

**DEMONSTRATION MILFOIL SUCTION HARVESTING
PROJECT**

**CRYSTAL LAKE, ELLINGTON/STAFFORD,
CONNECTICUT**

Prepared For:

**Town Of Ellington, Connecticut
And
Connecticut Department Of Environmental Protection**

Prepared By:

Northeast Aquatic Research, LLC

George W. Knoecklein, Ph.D.
74 Higgins Highway
Mansfield Center, CT 06250
860 - 456 - 3179

Final Report

June 18, 2007

Preface

Funding for this study of Suction Harvesting at Crystal Lake Ellington/Stafford Connecticut was made available through a 75% matching grant from the Connecticut Department of Environmental Protection under Section 22a-339a of the Connecticut Statutes: “Grants to Improve the Water Quality of Lakes Used for Public Recreation”. The required 25% matching funds were provided by the Town of Ellington, Connecticut.

For Information on Connecticut Lakes Grant Program, Please call Connecticut Department of Environmental Protection. Bureau of Water Protection and Land Re-use,
at 860 424 – 3176

Summary

This report summarizes the results of a demonstration suction harvesting project, targeting variable-leaved milfoil, conducted at Crystal Lake in Ellington Connecticut in 2006. Suction harvesting is a method of removing rooted aquatic plants from a lake through the use of a SCUBA diver assisted suction vacuum hose that is powered by a pump on a pontoon boat (see **Figure 1**). The diver can selectively remove target plants from the bottom and feed them into the hose where the plants are brought to the surface via the vacuum in the hose. This method has the advantage of removing only the target plant without the causing collateral damage to other plants or to the environment that other approaches generally cause.

Suction harvesting is a relatively new weed control method that has not had much evaluation. The goal of this study was to conduct a suction harvesting project, with both pre and post surveys, in order to evaluate the effectiveness and efficiency as a weed management / removal option.

Both a pre and post harvesting survey was conducted of the milfoil in the lake. The pre-survey of the overall distribution of milfoil in the lake was made to determine a suitable plot for this project. The post survey was made to ascertain how much milfoil had been removed and determine the method effectiveness and efficiency. A 0.4 acre patch of variable-leaved milfoil was harvested during this project. The project involved approximately 16 hours of harvesting equipment time, with a harvesting cost of \$ 3,500 and a remove efficiency of approximately 99 %.

Introduction

Crystal Lake in Ellington, Connecticut, has been infested with the invasive non-native, rooted aquatic plant variable-leaved milfoil (*Myriophyllum heterophyllum*) for several years. Northeast Aquatic Research conducted the first lake-wide intensive survey in 2000 to map the distribution of aquatic plants in the lake, and found approximately 4 acres of the milfoil. The findings of that survey were presented in Hapalosiphon Algae and Variable Water Milfoil Distribution and Abundance in Crystal Lake, Ellington/Stafford, 2000 by Northeast Aquatic Research. A second survey was conducted in 2003 by Northeast Aquatic Research using an Aquaview underwater camera to search deeper water areas. The 2003 survey found that milfoil distribution had increased since 2000 with new plants being found in deeper water along the northeast shore and more plants occurring in the area of the North Wetland Cove. The results of the 2003 survey were reported in 2003 Diagnostic Study of Crystal Lake, Ellington/Stafford, CT. by Northeast Aquatic Research.

Summary of the milfoil distribution observed during 2000 survey

During the 2000 survey, the plant was found in three separate locations (see Map 1). These were, in order of abundance, 1) the south wetland cove, 1.87 acres, 2) the north wetland cove, 2 acres, and 3) the outlet cove, 0.27 acres. Together these areas totaled 4.14 acres (**Table 1**).

1) South Wetland Cove:

The south wetland cove had one large and very dense stand and two smaller but equally dense stands of milfoil. The two smaller beds were on the outer edge of the cove and ran parallel to the sand bars that extend south from the enclosing peninsula. No milfoil was found outside of this sand bar. Within the south wetland there was one large bed of milfoil that was very dense and luxuriant, growing to the water surface. Variable-leaved milfoil was also found scattered throughout the cove mixed with the other aquatic species that grow there (see **Table 3**).

