Lost Lake & Knops Pond

Baseline Assessment Survey Report
November 2011

Prepared for:

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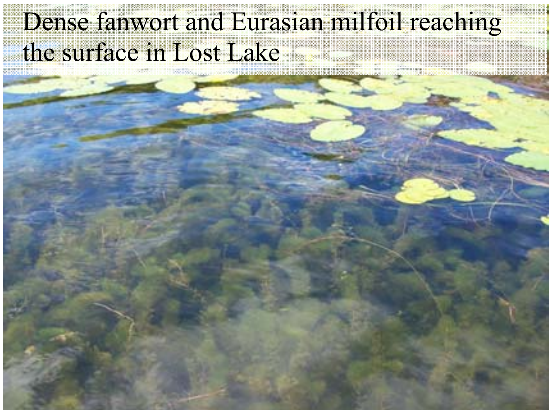
Introduction:

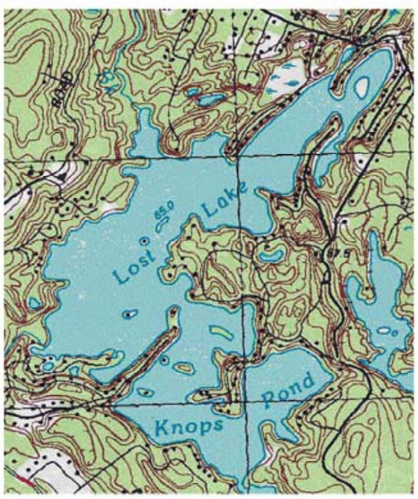


Dense fanwort and Eurasian milfoil reaching the surface in Lost Lake

A Biologist from Aquatic Control conducted a baseline biological survey of Lost Lake and Knops Pond on September 9 and 12 2011. The objective of this survey was to document current vegetation growth and water quality conditions in the waterbody and to provide management recommendations. Tasks included in this field inspection consisted of a vegetation survey, representative measurements of sediment depth and type, measurements of water depth, water quality sampling, water clarity measurements and algal identification and enumeration. The survey days were sunny with little wind, allowing for good visualization of the pond below the water's surface. Results of the survey are presented first followed by a discussion of management options and recommendations.

Site Description:

Waterbody:



Lost Lake and Knops Pond are two interconnected basins that make up an approximately 224 acre waterbody located in Groton Massachusetts. Martin's Pond Brook and an un-named brook in the south-western corner of Lost Lake comprise the primary inlets for the waterbody. The outlet of the waterbody is located in the north-eastern corner of Lost Lake. Here water exits Lost Lake and travels approximately 1600 feet before entering Whitney Pond.

Watershed:

Land Use Type	Area
Brushland/ Successional	21.8
Cropland	107.8
Forest	1174.4
Forested Wetland	122.2
Golf Course	14.2
High Density Residential	19.2
Low Density Residential	201.6
Medium Density Residential	32.9
Multi-Family Residential	29.8
Non-Forested Wetland	116.9
Open Land	19.8
Orchard	32.3
Participation Recreation	22.6
Pasture	79.9
Powerline/Utility	64.5
Transitional	0.3
Urban Public/Institutional	20.1
Very Low Density Residential	105.8
Water	241.5
Water-Based Recreation	0.3
Total	2427.8

The watershed of Lost Lake and Knops Pond was estimated using a USDA topographical map. The watershed is depicted on figure 3 and encompasses an area of 2427.8 acres. A watershed is defined as the land area from which surface water drains into a given lake or pond. Land uses and activities within the watershed can affect water quality and quantity. Figure 3 shows the reported land uses based on 2005 data compiled from the MA DEP and the table (left) summarizes the proportions of the different land use types in the watershed. Reviewing this information is a good place to begin addressing watershed management techniques and can form a basis for further investigations and monitoring (see watershed management section).

Survey Methods and Results:

Water Clarity, Water Depth and Sediment Depth:

Water Clarity was measured using a Secchi disk over the deep hole of each basin. The water clarity measurements at Lost Lake and Knops Pond were 13.3 feet (4.1 meters) and 13.5 feet (4.1 meters) respectively on the day of the survey. These clarity readings are desirable for a waterbody of this size and type.

Water depth measurements were collected utilizing a calibrated pole at predetermined locations throughout the littoral zone. The littoral zone of a lake or pond is defined as the area close to shore where light can penetrate to the bottom. The littoral zone for both basins is were areas where the water depth was less than 15 feet. The average water depth in the littoral zone observed at Lost Lake and Knops pond were 7.4 feet (2.3 meters) and 8.5 feet (2.6 meters) respectively. Reportedly, water depths exceed 15 feet in Lost Lake and 30 feet in Knops Pond.

Sediment is characterized as muck, sand, gravel or peat. The average unconsolidated (soft) sediment depth was determined by pushing a calibrated pole into the soft sediment until a firm refusal layer is reached. The unconsolidated sediment in the two basins varied in characterization (see table 1) but was primarily composed of muck. The average unconsolidated sediment depth measured in the littoral zone was approximately 3.3 feet in Lost Lake and 1.9 feet in Knops Pond.

Vegetation:

Water chestnut plant on the surface with fanwort growing below

The vegetation survey was conducted utilizing a variety of techniques including a throw rake, underwater camera system, and visual observations (figure 2). Five non-native invasive species were observed in the waterbody including fanwort (*Cabomba caroliniana*), variable milfoil (*Myriophyllum heterophyllum*), Eurasian milfoil (*Myriophyllum spicatum*), spiny naiad (*Najas minor*) and water chestnut (*Trapa natans*). On shore, Japanese knotweed (*Fallopian japonica* syn. *Polygonum cuspidatum*) and purple loosestrife (*Lythrum salicaria*) were also observed.

In Lost Lake moderate to dense patches of variable milfoil and fanwort were observed primarily in the northern most and southern most portions of the basin. Dense patches of Eurasian milfoil were observed throughout Lost Lake. Spiny naiad was observed in two locations in Lost Lake, behind the island in the northern-most cove and in a small section along the south-western shoreline. Two water chestnut plants were also observed along the south western shoreline. These plants were immediately hand-pulled. We recommend that the Association keep a diligent watch for other water chestnut plants and hand-pull them immediately.

Spiny naiad

Japanese knotweed covering the view of a sign warning boaters to check boats and trailers for invasive plant species

Variable milfoil and fanwort were prevalent in the majority of Knops Pond. Eurasian milfoil was far more scattered in this basin as compared to Lost Lake. Water chestnut and spiny naiad were not observed in Knops Pond.

