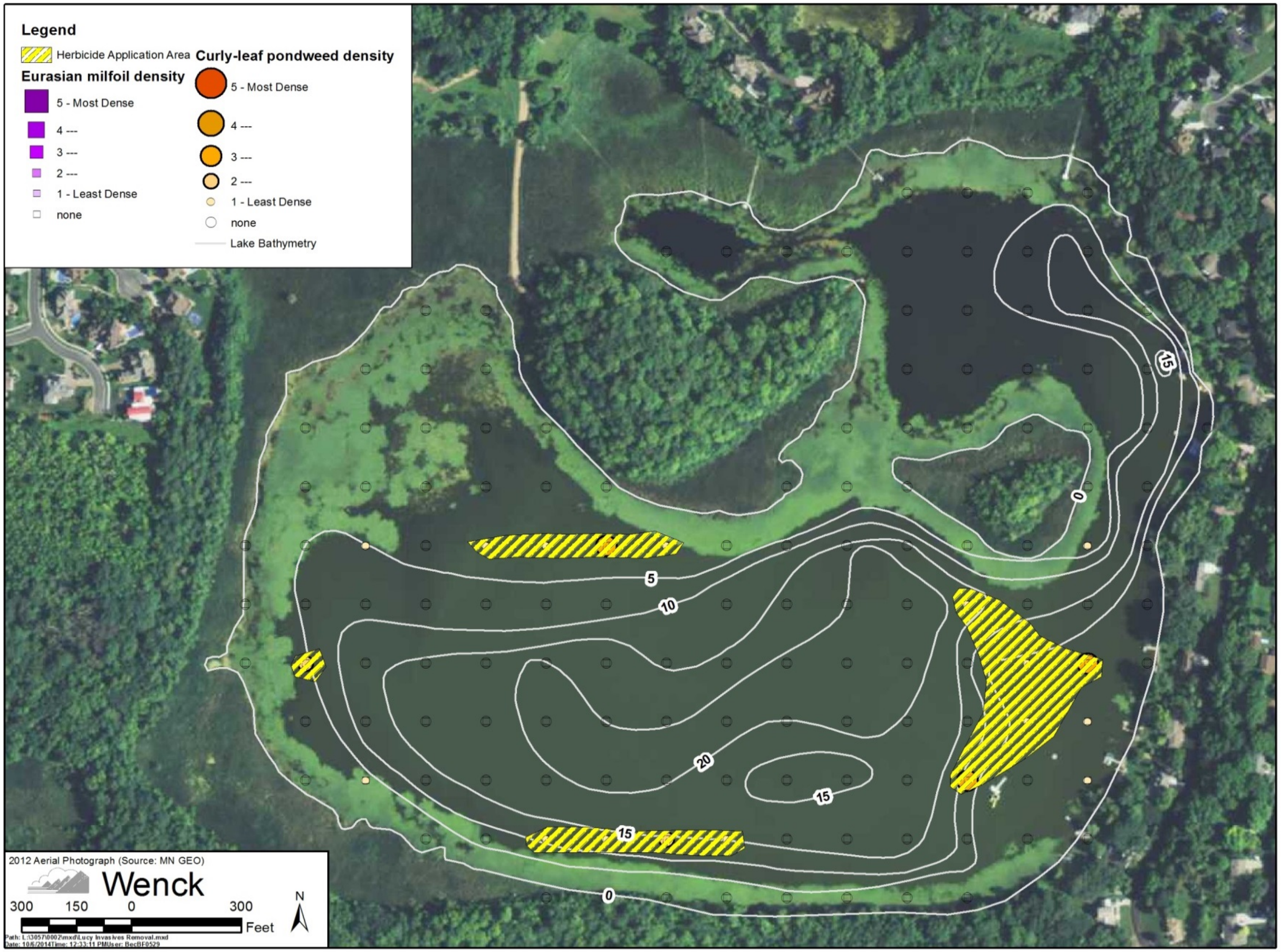


Figure 2.1. Lake Lucy invasive species management using contract herbicide application approach.