2) North Wetland Cove:

The north wetland cove also contained milfoil in association with other aquatic plants mostly water lilies and water shield. These beds were not mapped because of the difficulty in accessing the cove due to the prolific water lily coverage. However, milfoil was found growing outside the mouth of the cove for a distance of approximately 300 feet, growing as scattered patches of isolated plants and at low density that did not reach the water surface.

3) Outlet Cove:

The outlet cove refers to the narrow area of the lake near the dam. This area is about 500 feet long between the dam and a sand bar that nearly transects the lake. Within this area, milfoil was found in two smaller beds. One patch was about 50 feet across on the north side of the sand bar. The second patch about 60 feet long on the east shore of the lake adjacent to the dam.

Table 1. Milfoil Coverage Reported in 2000.

| Area | Acres |
|--------------------|-------------|
| South Wetland Cove | 1.87 |
| North Wetland Cove | 2.00 |
| Outlet Cove | 0.27 |
| Total | 4.14 |

Summary of the milfoil distribution observed during 2003 survey

Northeast Aquatic Research conducted a follow up survey during the summer of 2003 using an Aquaview underwater camera. The underwater camera was used to survey areas of the lake that were too deep to effectively examine from the boat. In Crystal Lake good water clarity provides sufficient light to allow variable-leaved milfoil to grow to depths of 20 feet. In order to ascertain the true distribution of milfoil in the lake these deeper water areas were observed, using the underwater camera, in addition to the shallow areas.

During the 2003 survey, the milfoil beds in the South Wetland Cove and the Outlet Cove were found to be essentially unchanged. The plants in the area of the North Wetland Cove were found to have spread further out into the lake, now located as far as 800 feet from the cove. Using the underwater camera, isolated plants were also found in a large area along the north east shore, and along the west shore.

North Wetland Cove:

The North Wetland Cove was now identified to consist of two areas of different abundances of variable milfoil, an inner core bed of about 2.5 acres where milfoil plants was growing at moderate density of about 40 % bottom cover, and an outer band of about 3 acres where plants were isolated and sporadic and had low density of between 1 – 10 % bottom cover. Within the inner core, the plants were observed growing in 5 to 8 feet of water and consisted of multi-stemmed clumps with shoots that were several feet long but did not reach the water surface, instead most shoots were observed lying on the ground. Plants in the outer band had a wider range of water depths, 4 – 15 feet deep and were less robust with fewer, shorter stems. This area of the lake appeared to have a more rocky substrate.

Northeast Shore:

In 2003, the use of the underwater camera revealed milfoil growing along the eastern shore, west and around the point from the North Wetland Cove beds. In that area, about 2 acres in size, sporadic isolated small plants were found in mostly deeper water, between 10 – 20 feet. These plants were small, and had short shoot lengths. They were found at very low density, perhaps one / 20 -30 square feet, although the precise number per unit was not measured due to the depth of the water.

Outlet Cove:

The two beds located in the outlet cove were again mapped in 2003 and were found to be similar to the prior survey. The two beds, located on the north side of the sand bar, and on the east shore of the lake adjacent to the dam, were small, at 0.14, and 0.13 acres, respectively. The plants in both these areas were growing in dense beds of 100% cover.

South Wetland Cove:

The South Wetland Cove contained a dense bed of milfoil that covered approximately 1.68 acres at a density of 100% bottom cover. There were two smaller beds of 0.1 acres each along the sand bars on the western side of the wetland cove.

West Shore of the Lake:

Additional milfoil plants were found in isolated locations along the west shore of the lake. One small bed was noted within the cove of the Crystal Lake Boat Club. Several isolated plants were observed scattered along the west shore between the Town of Ellington Beach and the State of Connecticut public boat ramp.

The 2003 survey showed that milfoil either had expanded its distribution in the lake or the plant was found in areas that could not be searched during the early surveys. The differences in milfoil included the North Wetland cove area now had 2.5 acres of dense inner core beds, and 3 acres of less dense outer band beds,. An additional area of about 2 acres on the north east shore line contained plants at very low density. These new sightings brought the total area of the lake infested with milfoil to 9.64 acres.

