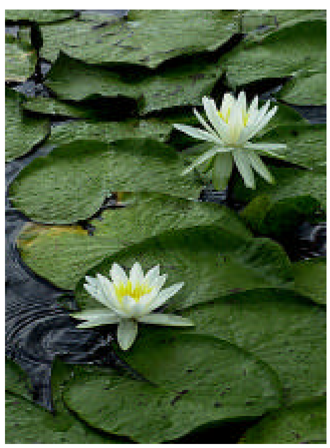
2003 LAKE ONOTA
AQUATIC VEGETATION ASSESSMENT



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SECTION 1: Introduction

1.1 Project Purpose

GeoSyntec Consultants (GeoSyntec) was contracted by the Massachusetts Department of Environmental Protection (MA-DEP) to conduct a comprehensive mapping and assessment of the aquatic vegetation in 617-acre Lake Onota (Pittsfield, MA) during the summer of 2003. The purpose of this project was to:

1. Provide an update on the composition and distribution Lake Onota's macrophyte community according to the macrophyte survey standards of the MA-DEP.

2. Provide training to volunteers from the Lake Onota Preservation Association (LOPA) in macrophyte identification and mapping through a training workshop and development of a **"*Field Guide to the Aquatic Plants of Lake Onota*"**.

3. Provide recommendations for a long-term approach for control of invasive aquatic plants, based on a review of the 2003 macrophyte survey, Onota Lake's past project history and a literature review of non-chemical plant management techniques.

1.2 Acknowledgements

GeoSyntec would like to like to acknowledge the support and contributions of time, knowledge, and historic data to this project by Mr. Robert Race and Mr. Richard Laureyns of the Lake Onota Preservation Association.

SECTION 2: Aquatic Vegetation Survey

2.1 Methodology

Prior to conducting the 2003 macrophyte survey, GeoSyntec reviewed the most recent previous macrophyte survey of Lake Onota, conducted by Aquatic Control Technology (ACT) in 2002, and various other lake survey reports and information (see References section) on recent macrophyte control efforts provided by Bob Race of the Lake Onota Preservation Association (LOPA).

View across the southern basin of Lake Onota.

The most recent macrophyte control project at the time of the survey had been conducted in the summer of 2002, when 70 acres of the Lake was treated with the herbicide Reward (diquat dibromide). As such, the 2003 vegetation survey reflects plant growth conditions approximately one year following the Reward application.

GeoSyntec also obtained high-resolution color orthophotography of the Lake Onota from MassGIS, for use as a base for all mapping conducted as part of this project.

On June 22 and June 27, 2003 GeoSyntec conducted a macrophyte survey of Lake Onota. The survey was conducted according to the aquatic macrophyte survey standards of the DEP-Division of Watershed Management (Standard Operating Procedures, Aquatic Plant Mapping, April 2, 2002). Aquatic vegetation was sampled from a boat. Plant species were identified at 47 sampling locations (Figure 1) by visual inspection and by using an aquatic vegetation grappling hook to sample submerged vegetation. At each station, the dominant plant(s) were recorded, as well as estimates of plant growth density and plant biomass. As categorized in Table 1, plant growth density is an estimate of aerial coverage when looking down to the lake bottom from the water surface. Plant biomass estimates the amount of plant matter within the water column. For example, a sampling station with dense growth of low-growing plants would have a high density rating but a relatively low plant biomass rating. A station with dense growth of a long, ropey plant like Eurasian milfoil, with stems reaching the water surface, would have both high plant density and high biomass ratings.

In addition to recording information from the 47 sampling stations, a running documentation of plant growth densities was estimated throughout the lakewide survey. Survey locations were mapped with a Global Positioning System (GPS) unit and related survey information was recorded on a hand-held PDA computer linked to the GPS. Prior to conducting the survey, the GPS/PDA unit was loaded with orthophotography and bathymetric contour information for Lake Onota, allowing GeoSyntec staff to confirm survey locations and ensure accurate mapping. Based on the above information, an aquatic vegetation map of Lake Onota (Figure 1) was developed using ESRI ArcView software.