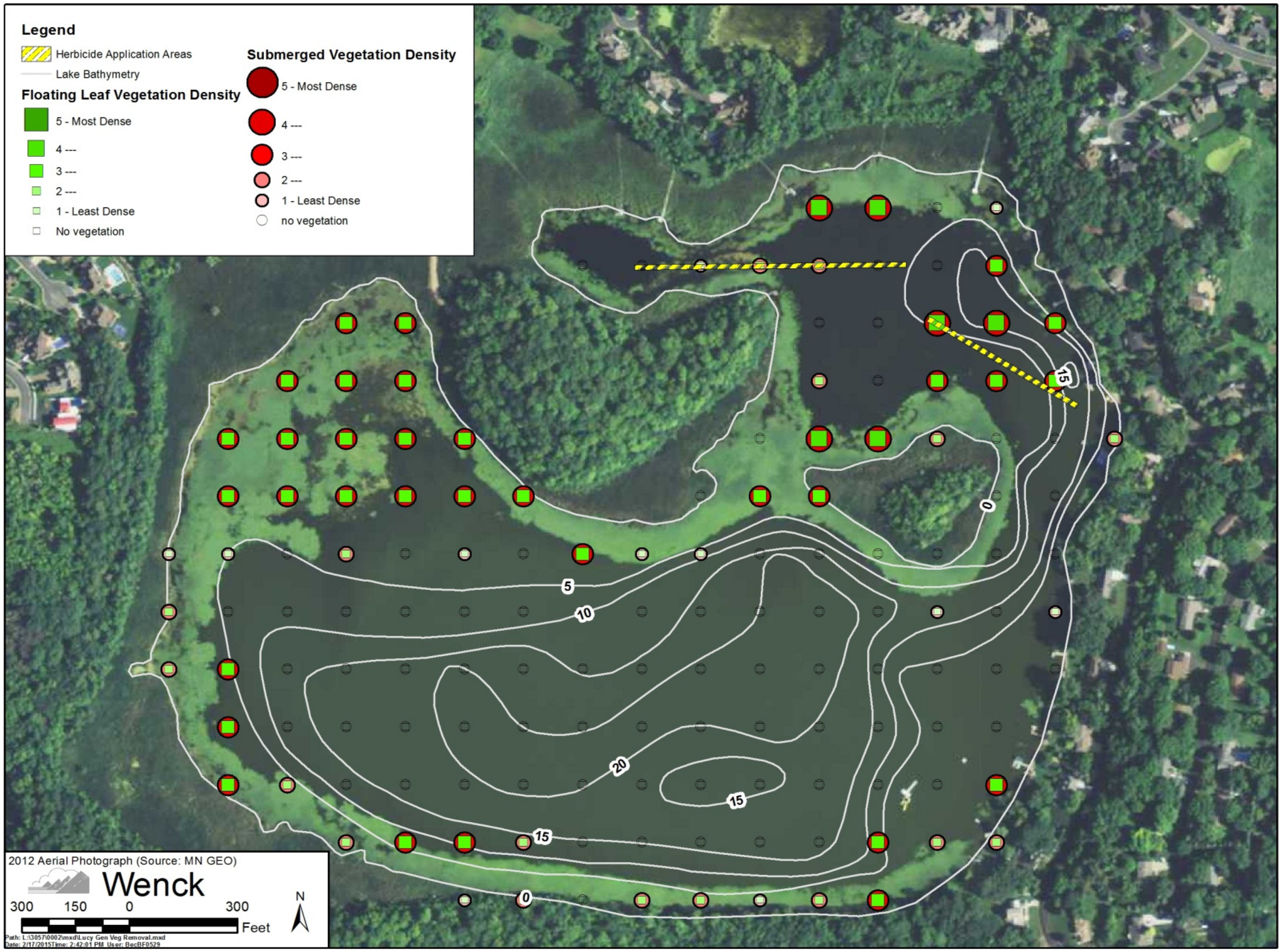


Figure 2.2. Lake Lucy recreational access management using contract herbicide approach. Note that the same removal areas need to be maintained from year to year per DNR regulations.

