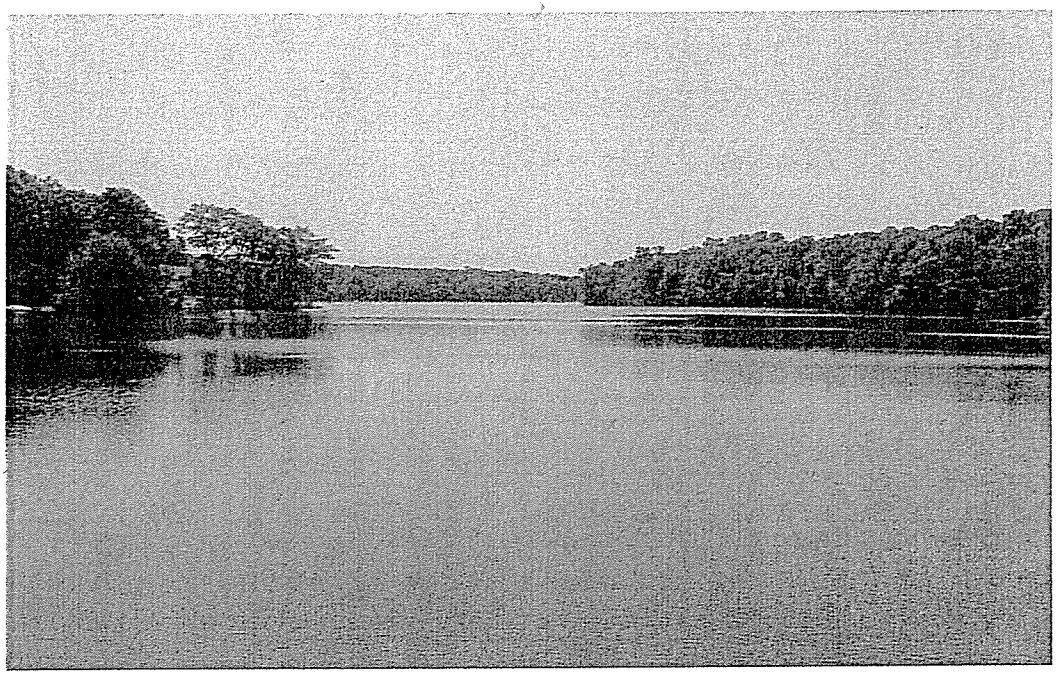
Prepared For:
Pickerel Lake Association
&
Town of Colchester

Pickerel Lake Aquatic Plant Management Report



November 2004

Prepared By:
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November 14, 2004

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INTRODUCTION

This report presents the results of an aquatic plant management feasibility study at Pickerel Lake in Colchester and East Haddam, Connecticut. The lake has a history of having dense aquatic plants throughout its entire area. This extensive growth of plants has limited recreation use, swimming, boating, and fishing, for several years. The goal of this study was to provide an investigation of the aquatic plant infestation at Pickerel Lake and generate a new set of feasible management options as well as an action plan to reduce the impairment caused by the weeds.

The dominant plant in the lake is a milfoil that has hybridized between variable-leaved milfoil (Myriophyllum heterophyllum) and cut-leaf water-milfoil (Myriophyllum pinnatum) (personal communication Don Les University of Connecticut). The hybrid can have characteristics of both its parents but usually looks very much M. heterophyllum in most respects. This makes it very troubling to identify and probably has lead to the variety of species names that have been given to the plant in Pickerel Lake.

The study included aquatic plant surveys, and limited water quality sample collection, conducted between 2003 and 2004, and a review of available documentation on the lake. There were two reports that provided extensive information about the weeds in Pickerel Lake. The first was a report by Atlantic Environmental Services, Inc. titled Feasibility Study of The Remediation of Pickerel Lake, Colchester/East Haddam, Connecticut, dated December 22, 1986. The second was the master thesis of William J. Dopirak, Jr. titled Analysis of Macrophyte Interactions in a Eutrophic Lake and in Experimental Microcosms, dated December 2002.

This study was funded, in part, by the CT Department of Environmental Protection Lake Grant Program and through matching funds from the Town of Colchester via the Pickerel Lake Association.

PROJECT SCOPE

This project involved three different evaluations,

- Limited in-lake testing,
- Limited baseline tributary water quality sampling, and
- Aquatic plant survey and management feasibility analysis.

In-lake Testing

The in-lake testing was performed once in April and once in July of 2003 with a follow-up testing visit in July 2004. During each sampling visit, water quality testing was conducted at one station located at a deep site of the lake near the dam. The testing included collecting water quality samples from 1, and 7, feet depths (analyzed for total phosphorus, nitrate nitrogen, ammonia nitrogen, and organic nitrogen), recording the dissolved oxygen concentration and water temperature, in-situ, at the surface and each one meter depth increment to the bottom, measuring the water clarity with a Secchi disk and collecting a sample of pelagic plankton (free floating microscopic plants and animals that live in the open water of the lake, as opposed to attached to surfaces), both phytoplankton and zooplankton using vertical methods.