2.2 Aquatic Vegetation Survey Results

GeoSyntec's June 2003 survey results indicate that Lake Onota has a relatively diverse macrophyte community, with 21 species documented. Three of these plants are listed as non-native, invasive species by the Massachusetts Natural Heritage and Endangered Species Program. These non-native plants are Eurasian milfoil (*Myriophyllum spicatum*), Curlyleaf Pondweed (*Potamogeton crispus*) and European Naiad (*Najas minor*). A discussion of these species and other key findings of the vegetation survey are summarized below:

Eurasian milfoil
(Myriophyllum spicatum)

- Eurasian milfoil was found at 55% of the sampling stations (26 of 47 stations), tying it with Curlyleaf Pondweed as the most widely distributed of the 21 plants found during the survey. Eurasian milfoil was also determined to be a dominant plant at 9 of the 47 sampling stations, also tying it with Curlyleaf Pondweed as the most dominant plant in Lake Onota. This highly invasive plant was well distributed throughout the lake, although its growth was generally at low to moderate densities at the southern end of the lake. The shallower northern basin had extensive plant beds with higher milfoil densities.

  It is worth noting that Eurasian milfoil was still found to be the dominant plant in the southeastern cove treated with the broad-spectrum contact herbicide Reward (diquat) in 2002.

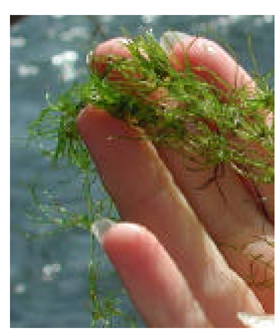
Curlyleaf Pondweed
(*Potamogeton crispus*)

- As stated above, the invasive Curlyleaf Pondweed is a dominant plant in Lake Onota. Like Eurasian milfoil, this plant is a native of Eurasia that was introduced to North America in the mid 1800's. Growth of this plant tends to peak in June, with die-back occurring by mid-summer. Curlyleaf pondweed was the most abundant plant in Lake Onota in terms of biomass during the June 2003 survey, and was particularly dense along the western side of the north basin. Curlyleaf pondweed was found intermixed with Eurasian milfoil at most of the sites where it was found, and it is expected that milfoil will dominate many of these areas later in the growing season.

- 38% of the sampling stations (18 stations) were dominated by non-native plants (Eurasian milfoil and Curlyleaf pondweed).

European Naiad
(*Najas minor*)

- European Naiad was found in very small amounts at only two sampling stations in the northern half of Lake Onota. Although this non-native plant has the potential to grow in dense beds and out-compete native plant species, its current contribution to the overall plant community of Lake Onota is quite minor. Future monitoring efforts should carefully document any changes in this plant's dominance and distribution throughout Lake Onota.



Stonewort
(*Nitella* sp.)

- The most dominant and well-distributed of the native species in Lake Onota was Stonewort (*Nitella* sp.), which was found at 36% (17) of the sampling stations and was dominant at 7 stations. Stonewort is actually a structured form of algae rather than a true vascular aquatic plant. Musk grass (*Chara* sp.), another structured algae, was also a dominant plant at two sampling stations.

- Yellow water lily was abundant along the shoreline at the northwest corner of the lake, and was dominant at 4 stations.
- Bigleaf Pondweed was found at six stations and was dominant at two stations in the southern end of the lake.
- A full list of plants present at each sampling station is provided in Table 1, which also provides information on vegetation density, biomass, and dominant plants at each station.

At the time of June 2003 vegetation survey, the deeper southern basin of Lake Onota was characterized by predominantly "sparse" (0-25% density) plant coverage. Plant beds in several shoreline and cove areas in this part of the lake exhibited moderate (26-50%) plant densities. Only one relatively small milfoil-dominated area in the southern basin was determined to have dense (50-75% density) growth. Plant growth in the southern basin is generally limited both by depth and by a rocky substrate, particularly along the western shore

Significant shoreline and central areas of the shallower northern basin exhibited either moderate or dense plant growth. The northern basin, much of which is impounded by the dam, is also characterized by soft organic sediments that are favorable to macrophyte growth. Considering that the survey was conducted in June, plant densities are expected to be higher in many areas during mid-late summer when most macrophyte species (including Eurasian milfoil) are at their peak.

Plant growth densities at the 47 sampling stations during the June 2003 survey were as follows:

Density Rating	# of stations	% of stations
Sparse: **0-25% density**	**33**	**70%**
Moderate: **26-50% density**	**9**	**19%**
Dense: **51-75% density**	**5**	**11%**
Very Dense: **76-100% density**	**0**	**0%**

Although differences in vegetation survey methods and timing of surveys makes it somewhat difficult to directly compare the results of GeoSyntec's June 2003 survey with other recent vegetation survey results from ACT, Inc. and LOPA, the following points of comparison are worth noting:

- Overall, the general distribution and densities of plant growth were similar to those documented by ACT in June 2002. A notable exception to this was the relatively low plant densities observed by GeoSyntec over most of the cove to the east of Thomas Island. In June 2002, ACT reported very dense growth (>75%) of Curlyleaf pondweed over nearly half of this area, with moderate growth (25-50%) over the rest of the area.
- Eurasian milfoil was noticeably absent from several GeoSyntec sampling stations in the south basin (stations 3, 4, 5 and 6) that were identified by ACT to have this plant in 2002.