Table 2. Milfoil Coverage Reported in 2003.

| Area | Acres | |
|--------------------|-------------|------------------------|
| | 2000 | 2003 |
| South Wetland Cove | 1.87 | 1.88 |
| North Wetland Cove | 2.00 | 5.50 |
| North East Shore | ~ | 2.00 |
| Outlet Cove | 0.27 | 0.27 |
| West Shore | ~ | <i>Isolated plants</i> |
| Total | 4.14 | 9.64 |

Description of The Different Rooted Aquatic Associations in Crystal Lake

The lake has four basic types of aquatic plant associations; 1) open water milfoil clumps, 2) short stature bottom covering plants, 3) wetland cove associations, and, 4) near shore emergents.

The open water milfoil is growing singularly in the open water part of the lake as large multi-stemmed clumps. There are no other tall aquatic plants growing in the lake so milfoil stands out and is easily spotted.

The short stature growing plants cover most of the shallow littoral zone that is not rocky, between the shore and about 10 feet of water depth. This community consisted almost exclusively of a short sterile form of arrowhead (probably *Sagittaria cristata*). Additional species were found closer to shore including golden-pert, (*Gratiola aruea*) diminutive species of stonewort (*Chara*) and muskgrass (*Nitella*), as well as basal rosettes of pipewort (*Eriocaulon*), and patches of quillwort (*Isoetes*). The dominant plant in this association was by far the arrowhead, which forms very dense, homogeneous beds that cover large areas of lake area.

The two wetland coves contained a high diversity of aquatic plants with several species that were not found elsewhere in the lake. The inner areas had significant portions of the water surface dominated by dense beds of white and yellow water-lilies (*Nymphaea odorata* and *Nuphar variegata*, respectively), and water shield (*Brasenia schreberi*) that caused 100% coverage with lily pads. Submersed species are bladderwort (*Utricularia*), pondweeds (*Potamogeton*) and naiad (*Najas flexilis*).

The lake also has several stands of emergent pipewort along the shoreline in very shallow water. In addition to this were several wetland species that were found bordering the lake including common reed (*Phragmites*), water-willow (*Decodon verticillatus*), and cattail (*Typha*).

Table 3. Rooted Aquatic Plant Species List For Crystal Lake.

| Common Name | Scientific Name | Comments |
|-------------------------|-----------------------------------|----------------------------|
| Variable-leaved Milfoil | <i>Myriophyllum heterophyllum</i> | Three beds |
| Pondweed | <i>Potamogeton ephedrus</i> | South wetland cove |
| Pondweed | <i>P. bicupulatus</i> | South wetland cove |
| Pondweed | <i>P. robbinsii</i> | South wetland cove |
| Pondweed | <i>P. perfoliatus</i> | West shore |
| Arrowhead | <i>Sagittaria cristata</i> | Short growing bottom cover |
| Bladderwort | <i>Utricularia</i> sp. | Both wetland coves |

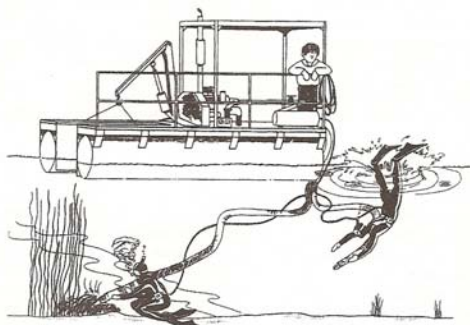
| | | |
|-------------------|------------------------------|----------------------------|
| Pipewort | <i>Eriocaulon</i> sp. | Shallow water around shore |
| Muskgrass | <i>Nitella</i> sp. | Short growing bottom cover |
| Quillwort | <i>Isoetes</i> sp. | Short growing bottom cover |
| White water-lily | <i>Nymphaea odorata</i> | Both wetland coves |
| Yellow water-lily | <i>Nuphar variegata</i> | Both wetland coves |
| Water naiad | <i>Najas flexilis</i> | Both wetland coves |
| Waterweed | <i>Elodia canadensis</i> | North wetland cove |
| Tape grass | <i>Vallisneria americana</i> | North wetland cove |
| Golden-pert | <i>Gratiola aruea</i> | Short growing bottom cover |
| Stonewort | <i>Chara</i> sp. | Short growing bottom cover |
| Watershield | <i>Brasenia schreberi</i> | Both wetland coves |

It was determined in 2003 that there were three possible courses of action:

- 1) do nothing and watch the beds annually to determine if they change size while also conducting lake wide surveys to ascertain that no new beds start,
- 2) chemically treat the three beds to control the plant from the lake, and,
- 3) install some type of bottom barrier, or hydrorake a boating lane through the southern wetland cove milfoil bed to allow boats to access the lake without having to cut through the milfoil.

