Lake Iroquois

Aquatic Plant Survey

Prepared For:

Lake Iroquois Association

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Background

Lake Iroquois is situated in northwestern Vermont and is bordered by the towns of Hinesberg, Williston, and Richmond. The lake has a surface area of approximately 244 acres with maximum and average depths of 37 feet and 19 feet, respectively (LIA SOTL Report). Lake Iroquois is considered to be a eutrophic lake by LIA due to phosphorus concentrations that exceed the threshold of 14 ppb, and chlorophyll-*a* concentrations that exceed the threshold of 7 ppb.

2014 Project Goal

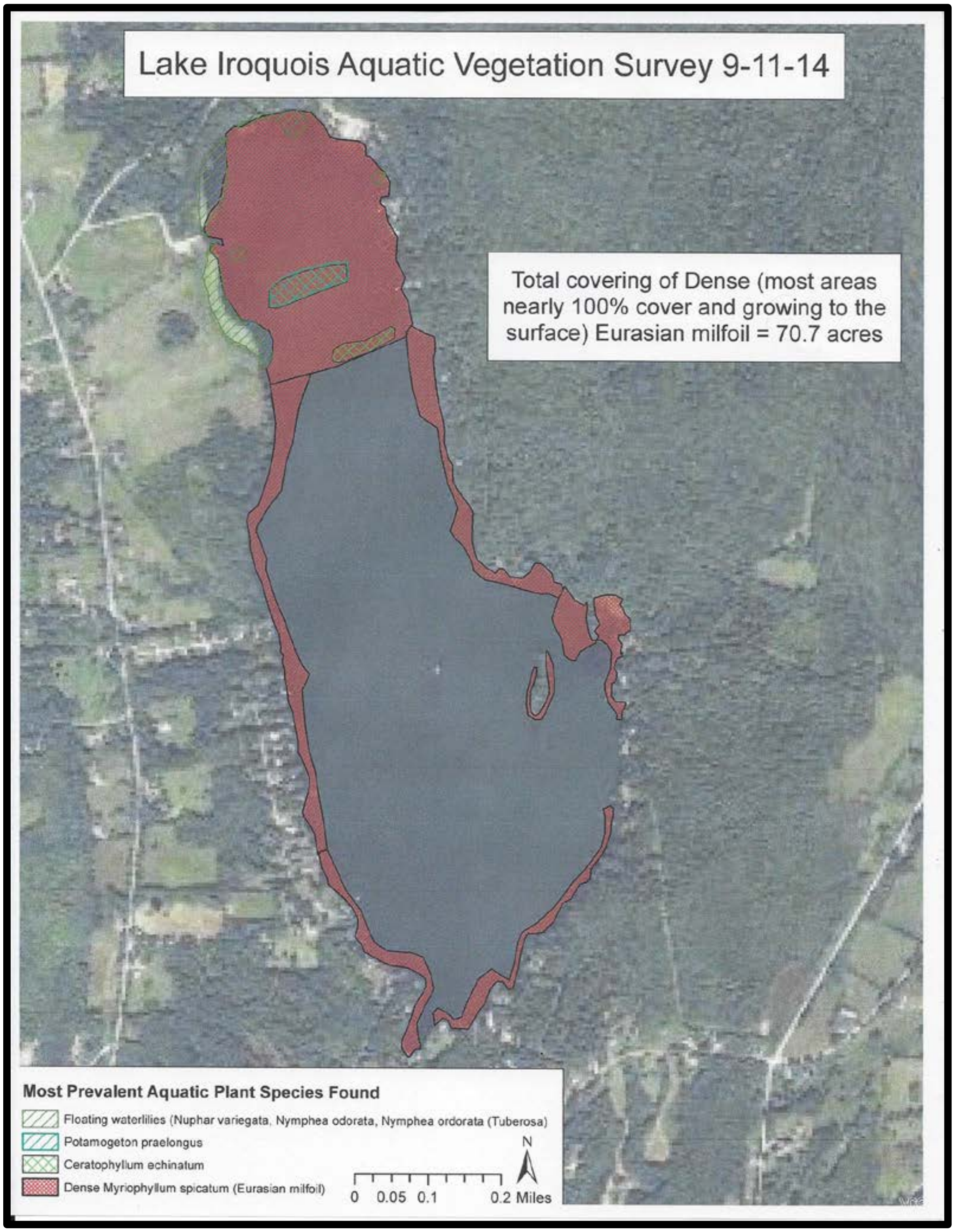
Northeast Aquatic Research (NEAR) was hired to conduct an aquatic plant survey of Lake Iroquois in order to provide an accurate, up-to-date estimate of the coverage of invasive Eurasian milfoil. This invasive non-native aquatic plant was reported (LIA SOTL Report) to be first discovered in Lake Iroquois in 1990 near the state fishing access. Our survey was conducted on September 11, 2014 and consisted of observing aquatic plant species presence and growth form at 136 locations (waypoints) around the shoreline of the lake, **Map 1**. Waypoints were typically made at regular 200 feet intervals. Plant cover between points was observed for similarity to last made point. Significant differences in species presence prompted making a new waypoint. The weather on the date of the survey was not entirely conducive for conducting detailed aquatic plant investigation due to strong Northerly winds, overcast skies, and intermittent rain showers. Due to these factors, venturing out to the center of the lake to investigate plant growth around the center island was omitted due to rough water, however shoreline surveying was completed without problem.