Baseline Tributary Sampling

The tributary sampling included sampling stream water during baseline conditions. The tributary samples were collected from the inlets that were found to be flowing on the date of the

visit. In April 5 tributaries were found flowing however all had either dried or were reduced to seeps by July.

Aquatic Plant Surveys

The surveys for invasive aquatic plants were conducted principally to document the distribution of variable-leaved water milfoil and fanwort within the lake but to also document the occurrence of any native species. Three visits to the lake were made to observe the distribution of aquatic plants in the lake. The dates of the different field activities conducted during the study are provided in Table 1.

Table 1. Field Activities At Pickerel Lake, 2003-2004.

	4-21-03	7-13-03	9-22-03	1-22-04	2-26-04	7-16-04
Lake Sampling	X	X		X Under-ice	X Under-ice	X
Inlet Sampling	X	X dry				
Weed surveys	X	X	X			X

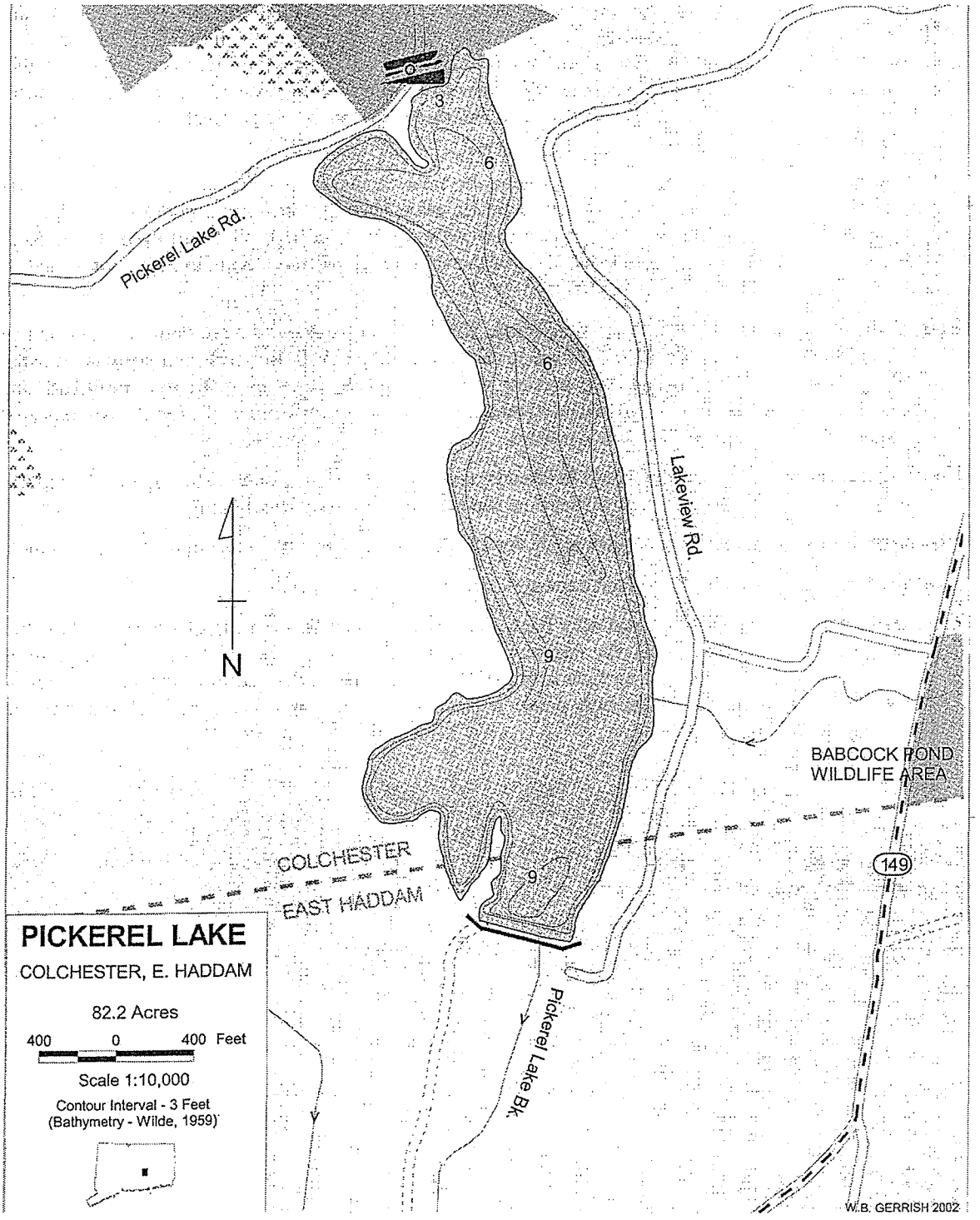
GENERAL LAKE CHARACTERISTICS

Pickerel Lake is a 82.2 acre lake in Colchester and East Haddam, Connecticut. The lake is featured in a number of state and federal compilations of Connecticut lakes, A Fisheries Survey of Lakes and Ponds of Connecticut (State Board of Fisheries and Game 1959), A Guide to Lakes and Ponds of Connecticut, an Interim Report (CT DEP 1987), Trophic Classifications of Forty-nine Connecticut Lakes (CT DEP Bureau of Water Management 1992), Water-Quality Characteristics of Selected Public Recreational Lakes and Ponds in Connecticut (USGS 1995).