- 2001 vegetation survey results from both ACT and LOPA report relatively widespread growth of the non-native European naiad (*Najas minor)*, with significant areas of very dense growth reported in the northern basin. As previously stated, GeoSyntec documented very small quantities of this species at only 2 sampling stations during the June 2003 survey.

2.3 Volunteer Macrophyte Identification and Mapping Training

On June 22, 2003, GeoSyntec conducted a training session for volunteers from the Lake Onota Preservation Association (LOPA) on macrophyte identification and mapping. These four volunteers plus also attended a macrophyte identification workshop provided on the day before by Rick McVoy of the MA-DEP at the LAPA-West Directors Picnic. Two of the LOPA volunteers had previous training at UMass Water Watch Partnership workshops and had done macrophyte surveys on Lake Onota in two or three previous years.

As part of the training materials for the workshop, GeoSyntec developed a **"*Field Guide to the Aquatic Plants of Lake Onota*"**, which includes color photos, line drawings and a description of the aquatic plant species found in Lake Onota. This field guide provides a useful monitoring and public education tool for LOPA, and can be used as a tool for future volunteer monitoring efforts.

At the training session, GeoSyntec trained volunteers on the methods for conducting a macrophyte survey according to the DEP aquatic macrophyte survey standards, including the appropriate methods for (1) species identification, (2) bio-volume estimates, and (3) estimating of aerial coverage throughout the lake. Base maps of Lake Onota, vegetation species tally sheets, and a draft version of the **"*Field Guide to the Aquatic Plants of Lake Onota*"** were distributed to all training session participants. The training session also included a brief (due to rain) aquatic vegetation mapping exercise on Lake Onota. The final version of the field guide is included as Appendix 1 to this report.

INSERT PLANT MAP (Figure 1)

INSERT TALLY SHEET – TABLE 1

SECTION 3: Review of Non-chemical Plant Management Techniques

As part of the Onota Lake Watershed Assessment Project funded by the Massachusetts Department of Environmental Protection, GeoSyntec has conducted a review of non-chemical techniques to control the growth of nuisance aquatic vegetation in Onota Lake. This section does not include a review of experimental techniques that lack a proven track record of successful lake applications, such as the application of fungal pathogens and plant replacement. Rather, this section provides a review of the non-chemical techniques that are most feasible for application to Lake Onota. Several techniques that are not likely to be feasible or recommended (e.g. artificial circulation, aeration, dredging) are also reviewed because they had been recommended or discussed in previous studies such as the 1991 Lake Onota Diagnostic/Feasibility Study (International Technology Corp.).

At present, the two invasive plant species that represent the greatest threat to the lake's ecosystem and its recreational uses are Eurasian milfoil (*Myriophyllum spicatum*) and Curlyleaf Pondweed (*Potamogeton crispus*). A third non-native species, European Naiad (*Najas minor*) is also currently present in the lake in very small amounts. In recent years, the Lake Onota Preservation Association (LOPA) has been active in its efforts to control the spread of Eurasian milfoil by both chemical and non-chemical methods. A brief summary of recent plant control projects at Onota Lake is as follows:

- Until 1998, LOPA conducted regular mechanical harvesting to control milfoil and other species. This method was determined to provide poor control and to encourage to the spread of milfoil.
- In 1999, a lakewide application of SONAR (fluridone) was conducted.
- In 2000, milfoil re-growth was spot-treated with Navigate (2,4-D).
- In 2001, minor milfoil re-growth was spot-treated with Reward (diquat).
- In 2002, several areas of milfoil growth were harvested by diver hand-pulling.
- In 2002, approximately 70 acres of Lake Onota were treated with Reward.
- In July 2003, approximately 10,000 native milfoil weevils (*Euhrychiopsis lecontei)* will be stocked in Lake Onota as a biological control agent for Eurasian milfoil.
- As part of an ongoing project funded by MA-DEP through the Section 319 Program, a culvert is planned for installation at the Thomas Island causeway. This project is intended to promote the flow of waters entering the lake from the north basin tributaries towards the lake outlet via the culvert.