Map 1 – Locations of waypoints made during NEAR 2014 survey

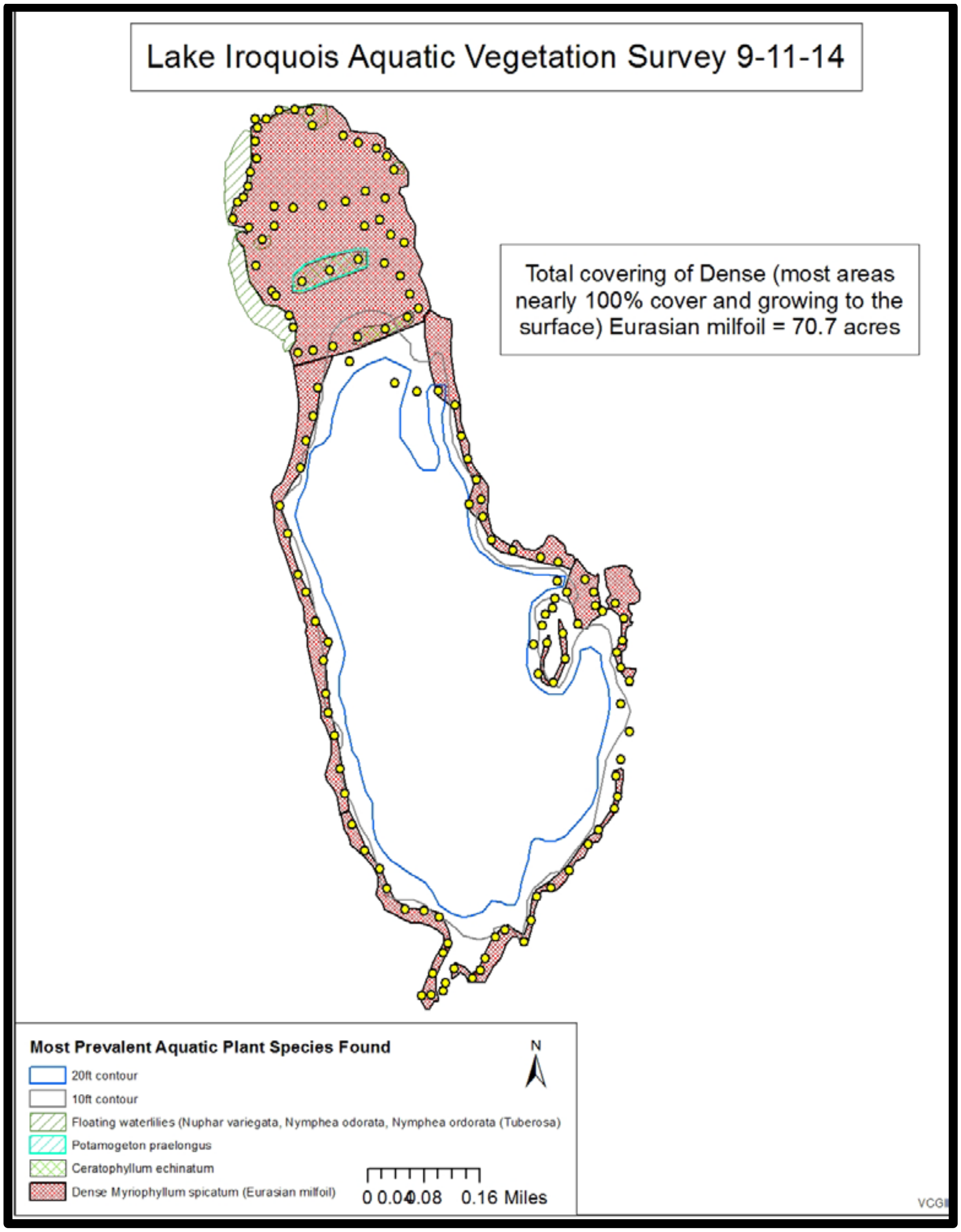
Survey Results

Eurasian milfoil was found to cover approximately 70 acres of Lake Iroquois at high densities (**Map 2**). The plant was usually growing to the surface in thick, matted, continuous beds in depths up to 14.2 feet (4.3 meters), however, in most areas Eurasian milfoil was found growing out to only 10 or 11 feet of water depth (**Map 3**).

Map 2 – Distribution of Eurasian milfoil in Lake Iroquois September 2014



Map 3 – Distribution of Eurasian milfoil in relation to the 10 and 20 foot water depth contours



The lake has a large littoral zone of 105 acres, or about 43% of the total lake surface area. On the date of our survey 70.7 acres of the lake was infested or about 67% of the littoral zone. This suggests that an additional 33 acres of milfoil colonization is possible in Lake Iroquois. The outer boundary of the littoral zone was estimated using 14 feet of water depth. This decision was based on our finding Eurasian milfoil growing to a maximum depth of 14 feet. The outer edge of the littoral zone is based on the depth of light penetration which will vary from month to month and year to year as the water clarity changes. Typically, summer clarity is what dictates the growth of plants so Secchi disk depth readings taken during the summer can estimate changes in size of the littoral zone. Average summer Secchi disk depths at Lake Iroquois have been between 2.8 and 4.6 meters for several years. Secchi disk depth on the day of our survey September 11, 2014 was 4.2 meters (13.8 feet). However, 5 and 6 meter Secchi disk depths have been recorded at the lake in the past. This suggests that should the LIA become successful at reducing phosphorus loading to the lake which leads to a subsequent decrease in lake phosphorus concentrations and water