In each case the surface area had been given as 88.6 acres. This was the value used by Atlantic Environmental Services in their feasibility study of Pickerel Lake in 1985, and by William Dopirak in his master thesis dated 2002. However, a new state lake compilation A Fisheries Guide to Lakes and Ponds of Connecticut (Jacobs and O'Donnell 2002), gave the surface area as 82.2 acres (**Figure 1**). This new value was probably the result of improved digital computer methods. This last value, 82.2 acres, was the value used in this report; however it should not be considered as representing a loss of lake surface area but as a different and perhaps more accurate estimate of the surface area of the lake.

Each of the documents listed above included a bathymetric map of the lake. A bathymetric map shows the water depths as a series of contour lines or intervals of increasing depth. In each case the bathymetric map was the same map. The first showing of the map was in the A Fisheries Survey of Lakes and Ponds of Connecticut which was published in 1959 but the field work was done sometime between 1953 and 1955. Using the contour lines as reliable estimates of water depth the lake contains about 161 million gallons, or about 489 acre-feet, of water. The Trophic Classifications of Forty-nine Connecticut Lakes (CT DEP Bureau of Water Management 1992) reported the lake volume at 173 million gallons which appears to be an overestimate even considering the larger surface area of 88.6 acres. This report will use 161 million gallons as the volume of the lake. The mean depth is about 5.9 feet with a maximum depth of 10 feet. The mean depth is a ratio of the volume and surface area; it is not the average depth which would be the arithmetic average of a set of recorded water depths. The mean depth gives the depth of the lake that would result if the whole lake was evened out to one uniform depth, like a square sided basin.

Figure 1. Bathymetric Map of Pickerel Lake (Jacobs and O'Donnell 2002).



The lake has a watershed of approximately 801 acres, as reported by A Fisheries Guide to Lakes and Ponds of Connecticut (Jacobs and O'Donnell 2002). The watershed of Pickerel Lake is the land area around the lake that captures rain water and directs it toward the lake. The watershed area also includes the surface area of the lake (**Figure 2**). Prior reports gave a similar value for the watershed. The Trophic Classifications of Forty-nine Connecticut Lakes (CT DEP Bureau of Water Management 1992), gave the size of the watershed as 801 acres. The Water-Quality Characteristics of Selected Public Recreational Lakes and Ponds in Connecticut (USGS 1995) reported the watershed size at 801 acres. The Gazetteer of Natural Drainage Areas of Streams and Water Bodies within the State of Connecticut (CT DEP Bulletin #1 1972), gave the Pickerel Lake watershed size at 1.39 square miles or 889.6 acres. This is higher than other estimates but may include drainage areas of the stream between Pickerel Lake and Moodus Reservoir. Determining the actual size of the watershed of Pickerel Lake is made complicated by the large wetland on the east side of CT Route 149 in the vicinity of Pickerel Lake Road. The drainage divide passes through this wetland in an unspecific way. Changing the location of watershed boundary in this large swamp (~65 acres) could add or subtract up to 60 acres from estimates of the lake watershed size.