In 2005 a fourth option, suction harvesting, became available for consideration in the control of milfoil in Crystal Lake. This method involves the use of SCUBA assisted suction harvesting apparatus. A demonstration project was proposed to determine if this method would prove to be effective in controlling milfoil in Crystal Lake. Suction harvesting is the process of removing plants and roots through the use of a suction hose powered by a pump on a boat and vacuum hose (see **Figure 1**). SCUBA divers selectively remove target plants from the bottom and feed them into the hose where the plants are brought to the surface via the hydraulic vacuum in the hose. Water from the pump is drained back to the lake through mesh bags that collect the plant fragments. Suction harvesting has the advantage of being very selective and potentially very effective at removing target plants. The milfoil growing in Crystal Lake is the only tall rooted aquatic plant in deep water, making the milfoil an easy target. It also means that native plants will not be inadvertently removed during the process.

Figure 1. Graphic Representation of a Suction Harvesting Operation.



2006 Demonstration Project Tasks

This project was set up to include the following tasks:

Pre Harvesting Survey,
Suction Harvesting Operation,
Post Harvesting Survey,
Summary Report, and,
Review Meeting.

Pre Harvesting Survey

The lake was surveyed for existing variable-leaved milfoil beds on August 21, 2006. The purpose of the survey was two-fold; 1) to document the locations of each of the major milfoil beds in Crystal Lake, 2) to select a suitable milfoil bed for the suction harvesting demonstration.

North Wetland Cove:

The survey results showed that the North Wetland Cove bed had expanded further out into the lake by another 100 feet or so and that plants within the bed were at a higher density than had been observed in 2003.

The plant density in the North Wetland Cove bed was found to consist of two general growth formations, an inner core where plants were large, robust and dense, and an outer band where plants were sporadic, isolated, smaller and less robust.

Within the inner core area the plants were found to grow in large multi-stemmed clumps of between 1 and 3 feet in diameter at the sediment surface. These clumps consisted of between 30 and 60 stems each about 5 – 8 feet long. These clumps were arranged roughly 10 feet apart giving a general density, or number of plant clumps per unit area, of about 64 / 100 square feet or about 0.006 clumps / square foot, or about 280 clumps per acre. However, each clump consisted of between 150 and 480 feet of shoot material that could spread out in an arching canopy extending several feet around each central stem base. Accounting for the linear length of milfoil shoots would mean that each acre of milfoil contained between 42,000 and 134,400 feet of shoot material.

The outer band contained far less plant material, generally plants were widely isolated and sporadic, with each clump containing few stems and of shorter length. Typical densities were 10 clumps for each 100 square feet or roughly 45 / acre. The plants were smaller with fewer, shorter stems, between 10 – 20 stems of between 2 and 4 feet long. This would mean that in the outer band, there was between 900 and 3,600 feet of milfoil shoot material. The plant density was even less in the area around the point toward the north.

Northeast and West shores:

Plants along the northeast shore, around the point from the North Wetland cove had not changed in density and were still found as rare isolated plants. The South Wetland Cove was also essentially unchanged, with no plants found outside of the sand

bars. No plants were found within the Crystal Lake Boat Club cove area although the 2003 survey reported plants located within the marina/ mooring field. There were rare, isolated plants found along the west shore.

Outlet Cove:

The outlet cove was found to be almost completely covered with milfoil. However, almost all the area between the sandbar and the dam, now about 1.5 acres, contained milfoil at high density, between 60 – 100% bottom coverage.