Native in-lake species observed included coontail (*Ceratophyllum demersum*), bladderwort (*Utricularia sp.*), robbin's pondweed (*Potamogeton robbinsii*), floating leaf pondweed (*Potamogeton natans*), waterthread pondweed (*Potamogeton diversifolius*), flatstem pondweed (*Potamogeton zosteriformis*), tapegrass (*Vallisneria americana*) white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegatum*), watershield (*Brassenia schreberi*), Floating heart (*Nymphoides cordata*), duckweed (*Lemna sp.*), watermeal (*wolfia sp.*), Pickerel weed (*Pontederia cordata*), muskgrass (*Chara sp.*) , spikerush (Eleocharis sp.), bur-reed (*Sparganium sp*) and water willow (*Decodon verticillatus*) (figure 2, table 1).

Water Quality:

Two surface water quality sample sets were collected on the day of the survey. The first sample set was collected over the deep hole in Lost Lake and the second set was collected over the deep hole in Knops Pond (figure 4).

To collect the samples, sterile one-liter sample bottles were submersed elbow deep and filled. The samples were sent to a Massachusetts Certified Laboratory to test for pH, alkalinity, turbidity, nitrate nitrogen, ammonia nitrogen, total Kjeldahl nitrogen, total phosphorous, true color, apparent color and E. coli. The results are summarized below in table 1.

Table 1: A Summary of Water Quality Sample Results for 2011

Parameter	Units	Lost Lake	Knops Pond
pH	S.U.	7.19	7.11
Alkalinity	$CaCO_3$/L	28.0	36.0
Turbidity	NTU	0.470	0.56
Total Kjeldahl Nitrogen	mg/L	< 0.1	< 0.1
Ammonia Nitrogen	mg/L	< 0.05	< 0.05
Nitrate nitrogen	mg/L	< 0.1	< 0.1
Total Phosphorous	mg/L	0.0320	0.0145
True Color	Pt-Co	10	5
Apparent Color	Pt-Co	15	10
E. coli	CFU/100ml	ND	ND

pH: pH is a measurement of the concentration of hydrogen ions (h^+) in solution, which reflects the acidity or alkalinity of the measured solution. The pH measurement scale ranges from 0-14, where zero is extremely acidic, seven is neutral, and 14 is the most basic. A pH measurement within the range of 5.5-8.5 S.U. is typical for the northeastern United States and is desired for maintaining a healthy fishery. Maintaining a stable pH ($\pm$ 1 S.U.) is also important, as frequent fluctuations can have adverse effects on water chemistry and fisheries. The pH levels measured in Lost Lake and Knops Pond were both near neutral and within the desired range.

Alkalinity: Alkalinity is a measure of the buffering capacity of a waterbody against acid additions such as acid rain and pollution, which can be detrimental to fish and wildlife populations. Total alkalinity measures the presence of carbonates, bicarbonates and hydroxides and is mostly a function of the surrounding soils and geology. Values below 20 mg/l typically illustrate that the pond may be susceptible to adverse fluctuations in pH (i.e. acid rain). The alkalinity measurements for the samples collected in both Lost Lake and Knops Pond indicate that both the waterbodies should be well buffered against pH fluctuations.

Turbidity: Turbidity is a relative measurement of the amount of suspended particles in the water. Turbidity values can range from less than one to thousands of units, however, values in most healthy ponds rarely rise above 5 NTU and typically <1 NTU in waterbodies used for swimming. The turbidity measurements observed in 2011 were both desirably below swimming standards

Ammonia nitrogen: Nitrogen is an essential element for plant growth. Nitrogen is found in the environment in several forms. High levels of nitrogen can indicate poor water quality. In particular high concentrations of ammonia nitrogen can be toxic to fish. Ammonia is also important due to the fact that it is a by product of the decomposition of organic material. In the presence of oxygen, ammonia is readily converted to nitrate nitrogen. Therefore high ammonia nitrogen concentrations may indicate low oxygen levels to anoxic conditions. Levels of ammonia nitrogen observed in the samples collected at Lost Lake and Knops Pond were all desirably below laboratory detection limits (0.100 mg/L).

Nitrate nitrogen: Nitrate nitrogen is the end product of the nitrogen cycle under aerobic conditions. Nitrate nitrogen is the form of nitrogen that is most readily available to plants as a nutrient source. High levels of nitrate nitrogen indicate an imbalance between the amount of nitrogen entering a system and the amount being utilized by organisms and may also indicate fertilizer or septic system inputs. Excess nutrients may stimulate nuisance plant and algae growth. Generally speaking nitrate concentrations higher than 0.3 mg/l are sufficient to support such nuisance plant and algae growth. Nitrate nitrogen levels were below detectable levels (0.400 mg/L) both waterbodies.

Kjeldahl nitrogen: Kjeldahl nitrogen results signify the amounts of organic or biomass nitrogen and ammonium in a sample. Since this form of nitrogen is not as readily utilized by plants as nitrate nitrogen, concentrations generally need to be greater that 1.0 mg/l to support nuisance algae and plant growth. The levels of Kjeldahl nitrogen in the samples collected from Lost Lake and Knops Pond were all less than laboratory instrument sensitivities. It is important to understand that each sample is representative of a mere "snap-shot" or conditions at a moment in time. As a result, it would be necessary to perform more frequent sampling to establish a more meaningful baseline/mean value for the continually fluctuating nitrogen and phosphorous levels.

Total Phosphorous: Although excess nitrogen can contribute to nuisance plant growth, the ratio of nitrogen to phosphorous in a system is equally important. This ratio will determine which nutrient is the most limiting (i.e.; which nutrient is found in least supply relative to the growth requirements of the plants). Phosphorus is usually the limiting nutrient for plant and algae growth in freshwater systems. Total phosphorus is a reading of particulate and dissolved phosphorus in the water column. Concentrations of 0.03 mg/l or greater are considered sufficient to stimulate nuisance algae blooms. Phosphorous levels were somewhat lower in Knops Pond than in Lost Lake. Both measurements were at or below the concentrations at which we generally observe nuisance algal blooms.

True Color/Apparent Color: Apparent color is the color of the unfiltered water that is caused by both suspended and dissolved matter. True color is measured after the water has been filtered to remove the suspended matter and is therefore the color due to dissolved constituents only. Water color can effect light penetration and, as a result, can limit rooted plant and algae growth. The disparity between true and apparent color can indirectly indicate the amount of suspended material in the water. The results from Lost Lake and Knops Pond indicate low levels of color in the water and that the color of the water is due almost equivalently to dissolved particles and as it is due to suspended particles.

Escherichia coliform: E. coli. is one of many naturally occurring bacteria found within the intestine of humans and animals. The presence of *E. coli* in pond and/or Pond water is indicative of some level of recent sewage or animal waste contamination. The current swimming standard for freshwater is no single sample shall exceed 235 colonies per 100 ml. The bacterial samples taken in both Lost Lake and Knops Pond were below laboratory detection levels indicating acceptable conditions for swimming and other contact recreation.