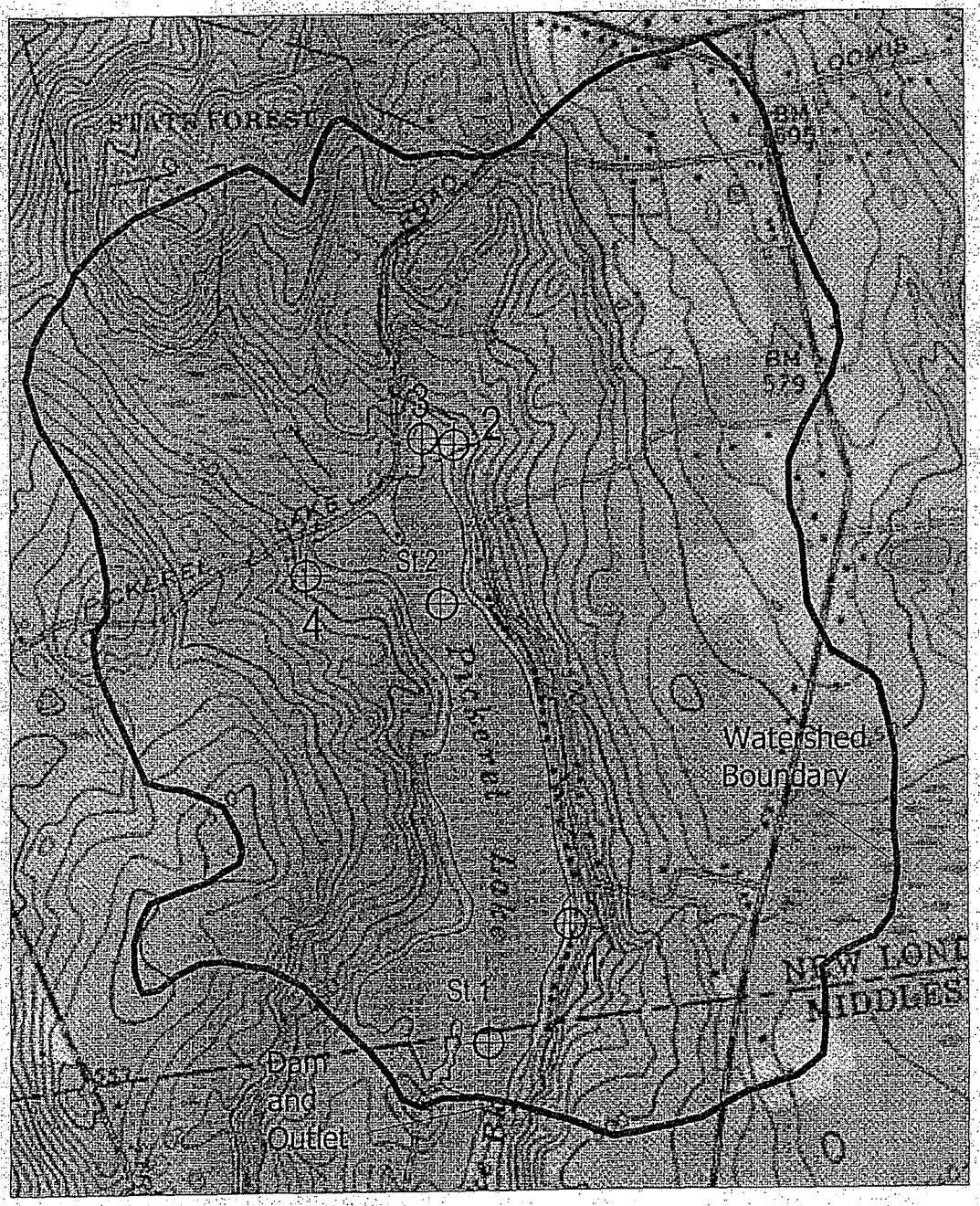
Pickerel Lake is part of the Salmon River basin (Basin Number 4700). The lake discharges to a short stream of about ½ mile before entering Moodus Reservoir. Moodus Reservoir empties to Moodus River which flows into the Salmon River near its mouth with the Connecticut River.

The lake is orientated along a north = south axis with the lakes outlet at the southern end and the state boat ramp at the northern end. There are two shallow coves or bays at the northern end of the lake and a large double cove / bay at the south end, to the west of the dam.

There were four streams found to flow into the lake, the largest appeared to be on the eastern side flowing roughly parallel to Pickerel Drive. Two were found flowing into the northeast cove and one into the northwest cove. Although each was found to contain flowing water in April 2003, each was dry when revisited in July 2003.

Figure 2. Pickerel Lake Watershed Boundary and Sampling Stations.

1-4 = inlet stations, St. 1&2 = In-Lake Stations.



LAKE AND STREAM WATER QUALITY

Water quality samples were collected from the lake on three occasions, April 21, 2003, July 13, 2003, and July 16, 2004. On each date a lake station near the dam was visited where temperature and oxygen measurements were taken and water samples were collected from the water column. In 2003, on both sampling dates, water samples were collected from top, middle, and bottom depths (3, 6, and 9 feet), in 2004 water samples were collected from only the top and bottom (3 and 9 feet), but from 2 stations, the one near the dam and one located at the northern end of the lake. In 2003, each sample was tested for total phosphorus, total nitrogen series, alkalinity, turbidity, specific conductance, and pH. In 2004 only, the samples collected near the dam had this full complement but samples from the northern station were tested for only the phosphorus and nitrogen parameters.

In April 2003 four inlet streams and the lake outlet were also sampled. Each of those samples were tested for the full complement of parameters. The water flow was also measured at the streams. In July 2003 none of the streams were flowing.

Temperature and Oxygen

The water temperature in April was between 13 °C (at the surface) and 10 °C (at the bottom). This is a normal condition for a lake at that time of the year. In July the temperature at the surface was 25.5 °C, but at the bottom it was 16 °C, with a sharp temperature change at about 6 feet (from 22 °C at 6.5 feet to 18 °C at 8 feet). This is a dramatic decrease in water temperature over 1.5 feet at only 8 feet below the water surface and demonstrates the affect of

the milfoil canopy. The canopy is very dense and effectively forms a barrier which is not penetrated by light so little water warming occurs below the canopy. The canopy typically forms at about 3 feet from the surface where the water depth is 7-9 feet deep. At this station the maximum water depth was 10 feet.

The oxygen levels in April were between 9.2 and 9.8 mg/L yielding between 83 and 93 percent saturation. Again this is normal for lakes in the spring. In July 2003 the oxygen was 8.2 mg/L at the surface and zero at the bottom with a sharp change in concentration between 1.5 meters and 2 meters (5 and 6.6 feet). The oxygen concentration went from 8.3 mg/L at 1.5 meters and 1.3 mg/L at 2 meters. This further demonstrates the affect of the milfoil canopy at limiting the diffusion of oxygen from the surface to the bottom of the lake. The milfoil canopy causes the water under the canopy to become devoid of oxygen during the summer months. Data collected during July 2004 showed a similar trend with relatively normal levels of oxygen above the canopy but with low levels becoming anoxic under the canopy.