South Wetland Cove:

The South Wetland cover was found to essentially unchanged in milfoil distribution and abundance. The large centrally located milfoil bed, the area where the densities bed of milfoil occurs in the South Wetland Cove was investigated. No additional milfoil was found growing outside of the cove or the shallow areas of the lake at the mouth of the cove.

Tributary Pond:

A small, 0.86 acre, pond, located on the far side of CT Route 140 from the lake was found to be completely full of variable-leaved milfoil that reaches the surface over the entire surface area. This pond outlets to the South Wetland area. On the day of the survey milfoil fragments were visible in the outlet stream going to the lake. The milfoil in the pond has the potential to re-infest the lake with new plant material.

Table 4. Milfoil Coverage Observed During Pre-Harvesting Survey 2006.

| Area | Acres | | |
|--------------------|-------------|------------------------|------------------------|
| | 2000 | 2003 | 2006 |
| South Wetland Cove | 1.87 | 1.88 | 1.88 |
| North Wetland Cove | 2.00 | 5.50 | 6.20 |
| North East Shore | ~ | 2.00 | 2.00 |
| Outlet Cove | 0.27 | 0.27 | 1.50 |
| West Shore | ~ | <i>Isolated plants</i> | <i>Isolated plants</i> |
| Total | 4.14 | 9.64 | 11.58 |
| Route 140 Pond | | | 0.86 |

Suction Harvesting Operation

The North Wetland Cove bed was chosen as the site of the suction harvesting trial. This bed was selected because it was apparently growing the fastest, it had been well documented from prior surveys, it had a variety of different growth forms of milfoil plants, and it had a small area that had well defined edges where milfoil ended. After reviewing the density of plants in the bed and considering the duration of harvesting time that was budgeted for under the project scope a circular area of the bed of approximately 100 feet in diameter was chosen as the harvesting trial area (see **Map 2**).

Lockhart Environmental, from New Milford, CT., conducted the suction harvesting operation at Crystal Lake. Lockhart Environmental performed the harvesting

over three days, August 31, 2006, September 1, and September 7, 2006. The operation required one day of mobilization to get to the site and set up the boat and pump system on August 30, and one day to de-mobilize on September 8, 2006. The three days of harvesting consisted of 4 – 5 hours of harvest time the first day, and 6 hours of harvest time on the second and third days for a total of 16 hours of actual harvesting time. The operation consisted of one diver manipulating the suction hose and removing plants in the water and one person in the boat managing the collected plants and operating the pump and return water system.

The harvesting was contained to an area of about 0.4 acres of the densest plant cover that occurs in the lake (not including the wetland coves). The operation to harvest approximately 0.4 acres of milfoil would have involved removing between 16,800 and 53,760 feet of shoot material. Lockhart Environmental recorded removing 29, 50-gallon bags of plant material over the three days of operation, or about 7.25 bags per 0.1 acre with about 1,200 feet of shoot material per bag. Based on this level of effort an area the size of 1 acre would require approximately 40 hours of actual harvest time and would remove about 72.5 bags of plant material.

The area of the inner core is about 2.5 acres. Based on 40 hr/acre the inner core area would require approximately 100 hours of harvester time. The outer band is approximately 3.7 acres but contains about 1/40th of the plant material as does the inner core area. However it is probably not safe to assume that this area would require 1/40th the time to harvest because the scattered nature of the plant distribution would mean the entire area would need to be searched. It may be safe to assume that this area might take about half the time as the inner core area requires, or about 20 hours / acre or 74 hours of harvester time, but would yield only about 5 bags of material.

The total suction harvester contracted cost for the trial operation was \$ 3,500, which included the two days of mobilization. The net cost of the harvesting alone was \$2,800 for a base price of \$175/hour. The cost of actual harvest time to complete the inner core, using 100 hours, would be \$ 17,500. The outer band would cost about \$12,950 for a total, both inner core and outer band, of \$ 30,450 and 175 hours of time, presumably spread out over about 30 days.