clarity improves, milfoil will colonize deeper water. NEAR has found milfoil growing in 22 feet of water depth in clear lakes but the plant has a theoretical depth maximum of 33 feet. If milfoil was to expand to the 20 foot contour the coverage would increase to about120 acres, about 70% more than found during our survey.

Aside from the extremely shallow areas dominated by water lilies, there were only two small areas--combined less than seven acres--of the shallower littoral area that were colonized by primarily native plants (*Ceratophyllum echinatum* and *Potamogeton praelongus)*.

Below is a list of all species identified during the September 2014 survey listed from most to least percent occurrence in the lake. Bold species are protected species in Vermont.

Lake Iroquois Aquatic Plant Species List			**Survey Date = September 11, 2014**	
#	**Common Species**		**#**	**Less Common to Scarce Species**
1	Myriophyllum spicatum		6	Potamogeton amplifolius
2	Vallisneria americana		7	Nymphaea odorata (subspecies tuberosa)
3	Nymphaea odorata		8	Ceratophyllum demersum
4	Elodea canadensis		9	Zosterella dubia
5	**Ceratophyllum echinatum**		10	Potamogeton hybrid (crispus x richardsonii)
			11	Chara sp.
			12	Potamogeton perfoliatus
			13	Potamogeton zosteriformis
			14	Polygonum amphibium
			15	**Eleocharis robbinsii**
			16	Potamogeton berchtoldii
			17	Utricularia macrorhiza
			18	Lemna trisulca
			19	Nuphar variegata
			20	Spirodela polyrhiza
			21	Eleocharis acicularis
			22	Nitella sp.
			23	Potamogeton nodosus

Bold = VT protected species

In Lake Iroquois, milfoil has become the dominant aquatic plant in the lake. The plant has so overrun the littoral zone that native aquatic plant species are disappearing. NEAR found 23 species during the September 2014 survey compared with 34 species that were present in the lake in 2012 according to the LIA species roster.