Total Phosphorus

In the spring of 2003 the phosphorus concentration was between 4 and 5 ppb. This is a very low level and suggests that the lake is oligotrophic. In the summer of 2003 phosphorus was 7 and 9 ppb from the 3 and 6 foot depths but 36 from the 9 foot sampling depth. The two upper samples again had oligotrophic levels similar to those observed in the spring. On July 16, 2004 the upper water samples had 4 and 10 ppb for Station 1 and 2 respectively, while the bottom samples had 9 ppb from Station 1 and 96 ppb from Station 2. The water sample from the 9 foot depth was higher indicating the differing conditions under the canopy of milfoil.

The low phosphorus levels in the lake may give a false reading of trophic status because of the presence of such a dense canopy of milfoil. The milfoil also had a thick covering of attached algae that could be withdrawing nutrients out of the water thereby giving the illusion that the lake is nutrient poor.

Nitrogen

The nitrogen in lake water occurs in two basic forms, inorganic and organic. The inorganic form is commonly represented by nitrate, ammonia and to lesser extent by nitrite. The organic form consists of organic nitrogen. All three forms were tested for in Pickerel Lake.

The values for ammonia and nitrate nitrogen were all below detection in April, nitrate was below detection in July 2003. In April the organic nitrogen ranged between a high of 615 and a low of 115 ppb with the lowest at the bottom and highest at the surface. In July 2003 the organic nitrogen ranged from a high of 1,620 ppb (at the bottom), and a low of 570 ppb (at the surface). In July of 2004 ammonia and total nitrogen were again higher under the canopy. These values suggest that ammonia is released from the sediments under the milfoil canopy due to low oxygen conditions, but even above the canopy there were considerable quantities of nitrogen.

Alkalinity

The alkalinity of the was very low, in April it was 4 mg/L indicating very soft water, in July 2003 it was slightly higher between 6 and 8 mg/L above the canopy. Below the canopy the alkalinity was 28 mg/L indicating the release of salts from the sediments due to the low oxygen

conditions. In July 2004 alkalinity was measured at Station 1 only, the values obtained were 10 mg/L at the surface and 8 mg/L at the bottom. Station 1 at that time showed signs of beginning oxygenated to the bottom, no ammonia difference and very little phosphorus difference between top and bottom.

Conductivity

The specific conductance of water is the capacity to carry an electrical current directly proportional to the amount of salts dissolved in the water. There are a number of ions that are commonly found in lake water, road salts used for winter deicing are examples. Typically, the salts are found in very low quantities hence our waters in the state are considered soft.

Specific conductance followed a similar trend the baseline conductivity in April was 64-65 µmhos/cm, while in July 2003 the 3 and 6 foot depths had readings of 65 and 70 µmhos/cm respectively. The 9 foot sample had a conductivity reading of 103 µmhos/cm, indicating a lack of oxygen at that depth.

Turbidity

The turbidity of the water is a measure of how cloudy the water is. The measurement is taken by passing a beam of light through the sample with a sensor the measures how much of the light gets through. The cloudiness of the water is measured against known standards of arbitrary levels Nephalmetric Turbidity Units (NTU).

The turbidity of the water was very low in April, ranging between 0.5 and 0.8 NTU. In July 2003 the turbidity was similarly low at the surface 0.9 NTU but considerable higher at the bottom 33 NTU.

Summary

The water quality data shows that Pickerel Lake had low levels of each of the parameters in April and in surface waters in the summer. Under the canopy of milfoil oxygen is exhausted due to lack of diffusion through the canopy from the surface. This lack of oxygen causes increases in phosphorus, nitrogen, alkalinity, and conductivity. It also decreases the available habitat for aquatic organisms including fish.

Stream Water Quality

The steams that were sampled are shown in **Figure 2.** Each of the 4 streams had low levels of phosphorus, between 3 and 7 ppb indicating good quality base flow quality. Ammonia was below detection (10 ppb) at all sites, nitrate was below detection in only Stream #1, the other streams had levels between 96 ppb and 117 ppb. The total nitrogen for the streams were; 1 = 128 ppb, 2 = 163 pp, 3 = 194 ppb, 4 = 288 ppb. These values indicate slight nitrogen loading to the streams.

Other values for the streams were normal, alkalinity varied between 2 and 6 mg/L again indicating soft water, conductance was between 84 and 157 µmhos/cm which is normal for eastern CT streams, turbidity was low at 0.4 to 0.9 NTU.