Temperature and Dissolved Oxygen:

Table 2: Lost Lake temperature and dissolved oxygen profile September 9, 2011

Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)
Surface	23.5	7.40
1	22.7	8.10
2	22.2	7.31
3	22	5.23
4	21.9	5.10
4.5 (off bottom)	21.4	0.21

Table 3: Knops Pond temperature and dissolved oxygen profile September 9, 2011

Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)
Surface	23.4	7.44
1	23.0	7.23
2	22.7	7.07
3	22.6	6.85
4	22.4	5.50
5	21.1	1.65
6	17.6	0.27
7	13.4	0.18
8 (off bottom)	13.0	<0.1

During the September survey a temperature and dissolved oxygen profile was recorded for both Lost Lake and Knops Pond at the deep spot locations (figure 4). The results indicate that Knops Pond is strongly stratified; the thermocline was located between 5 and 6 meters below the surface on the day of the survey. Good oxygenation was observed through the epilimnion of Knops Pond and relatively low oxygen levels were observed through the hypolimnion of Knops Pond. These low oxygen levels are relatively common in late-summer/ early-fall in strongly stratified lakes and ponds.

Stratification was not observed in Lost Lake. The results showed good oxygenation throughout the water column. Biological Oxygen Demand (BOD) near the pond bottom was represented by a sharp decrease in dissolved oxygen at the sediment water interface. BOD is the result of the aerobic breakdown of organic material by naturally occurring microbes.

Algae:

A surface grab algae sample was collected over the deep spots in both Lost Lake and Knops Pond. A third sample was collected along the shore of Knops Pond to analyze as concern had been raised over a brown/red sheen.

In both of the deep spot samples algae counts were relatively low (see attached). These results are consistent with the high water clarity measures observed. Dominant taxa included green algae (*Chlorphytes*), diatoms (*Bacillariophytes*), golden algae species (*Chrysophytes*), euglenoids (*Euglenophytes*), dinoflagelates (*Pyrrhophytes*). No blue-green algae species were observed.

The dominant species in the sample collected of the brown/red sheen was a flagellated euglenoid called *Trachelomonas*. A bloom of this species likely occurred due to a synergy of appropriate conditions (water temperature, nutrient influx etc). We are unaware of any health concerns related to blooms of *Trachelomonas*.

Management Options and Recommendations:

The conditions in Lost Lake and Knops Pond are similar to many other waterbodies in the region. Commonly referred to as "eutrophic", the waterbody is characterized by high biological productivity, excessive aquatic plant growth, increased sedimentation, and a nutrient-rich mucky bottom. Eutrophication (or "aging") of a pond is a natural process but can be accelerated due to pollution, invasive species expansion, development and wildlife activity.

In broad terms, lake management can be broken down into in-lake and watershed management techniques. In addition to active management, it is also recommended to conduct on-going monitoring of vegetation and water quality.

At the points sampled in our 2011 survey, the average percent of area covered by invasive species was 29 percent for Lost Lake and 43 percent for Knops Pond. This coverage is likely growing annually. As such the focus of our recommendations is on the management of nuisance aquatic plant species.

In-Lake Management Techniques:

In-lake management techniques are typically broken down into mechanical, physical, chemical and biological methods. The following is a discussion on the applicability of each technique to Lost Lake and Knops Pond.

Mechanical Techniques:

Mechanical techniques include mechanical cutting/harvesting and hydro-raking. Harvesting involves cutting the nuisance weed growth below the water's surface and collecting the cut plants for removal from the pond. In most cases, harvesting provides only short term control of the target plants and multiple cuttings over the course of a season may be required to maintain desirable conditions. Repetitive annual harvesting of some annual (seed producing) plants such as water chestnut or certain pondweed species, however, may result in long-term control.

In general, as compared to other vegetation control techniques, harvesting will be more expensive per unit area and will provide shorter term control. At Lost Lake and Knops Pond the use of volunteer efforts allow for budget conscious control. Reportedly the residents of Lost Lake and Knops Pond currently harvest the invasive weeds all summer long in order to maintain some level of open water for recreation and wildlife use. It should also be noted that fanwort, variable milfoil, Eurasian milfoil and spiny naiad all spread by fragmentation and as such harvesting will likely lead to an increase in density and distribution of these species.

Harvesting will not provide long-term plant control at Lost Lake and Knops Pond but does seem to provide some cost effective relief of nuisance conditions.

Another mechanical technique is hydro-raking. A hydro-rake can be described as a floating backhoe. The hydro-rake rakes the pond bottom and removes the plants including the root systems and associated hydrosoils. The Hydro-Rake is powered by hydraulic paddle-wheels and is capable of working in as little as 1.5-feet of water. Hydro-raking is typically not recommended for control of submersed plants especially those species that can reproduce through vegetative fragmentation, but rather for emergent plants, like cattails, and floating leaf plants, like waterlilies. Control of submersed plants is seasonal at best, while control of plants with significant root-systems can be 2-3 years or more. Hydro-raking would not be the method of choice for widespread control of submersed plants, but could be effective on areas of emergent vegetation and waterlilies and would be a valuable tool to clean individual shorefronts of leaf litter and other debris.

Chemical Treatment:

Chemical treatment is a recommended approach for control of invasive submersed weeds in Lost Lake and Knops Pond. Treatment with USEPA / State registered aquatic herbicides and algaecides does not pose an unreasonable risk to the environment or human health when used by licensed applicators in accordance with the product label.

Assuming the outflow could be held or retarded, the herbicide of choice for control of nuisance plant growth would be Sonar (fluridone). Sonar is a systemic herbicide that will provide control of Eurasian milfoil, variable milfoil, spiny naiad and fanwort for multiple years before a second treatment is required. Other herbicides can provide control of the milfoil species and naiad but fluridone is the only herbicide, currently registered in Massachusetts that will control fanwort. Clipper (flumioxazin) a new contact herbicide, may provide an option for annual control when it is registered by the state of Massachusetts. The density and distribution of fanwort has reportedly increased over the last several years. During our survey the high impact of the species on recreation and wildlife habitat was apparent. In areas of mixed assemblage (fanwort and milfoil) if the milfoil were controlled and fanwort were left to grow unabated, then fanwort would likely fill in the gaps where milfoil had been.

Sonar works slowly and requires a 45-60 day contact time with the plants to work effectively. The toxicity of Sonar is considered to be very low and it can even be used in drinking water reservoirs. Sonar can be applied as either a liquid (which provides

Nutrient precipitation/inactivation treatments are designed to make phosphorus (the primary nutrient that feeds algae growth) biologically unavailable. This type of treatment involves applying a metal salt, usually aluminum sulfate (alum) to sequester the phosphorus and settle it to the bottom of the Pond. Depending on pH and alkalinity, a buffering compound may also need to be applied. Alum treatments can be performed with a low dose to remove only the phosphorus from the water column (precipitation) or with a higher dose to also inactivate the top layer of sediment which can release phosphorus to the water under anoxic conditions.