Since 1984, 45 species have been found at one time or another in Lake Iroquois. By 2012, 10 of those species had been lost including two species of special concern, Vasey's pondweed (*Potamogeton vaseyi*) and straight-leaf pondweed (*Potamogeton strictifolius*). By 2014, a further 12 species were no longer found in the lake (4 of these species are shoreline plants which may still be present in the lake as NEAR didn't pay special attention to the shoreline during our survey). There were two species of special concern that were found in 2012 but not by NEAR in 2014: lesser bladderwort (*Utricularia minor*) and Nuttall's waterweed (*Elodea nuttallii*).

Excluding shoreline plants, species that were present in 2012 and not found during the 2014 NEAR survey include: *Lemna minor, Najas flexilis, Elodea nuttallii* (Uncommon in VT), *Potamogeton gramineus, Potamogeton spirillus, Potamogeton alpinus*, *Ranunculus* sp. and *Utricularia minor* (Rare in VT). Interestingly NEAR found *Eleocharis robbinsii* in 2014, which is the first occurrence of this state listed plant in the lake. NEAR also found a hybrid *Potamogeton* species identified by Barre Helquist as *P. richardsonii X crispus*. It is possible that some, or all, of these species are still present in the lake but have become so scarce as to make them virtually impossible or very difficult to find, essentially requiring each square meter of the littoral zone to be thoroughly investigated. These searches require specific detailed surveys designed to locate and map scarce plants.

If Eurasian milfoil continues to dominate the littoral zone, expanding its dominance from 74% surface coverage noted during this survey, expect to keep losing species diversity in this once vibrant plant community.

Milfoil control options

There are only a few ways that aquatic plant infestations can be effectively controlled. Essentially, it comes down to using herbicides which give the best scale of control for the money spent. Other methods–other than drawdown—are considerably more expensive, and have smaller scale of control. The only other large scale control method that is inexpensive is triploid grass-carp which is currently illegal in Vermont. The non-chemical methods are; hand-pulling, mechanical harvesters, drawdown, or milfoil weevils. Table below lists the approximate costs of different options including the two herbicides allowed in Vermont. Each management option has pros and cons so choosing a method correctly suited to the specific situation is necessary. Lake management also involves a significant degree of trial and error with deliberate analysis of success during and after each management attempt. Robust lake management requires considering the lake as a whole so that all management is consistent with all aspects of the water body. Individually attempting management in localized areas without knowing connections to the rest of the lake typically are not successful long-term, or can cause impacts to other sections or areas of the lake—essentially transferring the problem to somewhere else. Once whole lake goals are set and visions established, incorporate before and after survey analysis to assess success or failure based pre-described goals. Annually provide feedback to goal setting and visioning to determine if different strategies are needed for the next year.

Table 1 – Comparisons of different Eurasian milfoil control options:

Control Option	Estimated Cost	Benefits	Drawbacks	Bottom line
Winter Water-level drawdown	None--provided release by gravity is possible	Essentially a free control option	Plant control dependent on a number of environmental variables include winter air temperature and snow cover Winter water level drawdown impacts a number of lake factors including invertebrate populations, fisheries, dissolved oxygen of deep water.	Only controls plant beds that are exposed during winter freeze. Plants below drawdown level survive and possible move out further into the lake Requires outlet structure that allows water release and elevation difference between lake level and downstream
Mechanical harvesting/ cutting	Purchase cost ~ $250,000 per machine + ongoing labor and mechanical upkeep costs Contracting harvesters $5,000/ acre	No chemical herbicides	Heavy plant fragmentation and nearly immediate regrowth Generally increased density of harvested plants and causes rapid spreading, and density of plants	A staging area, disposal grounds, and qualified operational personnel are required Compared to 'mowing one's lawn,' regrowth is inevitable
Diver Assisted Suction Harvesting	$6,000-12,000/acre	No chemical herbicides	Very expensive for large areas of dense beds Slow work progress, re-growth possible	Not usually recommended for whole lakes, better option for small ponds or around personal docks Not likely for long-term control or dense beds
Milfoil Weevils	Based on stocking rate of	No chemical herbicides, biological	Very few stocked lakes report success over time.	Labor intensive stocking, typically two to three years before plants