Summary

The stream water chemistry in April indicated that the surface inlet water to the lake was of very good quality, low in nutrients and low in dissolved salts. However, this may not reflect true loading conditions to the lake. The milfoil and association of algae growths on its surface may mask the actual nutrient levels of groundwater seepage and water column concentration by rapid active uptake. The eastern shore of the lake has approximately 65 homes located within 200 feet of the lake shore. The lower tier, those with lake shore frontage, totals at least 50 homes. Each of these homes is within 100 feet of the shoreline and has a domestic waste water disposal system. Of these only a few have records or other drawing or documentation detailing the type or location of waste water system. There are only records for 25 of the 65 homes that line the lake shore in Colchester. Of the records that do exist several show that the waste water system is located between the lake and the house with probably less than 50 feet separating the system from the lake.

This situation suggests that the lake may be receiving nitrogen, as nitrate, and phosphorus from domestic waste water systems via the groundwater. This loading would go undetected when measuring water quality in the surface water streams. This aspect of the lake ecosystem is important to consider if a whole lake weed treatment were to be performed. Removal of the dense milfoil coverage in the lake may have two affects, first there would be a wholesale release of nutrients that were previous assimilated by the plants/algae complex, second there would be a rapid manifestation of true nutrient loading that is occurring at the lake. The milfoil is likely providing a vast capacity to absorb nutrients that would stop if it were removed from the lake on a large scale.

HISTORY OF WEED SURVEYS

There have been several detailed surveys of the aquatic plants in Pickerel Lake. The first was by Atlantic Environmental Services, Inc. July 28, 1986 (AES 1986). The second was by William J. Dopirak, Jr. over the course of the summer of 2001 (Dopirak 2002). A third was made by the DEP in 1996. An finally an intensive survey was made as part of this study. A list of the surveys and dates of observation is given in **Table 2.**

Table 2. Summary of Weed Surveys.

Year		Surveys Dates				
1953-55	CT F&G	Unknown				
1986	AES	July 28				
1989	USGS	August 2				
1996	CT DEP	Summer				
2001	Dopirak	May 15 - 20	June 25 - 30	July 26 - 30	August 18 – 23	October 6 – 11
2003	NEAR	4-16-03	7-22-03	9-22-03		
2004	NEAR	7-16-04				

1953-55 (actual date unknown)

The Fisheries Survey conducted in the early 1950's reported dense submerse vegetation throughout the lake with only scarce open water areas. No plant names were given however, it is possible that even at that time, the plant causing the problem was milfoil. The earliest occurrence of variable-leaved milfoil (Myriophyllum heterophyllum) in Connecticut was 1932 (Les & Mehrhoff 1999).

1986

A one-day survey of the aquatic plants in the Pickerel Lake was conducted by Atlantic Environmental Services, Inc. on July 28, 1986 as part of their feasibility assessment. They

noted that the lake had extensive growths of milfoil and fanwort that was found throughout the lake. The milfoil was referred to as Myriophyllum spp indicating that the there were more than one species represented in the lake. The report states that green water-milfoil (Myriophyllum verticillatum) and Northern Water-milfoil (Myriophyllum exalbescens now called sibiricum) were the dominant species of milfoil in the lake but that there was another unidentified species of milfoil observed. It is possible that the authors of the report, or at least the biologist that did the field work, were unable to reach a conclusion as to the actual identity of the milfoil that they collected. This led them to list all of the species that resembled the plant they found. It is unlikely that M. sibiricum was present in the lake because this plant has a limited range in CT being found mostly in the Northwest corner lakes.

The milfoil was found to grow better in deeper water were water depths were in excess of 7 to 8 feet. The maximum stem length that was observed was about 6 feet resulting in milfoil reaching the surface (topping out) in all areas were water depths were 6 feet or less. In deeper water the milfoil reached to between 2 and 3 feet and as much as 4 feet below the surface.

Fanwort (Cabomba caroliniana) was found at all water depths in Pickerel Lake but appeared to be the predominant plant along most of the east shore. The fanwort was not mentioned in the earlier work by the Fish and Game Survey, so may have been a recent invader. The later study conducted by USGS also did not mention fanwort. Several area lakes are known to have had fanwort infestations including Lake Hayward and Moodus Reservoir. However fanwort appears to be distributed from the boat ramp at the northern end southward suggesting that it was brought to the lake via a boat and trailer.

Other submersed species observed during the survey included snailseed pondweed (Potamogeton diversifolius), water bulrush (Scirpus subterminalis) waterweed (Elodea canadensis), bladderwort (Utricularia spp), and Stonewort (Nitella sp). The floating leaved species observed were white-water lily (Nymphaea odorata), yellow water lily (Nuphar advena), and water shield (Brasenia schreberi). Burreed (Sparganium sp) was the only emergent plant species observed.