Alum treatments are not appropriate for all waterbodies and further study would be needed including sediment/water testing, phosphorus/hydraulic budgets and bioassays. Given the levels of phosphorous observed in our first round of water quality tests, we do not anticipate that phosphorous inactivation will be necessary.

Physical Control Techniques:

Benthic weed barriers are used to cover the bottom of the Pond and control weed growth by shading and compressing the plants. Benthic weed barriers are typically used in small beach or dock areas and are not economical for control of large infestations. Barrier costs are in the range of \$1.00-\$1.50/ft^2 installed. Barriers would not be appropriate for widespread control of plants due to the lack of selectivity of this technique for plant control and the potential for the widespread hindering of access to the sediments by macro-invertebrates. However they would a good tool to clear small areas around docks or swim areas, if chemical treatment is not selected as a management option. We have seen some success with placing a barrier in an area for approximately six weeks to kill the plants below and then moving it to another location. The length of time required to kill the vegetative portion of the plants varies from lake to lake with sediment thickness, infestation size and density and water chemistry. This method would allow access to the lake bottom for aquatic organisms and would save the cost of buying enough barrier to cover the whole bottom. That said, barrier can be left in one location for the entire season, if desired. We recommend cleaning the silt off annually at a minimum to prevent plants from growing on top of the barrier. Although the barrier can be left in over the winter, we generally recommend removing it in the fall, cleaning it off, storing it over the winter and then redeploying it in the spring.

Pond dyes are intended to color the water and reduce the amount of sunlight that is available to feed weed and algae growth. These dyes are only marginally effective and not generally recommended for natural ponds with a flowing outlet.

Aeration of the water provides many good benefits, including oxygenation and circulation, but properly designed systems for large waterbodies can be prohibitively expensive and will not control rooted plant growth. Large waterbodies are also usually naturally well-oxygenated unless severely polluted and/or very deep. Oxygen levels observed in Lost Lake and Knops Pond would not justify the installation of an aeration system.

Dredging is usually a very costly technique and planning/permitting alone can often cost in the range of $20,000 or more. Since there is a moderate amount of sediment collected in the Pond, it would probably benefit somewhat from dredging, however the cost of such a project would likely be very high, with no guarantees that additional vegetation management would not be required. Based on an approximate unit cost of $20-$40 per cubic yard, dredging just 2-feet of sediment over a 2-acre area would cost in the range of $125,000-$250,000. A dredging feasibility study would be required to provide more details about a possible dredging project.

Drawdown is a commonly used and typically low-cost technique that can provide control of rooted plants in some waterbodies. The principal mechanism through which water level drawdown controls aquatic plants is exposure to unfavorable climates for an extended period of time. This is accomplished by lowering the water level of the waterbody and exposing the target plants to the open air, essentially killing the plants and certain reproductive structures, due to the combined effects of sustained freezing and/or drying. Water level drawdown can be performed during the summer or winter months, but due to several factors, including environmental impacts, waterbody usage, ability to refill and the added benefit of freezing temperatures, drawdowns are usually performed throughout the fall and winter months. The necessary waterlevel control structures are in place to control the water level. However, due to the shallow contours of the waterbody we would caution against a deep drawdown. Massachusetts Fish and Wildlife department should be consulted prior to drawdown to ensure adequate fish habitat is maintained. Reportedly the association is currently limited to a maximum 30 inch drawdown due to shallow wells. A drawdown of this depth will not provide complete control but may be worth considering as part of an integrated management program.

Biological Control Techniques

There are no plant specific biological agents known to be effective on the nuisance aquatic species present in Lost Lake and Knops Pond that are permitted in Massachusetts.

Watershed Management:

Only limited water quality data (chemistry, temperature, dissolved oxygen and clarity) was collected as part of this survey and a more detailed investigation would be necessary to identify watershed nutrient sources and assess the potential methods for mitigation.

Watershed management involves identifying and mediating or eliminating sources of nutrients and/or pollution in the watershed. The process of identification involves a thorough survey of the watershed area and further water testing, including sampling upstream tributaries and waterbodies. Samples are taken throughout the year to reflect both base flow and storm flow conditions. Calculation of the potential nutrient load can be made from land-use data using accepted coefficients. "Nearby" watershed areas must also be evaluated and include the residential lots around the ponds and direct runoff from the surrounding streets and other impervious areas.

Such a study is normally referred to as a "diagnostic/feasibility" study and can cost upwards of $20,000 or more. The ultimate goal of such as study is a review and cost vs. benefit analysis of "best management practices" (BMP's) which can be implemented by the Town and pond residents. The following list describes a selection of some common watershed management options broken down into two categories:

Source Control

Limit impervious area – Impervious areas such as parking lots, driveways, buildings and roads interfere with the natural absorption and filtering of storm water through soils. Limiting impervious areas will reduce flow volumes and mitigate plug flow of nutrients into the watercourse.

Minimize contaminant exposure – Regulating the use of potentially hazardous chemicals and other nutrient sources in the watershed area.

Control of fertilization, pet & yard wastes – Educational campaigns or ordinances to increase awareness of proper processing of pet & yard wastes and the control of fertilization practices (use low or no phosphorous fertilizers and only if necessary) and other activities which introduce nutrients in the watershed (ex. car washing). Establishing practices to limit nuisance waterfowl, such as signs warning against feeding, can also eliminate a significant source of nutrients.

Land Management – Minimizing introduction of land uses that have potential to negatively impact the ponds and preservation of natural woodland areas through review of the zoning laws in the watershed will prevent increases in nutrient loading. Possible development and adoption of a Town watershed protection by-law will also aid in this endeavor.

Street Cleaning – Frequent cleaning of any paved roadways in the watershed and maintenance of catch basins will promote cleaner storm water runoff.

Transport Mitigation:

Where substantial impacts have already been identified, some method of transport mitigation can be employed to minimize the pollution load from these sources.

Buffer Strips – Vegetated buffer strips of grass and/or shrubs can act as a biofilter to mediate nutrients from non-point sources before they enter the waterbody.

Catch Basins/Grease & Grit Traps ,Detention Basins, Infiltration Systems, Rain Gardens – For point source runoff from drainage systems, construction and/or improvement of catch basins, detention basins or infiltration systems can significantly reduce the nutrient load of stormwater inflow.

Constructed Wetlands – For larger areas, simulated wetlands can act as both settling/detention basins and help to process nutrients from runoff.

Watershed management and source control are important to the long-term health of the pond system. While there did not appear to be major nutrient concerns during our survey, it is always a good idea to monitor the watershed for changes in land-use and potential sources of nutrient loading. The simplest techniques can be implemented right away through education, including proper septic system maintenance, proper fertilization procedures, maintenance of buffer strips and minimizing use of potential contaminants/nutrients.