Other milfoil beds in the lake would require different levels of effort. The wetland coves are special cases that may or may not yield to this method of control. There are some small patches of milfoil near the South Wetland Cove that could be harvested but the inner cove area would need to be investigated further to determine what would be required and if it is feasible to use suction harvesting. The Outlet Cove area would also need further investigation. Assuming that the same level of effort could be applied to that outlet cove as was applied to the inner core area, there is approximately 1.5 acres of milfoil in the Outlet Cove which would take about 60 hours of harvest time and cost \$ 10,500 and probably yield about 110 bags of shoot material. The upper east side and the west side of the lake, where isolated plants were found, would need to be visually investigated, using SCUBA, to search of the scattered plants. It is difficult to assess how much time this would require but at least 25 hours, or about \$4,375 should be

allotted for this. The costs for harvesting the different beds in Crystal Lake are summarized in the following table.

Table 5. Suction Harvesting Costs And Time Requirements To Complete Milfoil Harvesting In The Open Water Areas Of Crystal Lake, Ellington, Connecticut.

| Bed | Cost | Hours |
|--------------------|------------------|--------------------------|
| North Wetland Cove | | |
| Inner Core | \$ 17,500 | 100 hr |
| Outer Band | \$ 12,950 | 74 hrs |
| Outlet Cove | \$ 10,500 | 60 hrs |
| West Shore | \$ 4,375 | 25 hrs |
| Total | \$ 45,325 | 259 hrs (43 days) |

Post Harvesting Survey

Both Northeast Aquatic Research and Lockhart Environmental conducted a post harvesting survey of the suction harvested area on September 21, 2006. The area was found to still contain scattered, isolated shoots that were between 1 and 2 feet tall. These shoots had a density of about 1 shoot / 10 square feet suggesting that for each large clump that was removed one, or maybe 2, short shoot segments remained. The remaining quantity of milfoil shoot material was between 400 and 800 feet / acre suggesting that the harvesting removed about 99 % of the milfoil plant material. The suction harvesting operation also created furrows in the sediment where portions of the top layer sediments had been removed when root systems were collected. In some cases these sediment areas had been carpeted with the short growing arrowhead plants, but in other cases, it had been barren sediments.

Recommendations

Suction harvesting was affective at removing variable-leaved milfoil from the selected trial area in Crystal Lake. The conditions were ideal for the use this method in Crystal Lake for the following reasons:

- 1) The lake water was very clear allowing excellent underwater vision,
- 2) There were no native plants growing with milfoil to interfere with milfoil removal,
- 3) The sediments were sand/gravel allowing for easy root removal, and causing less turbidity,
- 4) The water depths were not excessive, and,
- 5) The target plants were growing in an open arrangement not in closed canopy dense stand.

The use of suction harvesting to remove variable-leaved milfoil from Crystal Lake appears to be a viable method in the open water parts of the lake, although, it will be expensive and time consuming to do so (see Table 2). The milfoil growing in Crystal Lake could be controlled by only the use of bottom barriers or herbicides. Other methods would not work, such as drawdown, hydroraking, mechanical harvesting, and grass carp

because of one or more reasons. (Northeast Aquatic Research 2000¹, Northeast Aquatic Research 2003²)