Table 3. Aquatic Plants Observed In Pickerel Lake on July 28, 1986

Common Name	Scientific Name	Habitat	Abundance
Green Water-milfoil	Myriophyllum verticillatum	Submersed	Dominant
Northern Water-milfoil	Myriophyllum exalbescens	Submersed	Dominant
Fanwort	Cabomba caroliniana	Submersed	Dominant
Snailseed Pondweed	Potamogeton diversifolius	Submersed	Common
Water Bulrush	Scirpus subterminalis	Submersed	Common
Waterweed	Elodea Canadensis	Submersed	Uncommon
Bladdewort	Utricularia spp	Submersed	Uncommon
Stonewort	Nitella sp	Submersed	Uncommon
White Water-lily	Nymphaea odorata	Floating	Common
Yellow Water-lily	Nuphar advena	Floating	Common
Water shield	Brasenia schreberi	Floating	Common
Burreed	Sparganium sp.	Emergent	Local

1989

The aquatic plants in the lake were observed during an August 2, 1989 water sampling event by the USGS. They reported that the lake was dominated by green water-milfoil (Myriophyllum verticillatum) which was observed to be growing densely throughout the lake. Other species present included tapegrass (Vallisneria spp.), water shield (Brasenia schreberi), White water lily (Nymphaea odorata), and yellow water lily (Nuphar spp.). It is interesting to note that there was no mention of fanwort as being in the lake. Also of interest is the listing of

Vallisneria as being represented by more than one species which for CT is unlikely because there is only one species in our area = Vallisneria americana. This report again gave the species of milfoil as Myriophyllum verticillatum similar to the AES study.

Table 4. Aquatic Plants Observed In Pickerel Lake on August 2, 1989

Common Name	Scientific Name	Habitat	Abundance
Green water-milfoil	Myriophyllum verticillatum	Submersed	Dominant
Tapegrass	Vallisneria spp	Submersed	Present
Water shield	Brasenia schreberi	Floating	Present
White water lily	Nymphaea odorata	Floating	Present
Yellow water lily	Nuphar spp.).	Floating	Present

1996

The Connecticut DEP Environmental and Geographic Information Services conducted a survey of the aquatic plants in Pickerel Lake during the summer of 1996. The lake was dominated by milfoil (called Myriophyllum heterophyllum), and fanwort was also noted. The shallow coves were covered by both water lilies (white and yellow) and water sheld. This was the first survey that reported the presence of pondweeds and gave species names for the bladderwort. This survey did not find some of the species noted in the AE survey but reported new species not mentioned in that earlier survey. Species added include water naiad, wolffia, spriodela, pondweeds and bladderwort. The plants that were observed in 1986 but not reported in 1996 include water bulrush, stonewort, and waterweed.

Table 5. Aquatic Plants Observed In Pickerel Lake Summer 1996

Common Name	Habitat	Scientific Name
Variable-leaved Milfoil	Submersed	*Myriophyllum heterophyllum X*
Fanwort	Submersed	*Cabomba caroliniana*
Water-Willow	Emergent	*Decodon verticillatus*

Creeping Bladderwort	Submersed Free Floating, mixed in	*Utricularia gibba*
Large Purple Bladderwort	Submersed Free Floating, mixed in	*Utricularia purpurea*
Bladderwort	Submersed Free Floating, mixed in	*Uticularia gemiscarpa*
Swollen Bladderwort	Submersed Free Floating, mixed in	*Utricularia radiate*
White Water Lily	Floating leaved	*Nymphaea odorata*
Water Shield	Floating leaved	*Brasenia schreberi*
Yellow Water Lily	Floating leaved	*Nuphar variegate*
Pondweed	Submersed	*Poamogeton spirillus*
Pondweed	Submersed	*Potamogeton epihydrus*
Water-thread Pondweed	Submersed	*Potamogeton bicupulatus*
Water naiad	Submersed	*Najas flexilis*
Large Duck Weed	Floating	*Spirodela polyrhiza*
Duck Meal	Floating	*Wolffia sp*
Golden Pert	Tiny near shore	*Gratiola sp*
Burreed	Emergent	*Sparganium sp*
Arrowhead	Shallow water	*Sagittaria sp (rosettes)*

2001

The aquatic plants in Pickerel Lake were surveyed by William J. Dopirak as part of a Masters Thesis prepared for Central Connecticut State University (Dopirak 2002). He conducted 5 surveys of the lake during 2001 mapping the distribution of the milfoil and fanwort as well as preparing a species list and retaining voucher specimens. Maps from four of his surveys (**Figures 3-6**) are included in this report because they clearly show the progression of fanwort during the season. His report listed the milfoil as Myriophyllum heterophyllum, he also documented the presence of large beds of fanwort Cabomba caroliniana.

The vast majority of the lake was found to contain dense growths of milfoil and fanwort. The other species were found in only a select few areas. Most notably the cove at the northwest end and the large double cove at the southwest end were covered with floating

leaved species, water lily and water shield. One small area at the end of the tiny peninsula just west of the dam was found to contain a refuge for the pondweed.

This work was significant because it noted that fanwort tended to begin each year as small plants taking the season to grow to mature height while milfoil started growing under the ice such that in the spring it already had developed a large quantity of new growth. There was also a significant percentage of the biomass of the plant left standing at the end of the growing season. Although the plant was noted to fragment easily later in the year most of the biomass remained standing after senescence had taken place.

Table 6. Water Weeds In Pickerel Lake From 2001 Survey.