Even if a watershed management plan is enacted, actual improvement of the pond condition will be a slow process. Nutrient recycling within the system will likely support growth of nuisance plants and algae indefinitely. Eutrophication is a natural process and although we can attempt to slow its progress, some type of in-pond management is usually necessary.

<u>Monitoring:</u>

To maintain surveillance of the water quality and vegetation in Lost Lake and Knops Pond, we recommend initiating an annual monitoring program to include one to two rounds of water quality data and a mid-late summer vegetation survey. Samples should be collected late in the season both at the surface and within the hypolimnion for phosphorous to determine if internal nutrient cycling may be an issue. A temperature/dissolved oxygen profile and Secchi Disk transparency measurement should also be taken.

We would also recommend the association look into possible funding for a boat-ramp monitor at the public launch. A boat-ramp monitor will not only help to catch invasive plants coming in and out of the lake but will also serve to remind users of the lake about the importance of invasive species control.

<u>Permitting:</u>

Lost Lake is located within a rare species priority habitat area. As such a MESA form will need to be filed with the Notice of Intent. Reportedly the rare species, *Sparganium natans,* was observed in Knops Pond in 1992. The area where this species was previously observed was in shallow water along a small section of the water's edge of Knops Pond. As the Sparganium natans observed was the submersed form it may be impacted by a Sonar treatment. The species has not been observed since this initial observation. We are waiting for the final report from a survey conducted by NHESP in 2011 in order to make final recommendations regarding this species. If the species is located in the lake again, then we would recommend the use of a water impermeable limno barrier to hinder the movement of herbicide into the areas where it is found. We have used water impermeable barriers elsewhere in the state to protect at risk species.

Summary of Management Recommendations:

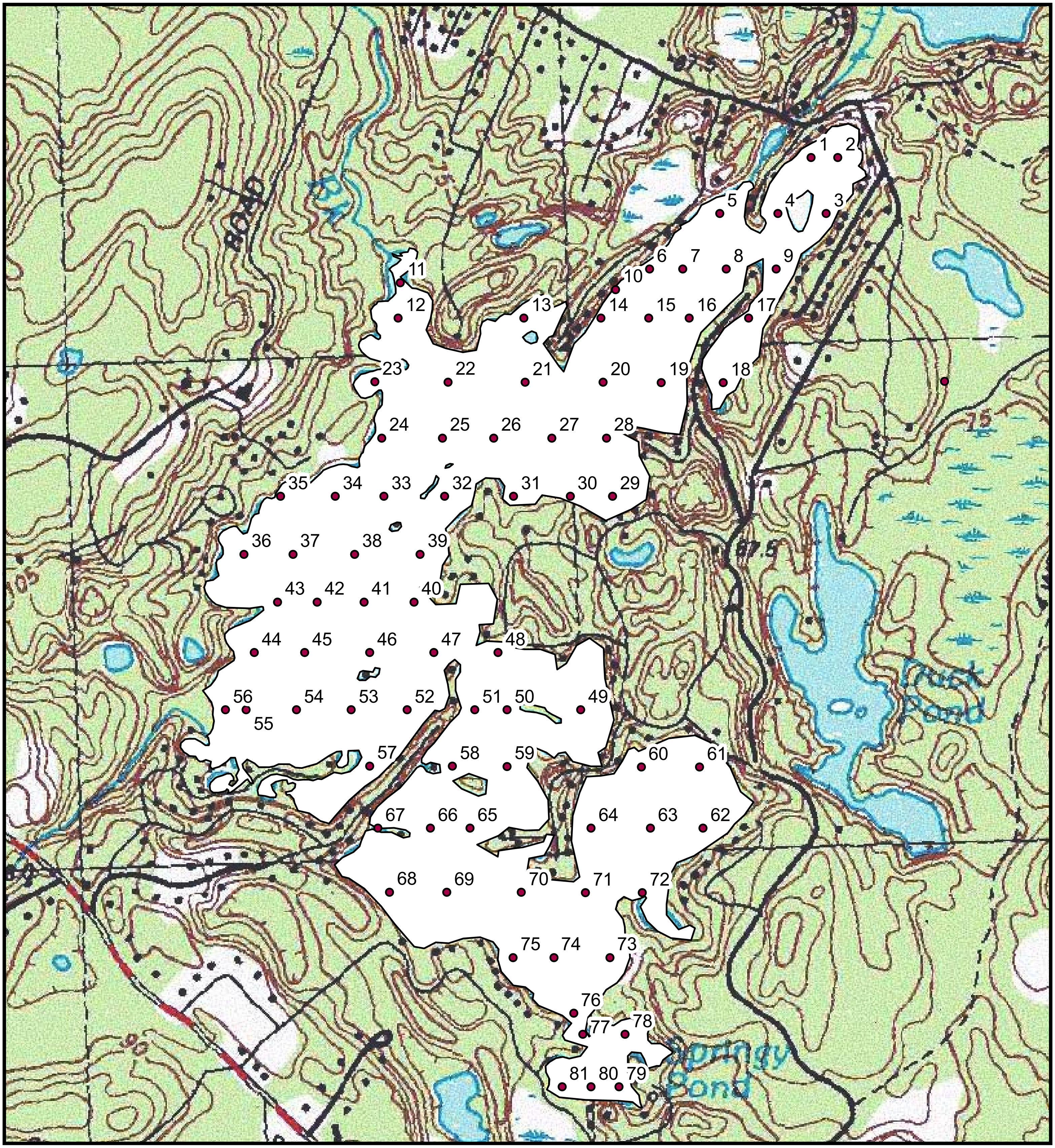
In summary, we recommend the following:

- Formulate long-term management objectives and develop and integrated plan to be implemented
- File a Notice of Intent with the Conservation Commission that conveys all objectives and management techniques that may be implemented including but not limited to:
    - Whole lake Sonar treatment
    - Treatment of non-native shoreline species, Japanese knotweed and purple loosestrife, with Aquapro (glyphosate)
    - Physical management techniques for small patches of re-growth in the years between treatments (Hand-pulling, suction harvesting and/or bottom barrier)
    - Spot-treatment with EPA approved herbicides for re-growth that is too extensive for physical management techniques
    - Limited winter drawdown (if permissible)
    - A volunteer effort to search for and hand-pull water chestnut
    - Annual water quality and vegetation monitoring

We hope that this information will aid you in future management decisions. If you have any questions or require additional information, please do not hesitate to contact our office.