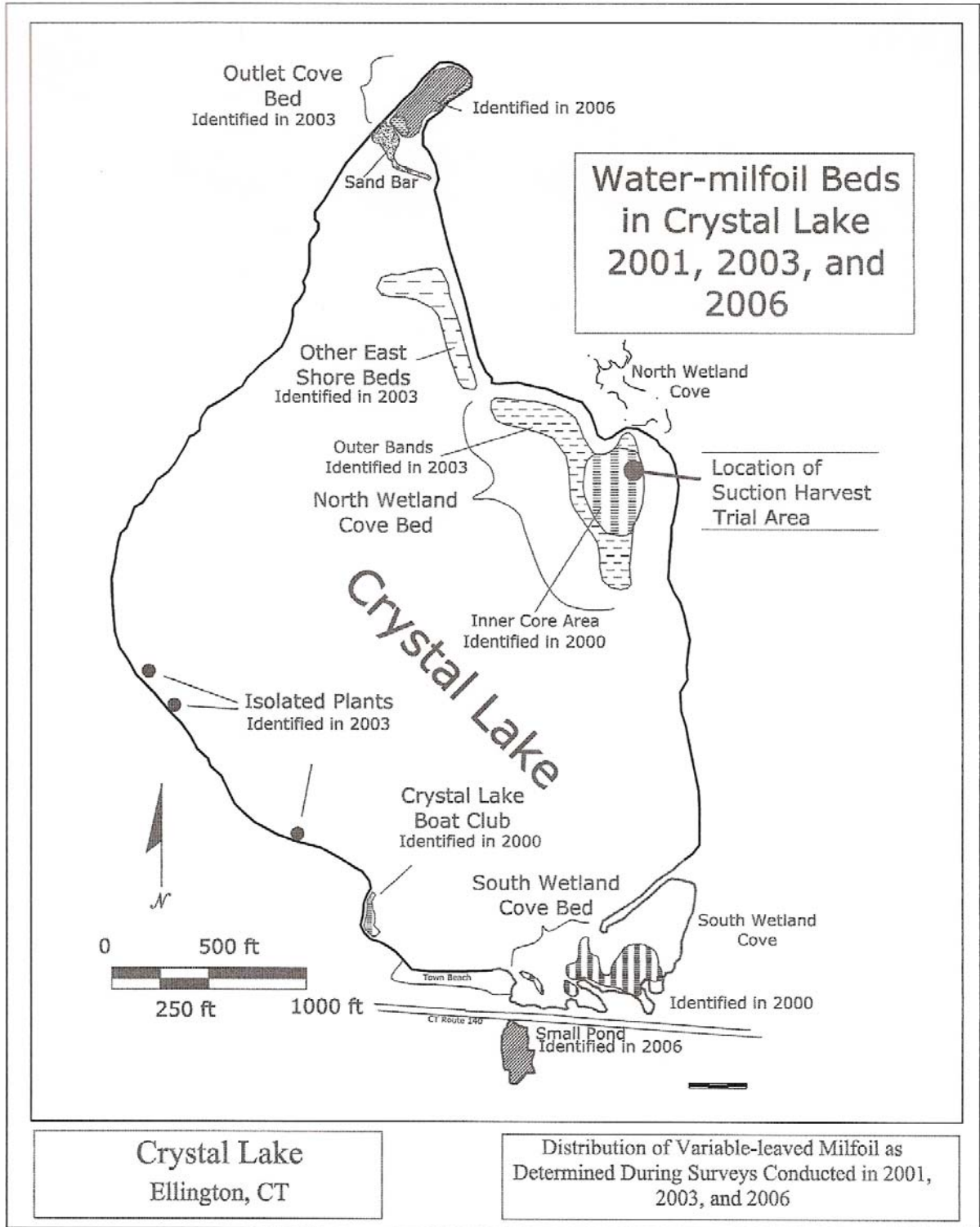
Because a small number of shoots remain after an area is harvested the site would need to be revisited the following year for clean up operation. Also annual or bi-annual (every two years) SCUBA surveys to check for the occurrence of isolated plants is necessary. As long as milfoil remains present in the wetlands, and in the small tributary pond re-infestation will be possible.

However, not all of the milfoil beds in the lake present the same ideal conditions. Both the wetlands, the North and South Wetland Coves, have plants growing very dense stands intermingled with several native species including water lilies and the sediments are organic and peaty. These factors would make suction harvesting difficult and less efficient inside the wetland coves. Other means will need to be considered in these areas. Either a barrier to retain fragments from moving into the lake, bottom barriers to limit migration of plants out into the lake and limit cutting by boat props, limited herbicides to initially decrease the standing crop of plant biomass facilitating a follow-up hand pulling effort, or an extensive suction harvesting effort. The pond across CT Route 140 would probably only be controlled through the use of a complete dredging or whole pond herbicide application.

¹ Hapalosiphon Algae and Variable Water Milfoil Distribution and Abundance in Crystal Lake, Ellington/Stafford, 2000. Northeast Aquatic Research, May 22, 2001.

² 2003 Diagnostic Study of Crystal Lake, Ellington/Stafford, CT. Northeast Aquatic Research October 26, 2004

Map 1. Distribution of Variable-leaved Milfoil in Crystal Lake.



Map 2. Detail Of North Wetland Cove Milfoil Bed Showing The Location Of The Suction Harvesting Trail Area.