Euhrychiopsis lecontei	about $1/weevil with many 1000s required	control		are affected, may impact *M. sibiricum*-reported to be in Lake Iroquois a State of VT listed plant
Herbicides				
Fluridone (Sonar) *Systemic*	$300-600/acre	Relatively nontoxic	Chemical treatment dispersed through whole lake, liquid application requires 60-90 days of contract	Typically whole lake treatments Longer irrigation restriction
Triclopyr (Renovate) *Systemic*	$900-1300/acre	Low toxicity to aquatic organisms Can be applied only to infested areas	Requires higher dose than Fluridone for effective milfoil control	Less effective chemical treatment, requiring a higher dose

At this time, the infestation is seriously out of control and calls of a significant method to reclaim the lake and the native aquatic plant community it once had. Although it appears that milfoil has spread to its maximum extent this is not the case. Existing beds of milfoil will continue to increase in density, that is plant material per square meter will increase, and spread to areas that did not have milfoil—there were in fact a few areas along the east and south sides where we did not find dense milfoil stands. The plant will also slowly creep out further into deeper water as root runners of the deep water plant extend outward, and more quickly if water clarity improves. Increased density of existing milfoil will further limit native plant survival. Weed control strategy ideas are offered here for review.

Option 1: Conduct a whole lake Fluridone treatment (probably about $150,000). Since this herbicide is applied as liquid and the whole lake is dosed, it affects all the Eurasian milfoil in the lake, such that the following year there will be virtually no Eurasian milfoil in the lake. The principal drawbacks to this approach are that many other aquatic plant species in the lake will also be affected, and the chemical needs to remain in the lake for 60-90 days. However, with such a dramatic loss of native species over the last several years, the remaining species in the lake now are all in jeopardy of loss. It is possible for milfoil to overwhelm most of the remaining submersed aquatic plants in the lake. It is likely that some of the common submersed plants will continue to exist but to what extent this will occur is very uncertain and will remain to be seen. However, with fluridone, Eurasian milfoil will also return in the following years but at a much reduced degree of cover and a much lower density such that most of the littoral zone of the lake will remain open for 2-4 years. During this time the seed bank and dormant root stocks of natives will begin to grow. In subsequent years the re-occurring milfoil can be effectively controlled with spot treatments or non-chemical means, leaving native beds to colonize. Over time native species will return.

Option 2: Conduct a deep water drawdown during the winter. Provided the lake has capability to lower the lake level during the winter, and there are no shallow wells along the shoreline, a deep water drawdown can be very effective at reducing milfoil density in the exposed area. The deeper the drawdown the more acres of milfoil will be affected. Exposed shore needs at least a week of sub-freezing temperatures for affective control of milfoil. However, drawdown will also affect all other plants in the exposed zone, as well as contiguous wetlands that rely on the lake level for inundation. Drawdown will also affect all the invertebrates in the drawdown zone and may have impacts on fish populations and long-term water quality. Also, prior to any drawdown, simple hydraulic analysis of potential refill volumes should be made to insure that there will be enough runoff in the spring to refill the lake.

Option 3: Treat small areas (10-20 acres) of the milfoil with Triclopyr herbicide sequentially each year. Pick areas where plants are causing severe impairment for first treatments. Such areas would include the channel from the boat ramp to deeper water, along shorelines where the most active use occurs, or where milfoil is interfering with other lake functions. Like Fluridone Milfoil will regrow the following season but a much reduced density and cover, allowing for at least one summer season to be milfoil free in the treated areas.

Option 4: Conduct mechanical harvesting of dense milfoil beds along shorelines were active use is currently impaired. Mechanical harvesters typically cut plants between 4-6 feet below the surface so provides relief from topped-out plant beds. Plants will regrow reaching the surface in a number of weeks so this type of control is very short lived, having the poorest control to dollars spent ratio. Harvested milfoil will need to be off-loaded to shore and removed. Harvesting using mechanical means produces fragments which eventually root and regrow causing spreading. Although there may be significant fragmentation by motor boats occurring now this boats produce considerable less fragmentation than harvesters because boats tend not to drive through milfoil beds all day. This option is not recommended because it will cause fragmentation causing further spread, stimulate lateral shoot formation leading to bushier plants, and cause increased transport of plant material to bottom waters where it will accelerate deep water oxygen loss.