APPENDIX

- Figure 1 – Survey Point Locations
- Figure 2 – Vegetation 2011
- Figure 3 – Watershed Land Use
- Figure 4 – Water Quality Sample Sites
- Field Data Table



Lost Lake and Knops Pond

Groton MA

Transect Point Locations

FIGURE:	SURVEY DATE:	MAP DATE:
1	9/9 &12/11	10/24/11

Legend

N

● Transect Point Location

0 500 1,000 2,000 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
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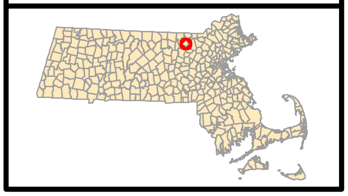
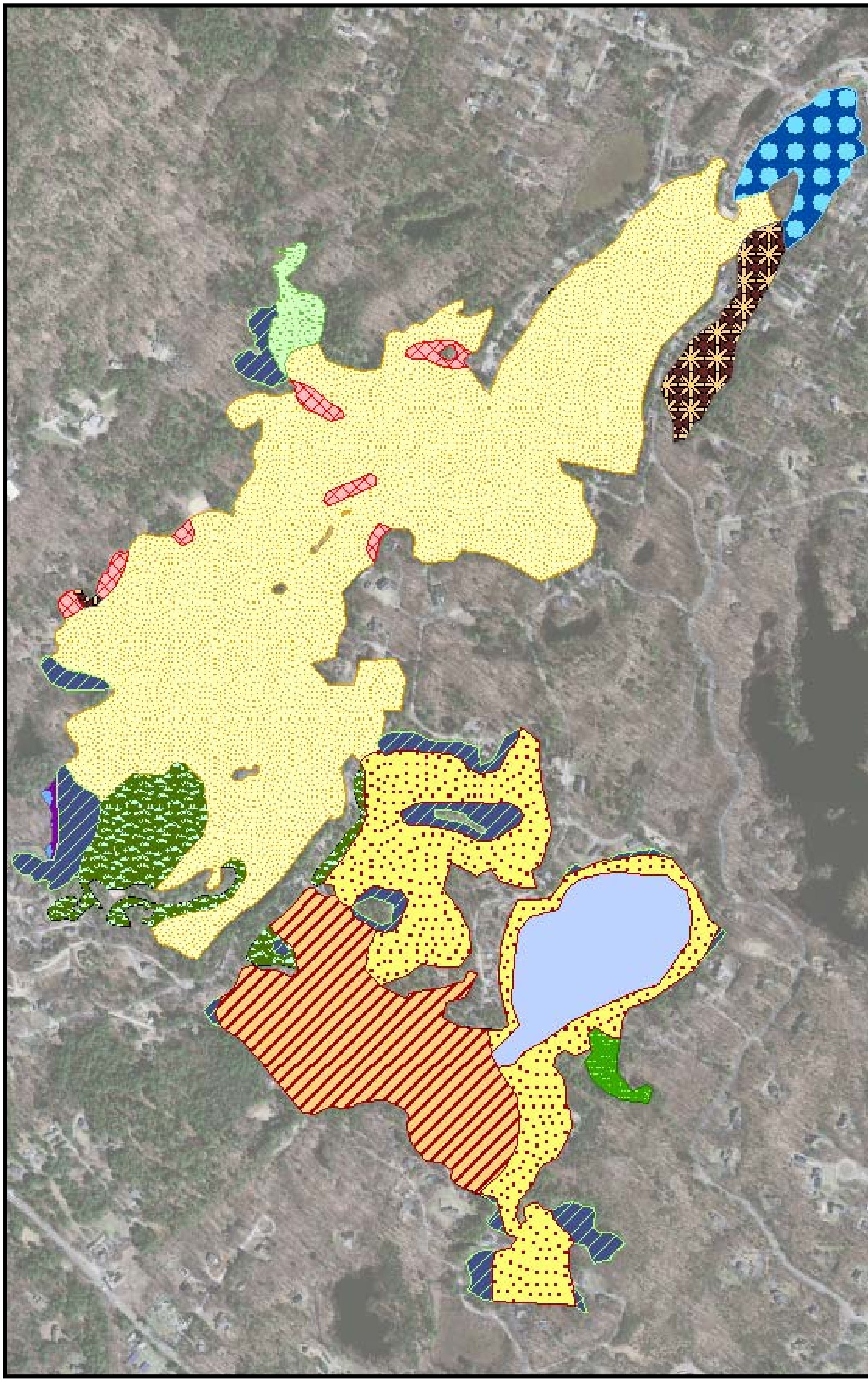
WEB: WWW.AQUATICCONTROLTECH.COM





Legend

- Dense fanwort growing to the surface with patches of varaible milfoil intermixed
- Fanwort and variable milfoil doimant with lesser amounts of robbins pondweed, bladderwort, thinleaf pondweed, Eurasian milfoil and waterlilies
- Fanwort, variable milfoil, eurasian milfoil and spiny naiad doimant with lesser amounts of robbins pondweed, tapegrass bladderwort, thinleaf pondweed, and waterlilies
- Surface cover of duckweed and watermeal with an understory of Eurasian milfoil fanwort coontail and Robbin's pondweed
- Moderate to high density cover of variable milfoil and fanwort
- Patchy distribution of high density variable milfoil and fanwort with lesser amounts of Robbin's pondweed, bladderwort, tapegrass and waterlilies
- Dense topped out Eurasian milfoil
- Moderate to dense bottom cover of Robbin's pondweed with lesser amounts of Eurasian milfoil, tapegrass, coontail bladderwort and waterlilies
- Dense spiney naiad which transitions to dense muskgrass near shore
- Light growth of filamentous algae
- Waterlily growth dominated by white and yellow waterlilies and watershield
- Wetland area: dominant aquatic plants include, waterwillow, burreed, waterlilies, tapegrass, bladderwort, and floatingleaf pondweed

Lost Lake and Knops Pond

Groton MA
Vegetation 2011

FIGURE:	SURVEY DATE:	MAP DATE:
2	9/9 &12/11	10/24/11

N

0 500 1,000 2,000 Feet

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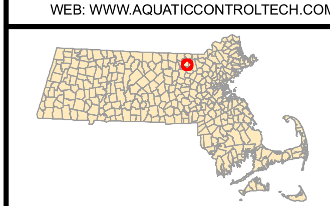