The following sections provide an assessment of in-lake, non-chemical techniques for the control of invasive vegetation and the feasibility of their application in Onota Lake. Although an important component of to the long-term ecosystem health and proper management of Onota Lake, watershed management techniques are not assessed as part of this report.

3.1 Artificial Circulation and Aeration

Artificial circulation and hypolimnetic aeration are lake management techniques applied in thermally stratified lakes (such as Lake Onota) to mitigate problems associated with hypolimnetic oxygen depletion. Hypolimnetic oxygen depletion can stress fish populations and result in the resuspension of phosphorus from lake bottom sediments into the water column. The re-suspended phosphorus is usually concentrated in the hypolimnion until fall turnover, when it is mixed into the euphotic layer and may result in an autumnal algae bloom.

Artificial circulation and hypolimnetic aeration are typically applied for the purpose of controlling nuisance algae blooms, not for controlling nuisance macrophyte species such as Eurasian milfoil. Based on communications with LOPA representatives and review of LOPA lake monitoring data, Lake Onota does not have a history of nuisance algae blooms and typically has water clarity that is well above the average for Massachusetts lakes.

As stated in the (*Draft) GEIR on Eutrophication and Aquatic Plant Management in Massachusetts,* artificial circulation and hypolimnetic aeration "have little if any effect on macrophytes". In theory, these techniques can reduce the resuspension of phosphorus from lake sediments caused by anoxic conditions, thereby reducing the total amount of soluble phosphorus available in the water to fuel algae growth. In contrast, rooted macrophytes obtain the majority of their nutrients from lake sediments and are much less responsive than algae to seasonal fluctuations in soluble phosphorus.

For the general purposes of managing water quality in Lake Onota, and particularly for the specific purpose of controlling the growth of invasive macrophytes, GeoSyntec does not believe that artificial circulation or hypolimnetic aeration are warranted based on a review of available Lake Onota data. Data presented in the 1991 D/F (International Technology Corp.) study and 2001 LOPA Water Quality Volunteer Monitoring Program report clearly indicates that the lake has a well-defined hypolimnion that becomes anoxic during summer stratification. However, monthly sampling data from the north basin and south basin deep holes indicate consistently low total phosphorus levels that are not indicative of conditions that would justify installation of a hypolimnetic withdrawal or aeration system. In 2001, total phosphorus readings at the deep-hole locations were consistently below 10 µg/l, a threshold which generally indicates excellent water quality.

3.2 Dredging

Lake dredging for control of nuisance macrophytes and removal of nutrient-rich organic sediments can be accomplished by either dry or wet excavation. Dry dredging involves either completely or partially draining the lake and removing exposed sediments with conventional excavation techniques and equipment. Wet dredging at lakes is most commonly accomplished by hydraulic dredging, which involves pumping sediments out of the lake as a wet slurry. Because the water level for Lake Onota is a controlled by a dam which impounds much of the northern basin, both dry dredging and hydraulic dredging are at least technically feasible for that part of the lake. However, the feasibility of conducting a dredging project at Lake Onota is significantly constrained by the high costs and environmental permitting requirements associated with this technique.

There are two methods to control nuisance macrophyte growth by dredging. The first method involves creating a less suitable substrate for plant growth by removing soft, organic sediments and dredging down to an inorganic layer (i.e. sand, gravel). The 1991 Lake Onota Diagnostic/Feasibility Study (IT Corp.) conducted a limited analysis of soft sediment depths and identified a targeted volume of 429,000 cubic yards of soft sediment for potential removal from the north basin, primarily in the areas around Thomas Island. The second method requires dredging to a depth that limits sunlight penetration to the sediments, thereby inhibiting or significantly reducing the growth of rooted aquatic plants. Given the above-average water clarity of Lake Onota and the soft sediment volumes estimated in 1991 D/F study, this approach is not recommended. The volume of sediment removal required to achieve light-limiting depths would be much greater than the volume of removal required to reach an inorganic layer in targeted areas of the north basin.

Hydraulic dredging is the most commonly used method for removing the large volumes of soft sediment estimated by the 1991 D/F study (429,000 cubic meters). In contrast, dry dredging is most feasible for small reservoirs with less than 30,000 cubic yards to be removed (Cooke, *et al*, 1993). Hydraulic dredging involves the use of floating equipment, combining the use of a cutter head to loosen sediments and suction to pump sediments out of the lake as a wet slurry. The slurry, which is 80-90% water, must be de-watered outside of the lake, allowing the sediments to dry out for later disposal and the water to drain back to the lake.