Option 5: Remove Eurasian milfoil using diver assisted suction harvesting. This method is very expensive and efficient only over small areas, typically less than an acre. Areas to be suction harvested have to be chosen carefully because of the limitation on how much can be removed in any given season. Suction harvesting typically shows control for longer periods due to most operators being able to get root material out as well. But, it is not a given that suction harvesters will be attempting to get as much root material out as they can, as in the interest of clearing as much area as possible end up just ripping the plants out and leaving most root material intact. Suction harvesting is suited to small beds and isolated re-growth. This option is not recommended because of the large costs, poor area of control, and relative lack of control over the process.

Option 6: Do nothing. For whatever reason doing nothing always results in nothing getting done. There is a myth that nature will take care of things and if left alone the lake will fix itself. This is not true. Doing nothing allows milfoil to maintain dominance over the lake which includes, the water quality, the aquatic invertebrate community, the fisheries populations, the shoreline animal populations, the recreational use of the lake, and the visual aesthetics. Dense stands of milfoil will cause phosphorus to increase in a lake by at least four ways, 1) bottom sediments in a dense stand of milfoil will become effectively isolated from the atmosphere as vertical mixing in the bed is reduced to near zero. Once isolated, water will become anoxic and internal release of phosphorus will occur. 2) Milfoil is a generally leaky plant in that phosphorus translocated from the sediments into the stems and leaves can leak out of the plant into the water column. 3) Continual build-up of organic matter from annual growth and senescence of huge amounts of plant material causes increased decomposition on the lake bottom both in the beds and in deeper water where accelerated oxygen loss will occur furthering internal phosphorus release from bottom sediments. 4) Dense stands of milfoil will foster growth of periphyton and associated planktonic phytoplankton which increases recycling of phosphorus in the water column where it can be used by, and cause, succession to bluegreen (cyanobacteria) forms. This option is not recommended because over health of the lake is compromised.

Dense stands of any aquatic plant, but most specifically invasive aquatic plants, retard diversity of aquatic insects within the beds. Loss of aquatic invertebrates affects the entire food chain. However, often dense beds of milfoil will pose problems for fisheries in that spawning beds are lost and linkages between young fish and aquatic insects are lost. Sometimes an illusion that milfoil improves fishing occurs because the edge of the milfoil stands are typically well defined making bass fishing off the edge of the beds very productive. However, this is not actually the case because the fish have become concentrated on this edge as there is nowhere else to go and the sources of prey fish has dwindled. When the entire littoral zone becomes a monoculture stand of milfoil, most functional aspects of this highly productive part of the lake are lost.

Increased lake monitoring is required in any event. The temperature and dissolved oxygen, in profile from surface to deepest water, should be measured monthly—beginning after ice-out to October--to track both the location of the thermocline and dissolved oxygen loss in deeper water. The maximum depth of Lake Iroquois is stated as 37 feet (11 meters) with recent water clarity of between 3 and 5 meters typical. These data imply a thermocline depth of about 6 meters, leaving about 5 meters of the lake depth from the thermocline to the bottom that is vulnerable to oxygen loss and subsequent internal loading of phosphorus, ammonium, sulfide, and methane. Water quality collections from different depths in the water are required to determine if phosphorus is being generated from an anoxic bottom layer.

Example of a 5 year plan

2015

Submit application to VT DEC for permit to apply herbicides in 2016

$2,500

Annual aquatic plant survey to document extent of Eurasian milfoil and extent of native species—specifically VT protected species

$5,000

2016

Treat Eurasian milfoil with a whole lake Fluridone herbicide, including notifications

$ 150,000

2017

Two aquatic plant surveys, first in spring, second in late summer

$ 10,000

2018

Two aquatic plant surveys, first in spring, second in late summer

Submission for permit to apply herbicides in 2019

$ 25,000

2019

Spot treat Eurasian Milfoil with Triclopyr -or-

Alternatively: use suction harvesting or bottom barriers on localized beds

$12,500

One aquatic plant survey in late summer

$ 5,000

Note: Cost figures are only estimates and bids should be obtained from actual contractors once LIA decides on their approach and the actual scope of the work.