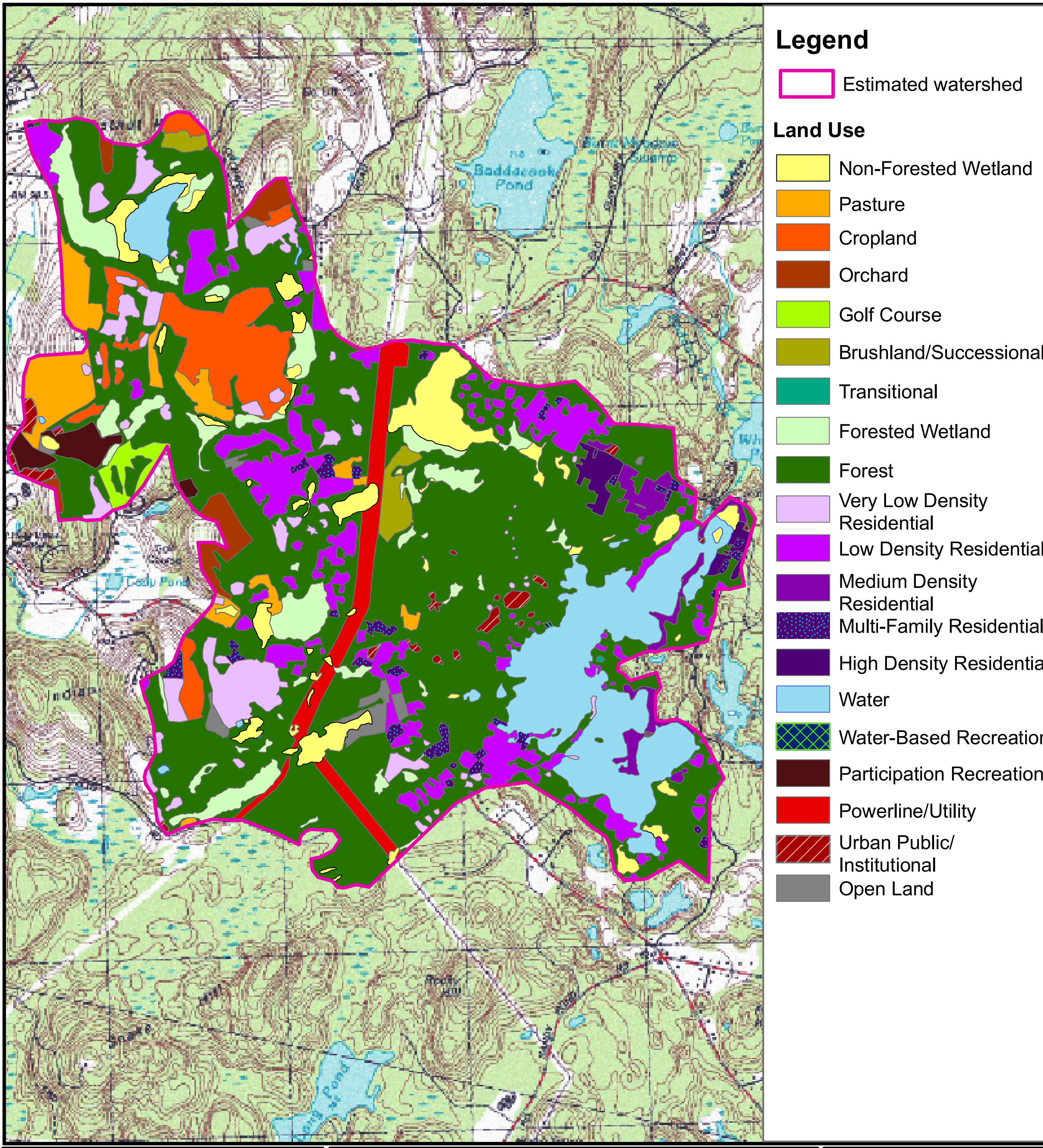

Lost Lake and Knops Pond

Groton MA
Watershed Land Use

FIGURE:	SURVEY DATE:	MAP DATE:
3	9/9 &12/11	10/24/11

Land Use Destinctions Source:
Mass GIS 2005 http://www.mass.gov/mgis/lus2005.htm

N

0 2,500 5,000 Feet

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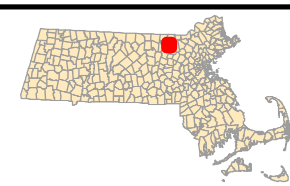