Reported costs for hydraulic dredging are highly variable, ranging from $4.70-$9.30 per cubic yard (*1996 cost estimates from draft GEIR adjusted to 2003 dollars*). Dredged material transportation, processing and disposal costs are likely to range from $2.30-$4.70 per cubic yard. At this price range, the hydraulic dredging of 429,000 cubic yards would cost between 3 to 6 million dollars, with the higher end of this estimate being more realistic. However, this price could be substantially higher if significant difficulties were encountered in siting dewatering and disposal areas. Dredging costs on a per cubic foot basis are also generally significantly higher for smaller projects, due to significant costs associated with project start-up and mobilization and other efficiencies of scale.

Dredging projects are subject to an extensive permitting process requiring local, state and federal permits and approvals. The most expensive permitting effort would be submittals required under the Massachusetts Environmental Policy Act (MEPA), which could range anywhere from $50,00 to $250,000. Other required submittals/approvals would include a Notice of Intent under the Wetlands Protection Act (Pittsfield Conservation Commission, MA-DEP), Section 401 Water Quality Certification for Dredging Activities (MA-DEP), Section 404 permit under the Clean Waters Act (Army Corps of Engineers), and a Drawdown Notification to the MA-Division of Fisheries and Wildlife.

3.3 Drawdown

Drawdown for the control of aquatic vegetation involves lowering the pond's water level during fall and winter to expose nuisance vegetation infestations. Exposing aquatic plant species to the elements for sustained periods of time (i.e. >6-8 weeks) facilitates desiccation and freezing of the plants and their root systems. Lake Onota has regularly conducted a limited (3-foot) drawdown for a number of years. The outlet pipe at the lake's dam is 8 feet below the spillway elevation.

Based on review of previous lake studies, communication with LOPA representatives, and GeoSyntec's 2003 vegetation survey, drawdown appears to provide an inexpensive and relatively effective macrophyte control within the limited littoral zone area of Lake Onota exposed by the annual 3-foot drawdown. Given the additional drawdown capacity of the dam, it may be beneficial to increase the drawdown depth to expose additional densely vegetated areas of the northern basin. Because of the northern basin's shallow depths and gradual bathymetry, a significant portion of the most densely vegetated portion of the lake would be exposed by increasing the drawdown to 5 feet. Any increase in drawdown depth will require that a Notice of Intent application under the Wetlands Protection Act be submitted to the Pittsfield Conservation Commission and the MA-DEP. The following permit submittal information is outlined in the DEP interim guidance for drawdown projects:

Summary of DEP Interim Technical Guidance 90-TG1: **Review of Lake Drawdown Projects under 10.53(4).**

Public and/or Private Water Supplies Determine any shallow wells or water supply intakes which could dry up during a drawdown.

Rare Species Demonstrate the absence of rare wildlife habitat or that drawdown will not adversely effect the habitat if present .

Fisheries Estimate of the total area and depth zones to be dewatered. Verify the presence of a deep-water pool or other refuge areas with sufficient dissolved oxygen levels to prevent fish kills. Provide anticipated drawdown/refill dates, an estimate of refill time, and estimated downstream flow rates during refill.

Alternative Analysis The Applicant should consider all reasonable alternatives for controlling the target plants and fully explain why drawdown (or drawdown used with other control methods) was chosen.

Control of Target Species Provide a list of aquatic plant species in the lake; a list of target species to be reduced; verification that target species would be reduced; and, verification that target species would be dewatered.

Dam Structure Document maximum drawdown depth and evaluate the dam's structural integrity to verify that the it can withstand drawdown (a MA Registered Professional Civil/Structural Engineer should make this evaluation).

Groundwater The potential impact of drawdown on groundwater levels, shallow drinking water wells, and bordering wetlands dependent on groundwater should be discussed.

Fisheries Discuss the potential positive and negative impacts to fish habitat, including downstream impacts to fisheries habitat resulting from low flows during refill. Provide estimated downstream flow rates during drawdown and refilling. Discuss the potential adverse impacts to freshwater shellfish species, including clams and crayfish.

Wildlife Habitat Discuss potential impacts on small mammals, waterfowl, invertebrates, amphibians, and reptiles. These impacts may be related to the timing of the drawdown versus the start of hibernation or brumation periods and reductions in vegetation preferred by wildlife.

Flood Control and Storm Damage Prevention Discuss the potential for downstream flooding during the drawdown and prevention of damage to public interests by flood waters or storms.