Another alternative that was not assessed as a part of this study was for the lead LGU to own and operate a harvester or for a contract harvester to remove vegetation. This alternative was not deemed feasible at this time due to the access limitation on Lake Lucy.

2.2 TARGETED ALTERNATIVES ASSUMPTIONS

The following assumptions were made for assessing the alternatives. These assumptions, developed through conversations with vendors, contractors, the City of Eden Prairie, and the RBCWD are believed to be reasonable.

Assumptions:

- Each scenario assumes the project begins in 2015.
- Each scenario was evaluated to determine equipment (capital) costs and operations cost based on a 15-year operations period to give a total cost adjusted to annual inflation for each scenario.
- A 3% inflation rate was used in the annual cost calculations.
- All scenarios were considered feasible.
- Invasive species harvesting scenarios assumed the lake would be harvested once annually in the early spring.
- Invasive species herbicide treatment scenarios assumed the lake would be harvested once annually in spring.
- Chemical application cost per acre was assumed to be $500 /acre treated. This was derived from quotes from local applicators that ranged from $400 to $600 /acre treated.
- Recreational navigation channel harvesting scenarios assumed the channels would be harvested three times annually.
- Chemical application cost per acre was assumed to be $500 /acre treated. This was derived from quotes supplied by the City of Eden Prairie who have recently conducted mechanical harvesting on Mitchell Lake.
- Recreational navigation channels were assumed to be 15 feet in width.
- Recreational harvesting in non-navigation scenarios assumed the lake would be harvested three times annually.

- Recreational harvesting in navigation channels was assumed to occur three times annually
- Each alternative assumes the lead LGU would obtain a Minnesota DNR Aquatic Plant Management Permit annually.
- Harvesting alternatives assume a minimum cutting depth of 3 feet and a maximum depth of 7 feet.
- Herbicide treatments were assumed to be carried out once annually.
- For each alternative it is assumed that the lead LGU would complete the permitting. Annual monitoring of herbicide treatment effectiveness would be completed by the lead LGU or hired professionals.
- Herbicide scenarios assume there will be monitoring and reporting completed by the City or lakeshore residents after each year of treatment.

2.3 ASSESSMENT OF IMPACTS

A brief assessment of potential impacts of aquatic plant management (both positive and negative) for the proposed alternatives was completed to address environmental impacts on fisheries, fish habitat, and water quality and is presented below.

2.3.1 Environmental Impacts on Fisheries and Fish Habitat

Aquatic plants are an important part of lake ecosystems, and the value of maintaining aquatic plants to foster diverse aquatic ecosystems has been well documented. Aquatic plants are an essential component of fish and wildlife habitat. The Aquatic Ecosystem Restoration Foundation (2003) states that aquatic and littoral vegetation provides fish, waterfowl and some mammals with:

- Oxygen
- Habitat
- Food sources
- Breeding areas
- Refuge for predators and prey
- Stabilized bottom sediments.

These resources are not only important for good sport fisheries, but also for other recreational activities, aesthetic enjoyment of water resources, and maintenance of healthy aquatic and littoral ecosystems.

Herbicide treatment with Diquat was investigated for this project to control native vegetation for recreational access. The use of low-dose applications of Diquat to control aquatic vegetation is expected to have virtually no negative impact on fisheries and fish habitat. The compound is a selective contact herbicide that disrupts biological processes unique to plants, such as interfering with plant respiration and disrupting plant cell membranes. Finally, Diquat compounds do not bioaccumulate in fish or hydrosoil.

2.3.2 Impacts on Water Quality

Water quality impacts of aquatic plant control methods may be both positive and negative.