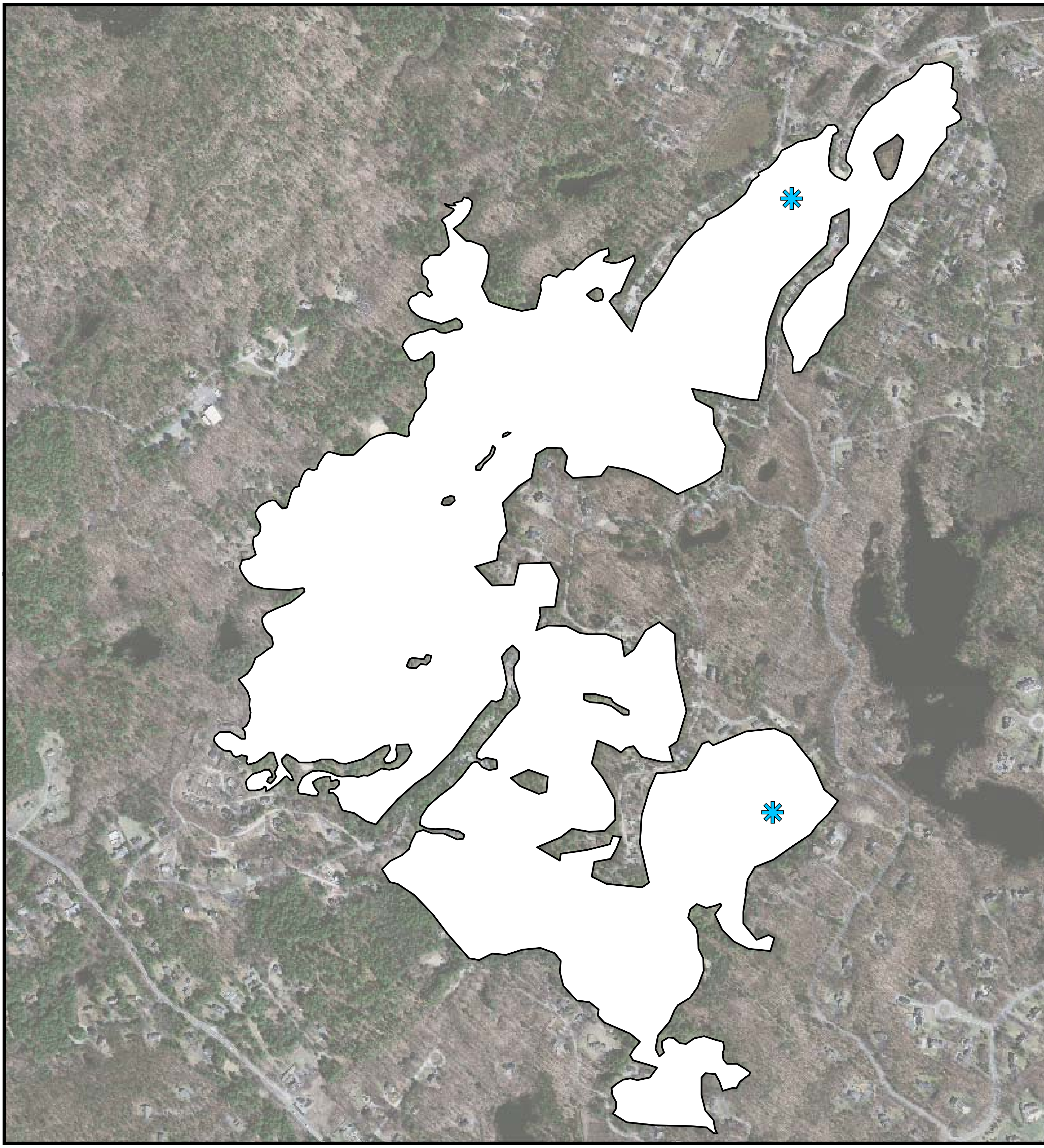

Legend

Water quality sampling site

0 500 1,000 Feet

N

Lost Lake and Knops Pond

Groton MA
Water Quality Sample Site Locations

FIGURE:	SURVEY DATE:	MAP DATE:
4	9/9 &12/11	10/24/11

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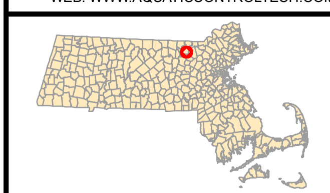

Point Number	Water Depth	Sediment Depth	Sediment Type	Biomass	Percent Cover	Invasive Species Percent Cover	Plant Species Percent Cover																				
							Cabomba caroliniana	Myriophyllum heterophyllum	Myriophyllum spicatum	Najas minor	Ceratophyllum demersum	Potamogeton robbinsii	Potamogeton zosterformis	Potamogeton natans	Potamogeton diversifolius	Utricularia vulgaris	Utricularia purpurea	Isoetes sp.	Eleocharis sp.	Valisneria americana	Nymphaea odorata	Brassenia schreberi	Nymphoides cordata	Nuphar variegatum	Lemna sp.	Wolfia sp.	Chara sp
1	7	4	muck	4	100	90	50	30	10			10															
2	5.5			2	100	80	20	5	5	50		5				1				5	5	5					
3	7	3	muck	3	100	38	20	10	5	3		60											1				
4	7			3	100	90	20	60	10			10															
5	11			1	80	10	10					70															
6	8			1	100	0						100															
7	9.5	13	muck	1	100	10	10				10	80															
8	11			1	100	0						100															
9	7.5	3.5	muck	2	100	70	8	60	2			20															
10	8			1	100	0						100															
11	3.5	2	muck/sand	3	60	50	30		20												8				1	1	
12	4			4	70	60	40		20																5	5	
13	6	0.33	muck/sand	3	100	30			15	15		60								10							
14	8			1	100	0						100															
15	8.5	3.5	muck	1	100	0																					
16	9			3	90	5			5		40	45															
17	6.5	3	muck	4	70	51	40	10	1			15										4					
18	5.5			4	100	66	60	6			1	30										3					
19	11	>2	muck	1	100	0						100															
20	8			2	100	5			5		10	85															
21	7.5	4	muck	2	100	10			10		5	85															
22	8			2	100	10			10		10	80													5	5	
23	6	1.5	muck/rock	4	100	15	5		10		5	60	2							10		5		3			
24	7			3	100	10			10			70								20							
25	8.5	3.5	muck	2	100	20			20		40	40															
26	10			2	100	20			20		20	60															
27	8	4.0	muck	2	100	10			10		30	60															
28	7			2	80	0						30								50							
29	7	3.0	muck	2	100	10			10			85								5							
30	7.5			2	100	10			10		20	70															
31	7.5	4.0	muck	2	100	10			10		90																
32	8			2	85	10			10			70								5							
33	10	>3	muck	3	90	30			30			60															
34	8			3	100	70	20	10	40			30															
35	8	2.0	muck/sand	4	100	40		10	30			45									10	5					

							Plant Species Percent Cover																				
Point Number	Water Depth	Sediment Depth	Sediment Type	Biomass	Percent Cover	Invasive Species Percent Cover	Cabomba caroliniana	Myriophyllum heterophyllum	Myriophyllum spicatum	Najas minor	Ceratophyllum demersum	Potamogeton robbinsii	Potamogeton zosterformis	Potamogeton natans	Potamogeton diversifolius	Utricularia vulgaris	Utricularia purpurea	Isoetes sp.	Eleocharis sp.	Valisneria americana	Nymphaea odorata	Brassenia schreberi	Nymphoides cordata	Nuphar variegatum	Lemna sp.	Wolfia sp.	Chara sp
36	8			3	100	90	70	10	10			5								5							
37	8	3.0	muck	3	100	40	10	10	20			40															
38	7.5			2	90	10			10			80															
39	8	4.0	muck	3	100	20			20			60								20					10	10	
40	7.5			3	100	10	5		5			30								60							
41	7	5.0	muck	1	100	0						100															
42	8			2	100	30		10	20																		
43	4	0.0	rock/sand	1	5	0												5									
44	7			4	100	80	10	60	10			18		2													
45	7	4.0	muck	3	100	15		10	5							5				80							
46	7			2	100	2		1	1			48								50							
47	7.5	2.5	muck	2	95	15		10	5			10								70							
48	7			4	100	90	50	40													10						
49	6.5	2.5	muck	4	100	45	20	20	5					5						10	10	20					
50	6.5			3	100	30	20	10											30		20	20					
51	7.5	5.5	muck	3	100	40		40				15			15					30							
52	7			2	100	10		5	5			30								60							
53	7	4.0	muck	2	100	20		20				80															
54	7			3	100	100	80	20																			
55	6.5	2.5	muck	4	100	90	90													5				5			
56	4			4	100	30	5	5		20										20	10	5		5			30
57	7	1.5	muck/sand	3	100	80	70	10												20							
58	6			2	60	50	30	20							5				5								
59	4	0.0	rock/sand	0	0	0																					
60	>15			1	5	5	5																				
61	>18			0	0	0																					
62	>15			0	0	0																					
63	>20			0	0	0																					
64	>15			0	0	0																					
65	10.5			3	90	90	80	10																			
66	9			2	90	90	10	80																			
67	6	4.0	muck	4	100	100	90	10																			
68	10			2	95	90	80	10								5											
69	>15			2	50	50	50																				
70	13		rock	3	40	40	20	20																			

Point Number	Water Depth	Sediment Depth	Sediment Type	Biomass	Percent Cover	Invasive Species Percent Cover	Plant Species Percent Cover																				
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71	>15			1	10	10	10																				
72	4.5	0.0	sand	3	90	60	20	40						10						20							
73	13			3	80	80	80																				
74	>15			2	60	55	40	15								5											
75	14			2	50	50	50																				
76	6	0.0	sand	1	95	5	5																				
77	6	0.5	sand	1	100	80	40	40								10			10								
78	7			4	100	30	20	10									20		20		10						20
79	13.5			2	70	60	20	40													10						
80	14			2	20	10		10											10								
81	5.5	2.5	muck	4	100	60	30	30						10			10		10			10					