Prevention of Pollution Discuss (1) the anticipated impact of drawdown on the productivity, nutrient cycling, sediment inputs and potential for algal blooms and (2) the potential for flushing nutrients, sediments and other pollutants to downstream lakes and ponds. A 401 Water Quality Certificate should also be obtained from the Division of Water Pollution Control.

3.4 Harvesting

- **Mechanical Harvesting:** Mechanical harvesting involves the use of barge-type boats that are designed to cut aquatic plants and remove them to a storage area on the boat via a conveyor belt. As stated in Section 1, LOPA conducted regular mechanical harvesting to control milfoil and other species until 1998. This method was determined to provide poor control and to encourage to the spread of milfoil. This assessment is supported by the Draft GEIR on Aquatic Plant Management, which states, "…harvesting can cause the spread of plants like Eurasian watermilfoil to uninfested areas of the lake because of watermilfoil's ability to regenerate from fragments".

  Mechanical harvesting also has a very limited duration of effectiveness for Eurasian milfoil, which can rapidly regrow (harvesting of Eurasian milfoil in LaDue Reservior, OH resulted in complete regrowth in 21 days (Cooke *et al*, 1993)). Curlyleaf pondweeds (and other plants that do not propagate readily from fragments) are better suited for control by mechanical harvesting. Harvesting may promote the re-growth and spread of milfoil, which both propagates by fragments and aggressively colonizes new areas following "disturbances" caused by plant management activities.

As previously stated, the two most dominant nuisance plants in Lake Onota are Eurasian milfoil and Curlyleaf pondweed. GeoSyntec's 2003 vegetation survey documented that these species are found growing together in over 70% of the places where they are found in the lake. Although mechanical harvesting may be a suitable control option for nuisance Curyleaf pondweed growth in some settings, the non-selective nature of this control technique and the broad distribution of Eurasian milfoil in Lake Onota support the previous LOPA determination that this technique is not appropriate as a long-term invasive plant control strategy.

- **Hand Harvesting/Suction Harvesting:** Hand harvesting is conducted by trained divers who pull targeted aquatic plants, place them in collection bags and remove them from the lake. To the extent possible, plants are pulled out with their root structure to minimize the potential for plant re-growth. Like hand harvesting, suction harvesting is conducted by divers that pull out individual plants and root masses by hand. After pulling the plants, the diver feeds them into a vacuum hose that pulls the plant onto a boat for later disposal.

  Due to the labor-intensive nature of these techniques, they are most appropriate for use in very small areas where pioneer infestations have been identified, or where other plant control techniques are not either permittable or feasible. Given the extensive size of the nuisance plant beds in the northern basin of Lake Onota, diver hand pulling or suction harvesting is not likely to be a cost-effective option in this part of the lake. However, hand pulling or suction harvesting may be worth considering as a means of providing spot control for new areas of milfoil growth as they appear in the south basin. With the exception of a few shoreline and cove areas, plant growth throughout much of the south basin is generally sparse. Over the past several years, small pioneer infestations of milfoil have been documented at several locations along the south and southeastern shores of the Lake. Hand or suction harvesting may be appropriate for providing species-specific control in such limited areas, and the relatively coarse substrate found in the south basin is less likely to create the serious visibility problems for divers that can impede this approach in areas with soft organic sediments.

  The cost of hand harvesting is difficult to estimate on a per-acre basis because the rate at which divers can harvest a specified area varies greatly as a function of plant distribution, density, and stem height. Substrate composition will also affect the rate of plant removal, as water bodies with highly flocculent sediments will become turbid very quickly as plants are pulled, making it difficult for divers to see what they are doing. For an ongoing Eurasian milfoil hand harvesting project at Wachusett Reservoir, the Metropolitan District Commission (MDC) reports a 2003 hourly rate of $163/hour for a 3-person team comprised of a lead diver, assistant diver and boat tender. In the summer of 2002, a total of 488 diver hours were used in efforts to hand harvest the littoral zone (area of rooted plant growth) of 17-acre Upper Thomas Basin of Wachusett Reservoir, for a total cost of $40,000.

- **Hydroraking:** The mechanical Hydro-Rake can best be described as a "floating backhoe" with a York Rake attachment. The barge is paddle wheel driven to facilitate operation in shallow water (<2 feet) and it can effectively work to depths of about 12 feet. The Hydro-Rake is most effective at removing plants with large/well-defined root

systems, typically floating-leafed (such as pond lilies) and emergent species (such as cattails). Plants with slender stems and root systems that can pass between the tines of the hydrorake and re-root from fragments (such as milfoil) are not well-suited for control by this technique. A hydro-rake is operated from the water, thereby avoiding damage to sensitive shoreline habitat and property. This machine "rakes" the upper sediment layer collecting plants and their attached root systems. The plants and attached sediment are placed on a barge that is floated to an area for off-loading and disposal. By disturbing sediments and uprooting plants, hydro-raking results in temporary increases in turbidity in the locus of operation.