Controlling the abundance of nutrients can also prevent negative water quality impacts associated with the life cycle of aquatic plants. According to James, et al. (2001), plants can directly recycle phosphorus from the sediments through root uptake, incorporation into plant tissue, and subsequent senescence (i.e., decomposition). They can also indirectly recycle phosphorus from the sediments by increasing pH in the water column through photosynthetic activities. Phosphorus release from sediments can be enhanced at high pH as a result of ligand exchange on iron oxide contained in the sediment. In addition, senescence/decomposition of the plant material can contribute to low dissolved oxygen conditions at the sediment water interface. Low oxygen conditions contribute to weakening of the iron-phosphate bond leading to phosphorus release from sediments.

Phosphorus loads from plant senescence and sediment effects cannot be estimated without detailed study; however, it can be significant, especially if the subsequent release of phosphorus from senescence can then be used by algae resulting in nuisance algae blooms and decreased water clarity. Thus, effective control options can have an overall positive effect on water quality (improved water clarity and lower phosphorus loading) and the native plant and animal community in Lake Lucy if properly executed and managed.

3.0 Assessment of Alternatives

3.1 ALTERNATIVE ASSESSMENT

Each of the alternatives was evaluated for a 15 life-cycle cost for long term comparison and budgetary planning. The first three scenarios focus on management of invasive species with the 4th alternative focusing on management of vegetation for recreational access to the lakes.

3.1.1 Invasive Species Control

Current densities of Curly-leaf pondweed in Lake Lucy do not warrant management at this point in time. However, long term monitoring should be conducted to track changes in the Curly-leaf pondweed extent and density.

Based on the current extent of Curly-leaf pondweed, herbicide applications have an annual average cost over 15 years of $7,524 (Table 3.1).

Table 3.1. Cost Estimates by Targeted Alternative.

Alternative	Description	Acres[2]	15 Year Life Cycle Cost[1]	Annual Cost[1]	Cost/Acre/Year
1	Invasive Contract Herbicide	4.5	$112,859	$7,524	$1,660
2	Recreation Area Herbicide	0.8	$75,114	$5,008	$5,940

[1]Each annual cost adjusted to inflation and summed to obtain a total lifetime cost.

[2]Acreage is equal to the sum of area harvested throughout the year (Acreage = acres harvested x times harvested)

3.1.2 Native Species Management for Recreational Access

The second alternative focuses on managing the overgrowth of native vegetation which limits recreational access to the lakes. Management of recreational channels would be completed using an herbicide such as diquat since access to the lake prohibits the use of a harvester. The average annual cost over 15 years to maintain the recreational channels is $5,008.

There are additional activities that lakeshore owners can complete to improve recreational access to the lake. Each lakeshore owner is permitted to clear a 15 foot wide channel from their dock to the recreation access provided in the lake overall. Lakeshore owners can also clear their own areas up to 2,500 square feet and 50 feet of shoreline or 50% of shoreline, whichever is less. This scenario assumes that each lakeshore owner is responsible for these activities on their own. However, there may be some cost savings if harvesting is already being conducted on the lake.

3.2 OTHER AQUATIC PLANT MANAGEMENT ACTIVITIES

There are a number of other activities that can be completed to improve native vegetation in Lake Lucy and offset any potential negative impacts to the lake. Following is a description of these activities.

3.2.1 Nitrogen Load Reductions

One of the likely contributors to the overabundance of native vegetation in Lake Lucy is the buildup of nitrogen in lake sediments. To offset these impacts, opportunities to reduce nitrogen loading to the lake should be explored. Recent technological advances in nitrogen removal such as woodchip bioreactors recently demonstrated a high potential for nitrogen removal from stormwater runoff. However, an analysis of the watershed for suitability and impact would be required.

3.2.2 Shoreline Restoration

Submerged aquatic vegetation is critical for supporting a healthy biological condition in shallow lakes such as Lake Lucy. Some of these ecosystem services may be disturbed by management activities aimed at improving recreational access to the lake. To offset these impacts, lakeshore owners should maintain as much native shoreline as possible and minimize fragmentation of the plant community as much as possible. Homeowners could work with the LGU for planning and to determine funding availability.