Based on the 2003 vegetation survey, GeoSyntec did not identify any high priority areas where hydro-raking is recommended at this time. Most of the "nuisance" plant growth in the lake comes from submerged species (Eurasian milfoil and Curlyleaf pondweed), which are not ideal targets for this technique. Only a relatively small area along the northwest corner of the lake is dominated by floating-leafed plants (yellow water lily). This area of the lake provides ecological diversity and habitat values and is not recommended for any plant control activities.

3.5 Biological Control

- **Insects:** In 1995, the Massachusetts DEM conducted the first intensive field trials of the native milfoil weevil (*Euhrychiopsis lecontei*) as a biological control for Eurasian milfoil at Lake Mansfield (Great Barrington, MA) and Upper Goose Pond (Lee/Tyringham, MA). Since this time, milfoil weevils have become an accepted and commercially available milfoil control technique.

Adult milfoil weevil

Milfoil weevils provide a potentially sustainable and environmentally safe alternative to traditional milfoil control techniques such as harvesting and herbicides. In contrast to these methods, weevils provide an extremely species-specific control of Eurasian milfoil. Adult weevils and larvae feed on milfoil leaves, while the larvae also damage the plant and slow its growth by burrowing through the plant stems. Weevils will not eradicate milfoil, but offer the potential to reduce and slow its growth to non-nuisance levels.

As with any biological control technique, there are a number of site-specific factors that influence the degree of milfoil control caused by weevils and the speed with which the desired level of control is attained. These factors include the extent and density of milfoil growth, the number of weevils stocked per site, human disturbance of stocking sites, and fish populations that predate on weevils. As such, the use of weevils for milfoil control requires both patience and acceptance of a degree of uncertainty in the results. In most cases, it will take at least several seasons for the weevils to cause a significant milfoil decline, although dramatic localized effects in the immediate vicinity of a stocking site are not uncommon within one season. Even in cases where the process takes longer, such as when a relatively small number of weevils are introduced to a very large lake, there are obvious benefits to initiating a long-term control of milfoil. As long as milfoil is available as a food source, the milfoil weevil population can be expected to gradually increase in both size and distribution throughout milfoil-infested portions of the lake.

In New England, the weevil normally produces three generations in the summer. In autumn, the adult weevils migrate to the shoreline of the lake, where they over-winter beneath decomposing leaves. The following spring, the adults fly back to the milfoil plants in the lake. The long-term goal of a milfoil control program using weevils is not the eradication of Eurasian milfoil, but rather the sustainable control of Eurasian milfoil at low, non-nuisance densities.

Based on the 2003 vegetation survey, there are several important factors to consider when assessing the use of weevils for Eurasian milfoil control at Lake Onota:

1. **Appropriate Stocking Areas**: Weevils are ideally stocked in moderate to large-sized plant beds that are dominated by healthy Eurasian milfoil. Although there are several areas in the lake that could be suitable for use as weevil stocking areas, most of the milfoil beds in the southern part of the lake were either too small or had relatively sparse milfoil growth. During the 2003 survey, an area off of the central portion of the western shore was identified as having the best overall potential for weevil stocking.

2. **Composition of Dominant Plants within the Lake**: When considering the use of weevils for Eurasian milfoil control, it is important to bear in mind that the weevils are extremely selective eaters and will not feed on other aquatic plants within Lake Onota. As such, declines in Eurasian milfoil dominance caused by weevils would create an opportunity for other plants to increase in dominance. Although it seems likely that native plant species would be the beneficiaries of this shift in dominance in the mid-late growing season, growth of Curlyleaf pondweed may also have less competition and could become even more dominant during the early growing season.

3. **Coordination with Other Plant Management Strategies**: Plant management strategies such as harvesting and herbicide application can have a negative impact on milfoil weevil populations. For example, although herbicides will not directly harm weevils, the resulting temporary crash in milfoil growth will reduce the weevil's available food source, thereby leading to a parallel crash in the weevil population. Harvesting machines cut, collect and remove the top several feet of plant stems, where most weevils feed and lay eggs.

   It is important to consider a long-term plant management strategy prior to initiating a control program with weevils. In most cases, weevils require 3-5 years to achieve a significant degree of milfoil control, although localized impacts near the stocking areas are often obvious within the first year.

   The use of milfoil weevils could be an appropriate part of a long-term integrated strategy for nuisance macrophyte control at Lake Onota. With state funding from a MA-DEM (now MA Department of Conservation & Recreation) Lakes and Ponds Grant, LOPA initiated a weevil stocking project in Lake Onota in July 2003. GeoSyntec stocked 10,000 weevils at a location off of the lake's western shore and a milfoil bed at the southwestern corner of the lake was also established as a monitoring control plot. Follow-up monitoring is scheduled for late August 2003 and July 2004.

3.6 Benthic Barriers

The use of PVC coated fiberglass bottom weed barriers (i.e. Aquatic Weed Net™ or Palco™) are effective for small, dense patches of nuisance vegetation, but are not cost effective or feasible for large areas. Benthic barriers most frequently used in relatively small areas that are important for recreational access to open water, such as beaches and boat launch areas. Benthic barriers are expensive to install and maintain, with costs generally ranging from \$1.00-\$1.25/ft^2 (a one-acre expanse would cost in the range of \$43,560 -\$54,450 for materials & installation). Labor (and related costs) associated with semi-annual maintenance to retrieve, clean and re-deploy the barriers vary widely according to the specific application, but can be significant. In addition, covering expansive areas of the lake bottom will have detrimental impacts on invertebrates and other types of wildlife.

The effective lifespan for benthic barriers will vary according to how they are deployed and how well they are maintained. Most case studies indicate that benthic barriers provide effective localized macrophyte control for at least several seasons. It is likely that the duration of the beneficial effects of benthic barriers would be several years until damage occurred to the lining.

3.7 Summary of Recommendations

A summary of the recommendations discussed above with regard to non-chemical aquatic plant management techniques for Lake Onota is as follows:

- **Artificial Circulation and Aeration:** For the general purposes of managing water quality in Lake Onota, and particularly for the specific purpose of controlling the growth of invasive macrophytes, GeoSyntec does not believe that artificial circulation or hypolimnetic aeration are warranted based on a review of available Lake Onota data.

- **Dredging**: The feasibility of conducting a dredging project at Lake Onota is significantly constrained by the high costs and environmental permitting requirements associated with this technique. Dredging of the area in the northern basin prioritized by the 1991 D/F study would (primarily around Thomas Island) would cost an estimated $3-6 million dollars.

- **Drawdown**: Lake level drawdown appears to provide an inexpensive and relatively effective macrophyte control within the limited littoral zone area of Lake Onota exposed by the annual 3-foot drawdown. It may be beneficial to increase the drawdown depth to expose additional densely vegetated areas of the northern basin. A significant percentage of the most densely vegetated portion of the lake would be exposed by increasing the drawdown to 5 feet.

- **Mechanical Harvesting:** Although mechanical harvesting may be a suitable control option for nuisance Curyleaf pondweed growth in some settings, the non-selective nature of this control technique and the broad distribution of Eurasian milfoil in Lake Onota support the previous LOPA determination that this technique is not appropriate as a long-term invasive plant control strategy.

- **Hand-Harvesting:** Small pioneer infestations of milfoil have been documented at several locations along the south and southeastern shores of the Lake. Hand or suction harvesting may be appropriate for providing species-specific control in such limited areas, and the relatively coarse substrate found in the south basin is less likely to create the serious visibility problems for divers that can impede this approach in areas with soft organic sediments.

- **Hydro-raking**: GeoSyntec did not identify any areas where hydro-raking is recommended at this time. Most of the “nuisance“ plant growth in the lake comes from submerged species (Eurasian milfoil and Curlyleaf pondweed), which are not ideal targets for this technique. Hydro-raking is most effective at controlling plants with large/well-defined root systems, typically floating-leafed (such as pond lilies) and emergent species (such as cattails).

- **Biological Control**: Milfoil weevils could be an appropriate part of a long-term integrated strategy for Eurasian milfoil control at Lake Onota. In July 2003, 10,00 weevils were stocked at a site on the lake’s western shore. For weevils to successfully persist as part of a long-term management strategy, it will be important to coordinate other plant management techniques for compatibility with the weevils. For example, harvesting machines cut, collect and remove the top several feet of plant stems, where most weevils feed and lay eggs.

- **Benthic Barriers:** Benthic barriers are relatively expensive to install and maintain, with costs generally ranging from $1.00-$1.25/ft^2. However, benthic barriers can provide effective macrophyte control over high-use areas of limited size, such as swimming areas and boat launching areas.

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