3.2.3 Whole Lake Drawdown

One of the more common techniques for managing vegetation in shallow lakes is a growing season or winter whole lake drawdown. The purpose of a drawdown is to consolidate sediments, increase sediment nitrogen loss by increasing denitrification, and to reinvigorate the native vegetation population. This technique is most often used when there are no vegetation present and the outcomes of completing a drawdown in a lake with a robust population is difficult to predict. A lake manager must use caution when prescribing a lake drawdown due to this uncertainty. Furthermore, a drawdown often results in significant loss of recreational opportunities for one or more years depending on weather conditions. However, this technique may be required to make wholesale changes in the lakes plant community. In Minnesota, a whole lake drawdown requires a minimum of 75% approval by lakeshore owners.

4.0 Summary and Recommendations

4.1 RECOMMENDED ACTIONS

Lake Lucy is a shallow that supports a robust submerged aquatic vegetation population that inhibits recreational uses such as swimming, boating and fishing. There is currently one invasive vegetation species in Lake Lucy, Curly-leaf pondweed. Curly-leaf pondweed is found in low density in a few areas of the lake. Management of Curly-leaf pondweed is not necessary at this time.

The native submerged aquatic vegetation population is dominated by coontail and water lilies which grow to nuisance levels inhibiting some recreational use of the lake. The thick mats often prevent boating and swimming due to their density. Fishing can also be difficult due to the density of the plants. Therefore, some management of the native vegetation population is necessary to further support recreational uses of the lake.

4.2 PREFERRED ALTERNATIVE

The best alternative for improving vegetation conditions in the lake is to use some herbicide to maintain channels to the northern part of the lake. While Curly-leaf pondweed is present in the lake, it is not at the extent or density that requires management at this time. However, the population should be continued to be tracked and managed if the extent or density reach critical levels.

This plan requires the lead LGU to contract with a commercial herbicide applicator listed on the Minnesota DNR "Commercial Mechanical Control Companies" list. Herbicide applications should be completed three times annually to maintain the access channels.

The average annual cost to implement alternatives 2 is $5,008 for a 15 year period.

4.3 PROJECT FACILITATION

A lead LGU must be selected to facilitate and lead the project. This lead LGU will serve as the lead agency for implementation and monitoring of the project, but will work closely with lakeshore residents and the DNR regarding implementation. It should be noted that that two LGU's could take the lead for different aspects of the project such as invasive species control versus recreational access. However, coordination between these two efforts would be needed.

The lead LGU must work with the DNR to confirm harvesting and herbicide areas annually. Coordination among the groups will ensure the application and harvesting are effective in meeting the goals of this plan.

4.4 PROJECT FUNDING

Funding options for the management of aquatic vegetation, including invasive plants, are more limited than for other types of lake improvement actions because these ongoing activities are considered maintenance and not capital improvements. Typically, grant funding is limited for these types of activities (DNR sometimes has a small pool of money for invasive species control). General operating funds from counties, cities, watershed management organizations, and lake associations are potential sources, as are direct payments by property owners. Another option is the establishment of a Lake Improvement District. Lake Improvement Districts are special units of government created by county boards, either on the board's own initiative or by petition by the majority of property owners in the proposed district. The governing board of a district may impose service charges, levy taxes or special assessments, or issue obligations to fund operations and improvements

5.0 References

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6.0 Appendix A

Table A1. Total and annual cost estimate by alternative. Cost estimates assume a 3% annual inflation rate.

Year	Invasive Removal Herbicide	General Removal Herbicide
1	$6,068	$4,039
2	$6,250	$4,160
3	$6,438	$4,285
4	$6,631	$4,413
5	$6,830	$4,546
6	$7,034	$4,682
7	$7,246	$4,822
8	$7,463	$4,967
9	$7,687	$5,116
10	$7,917	$5,269
11	$8,155	$5,428
12	$8,400	$5,590
13	$8,652	$5,758
14	$8,911	$5,931
15	$9,178	$6,109
Total	**$112,859**	**$75,114**