Common Name	Habitat	Scientific Name	Estimated % Coverage
Pipewort	Emergent *rare along shore*	*Eriocaulon aquaticum*	*1*
Golden Pert	Emergent *rare along shore*	*Gratiola aurea*	*1*
Creeping Bladderwort	Submersed Free Floating	*Utricularia gibba*	*Mixed with milfoil*
Large Purple Bladderwort	Submersed Free Floating	*Utricularia purpurea*	*Mixed with milfoil*
Swollen Bladderwort	Submersed Free Floating	*Utricularia radiata*	*Mixed with milfoil*
White Water Lily	Floating leaved	*Nymphaea odorata*	*4*
Water Shield	Floating leaved	*Brasenia schreberi*	*4*
Yellow Water Lily	Floating leaved	*Nuphar variegata*	*4*
Water Starwort	Submersed	*Callitriche heterophylla*	*1*
Fanwort	Submersed *mixed with Milfoil*	*Cabomba caroliniana*	*35*
Water-thread Pondweed	Submersed *rare*	*Potamogeton diversifolius*	*1*
Variable-leaved Milfoil	Submersed *throughout*	*Myriophyllum heterophyllum*	*85*

Figure 3. Dopirak Aquatic Plant Distribution Map for Pickerel Lake, Early Spring 2001.

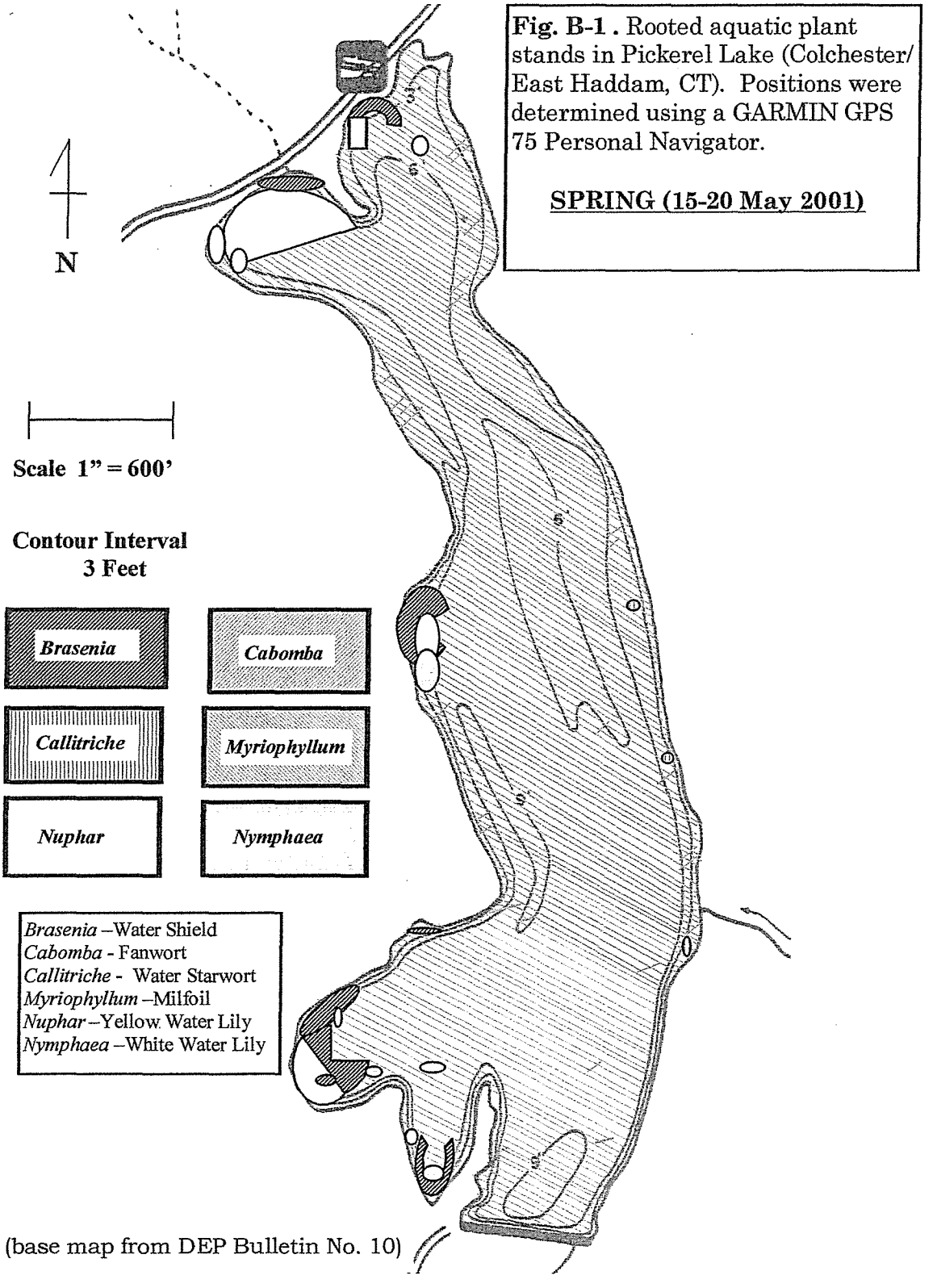


Figure 4. Dopirak Aquatic Plant Distribution Map for Pickerel Lake, Late Spring 2001.

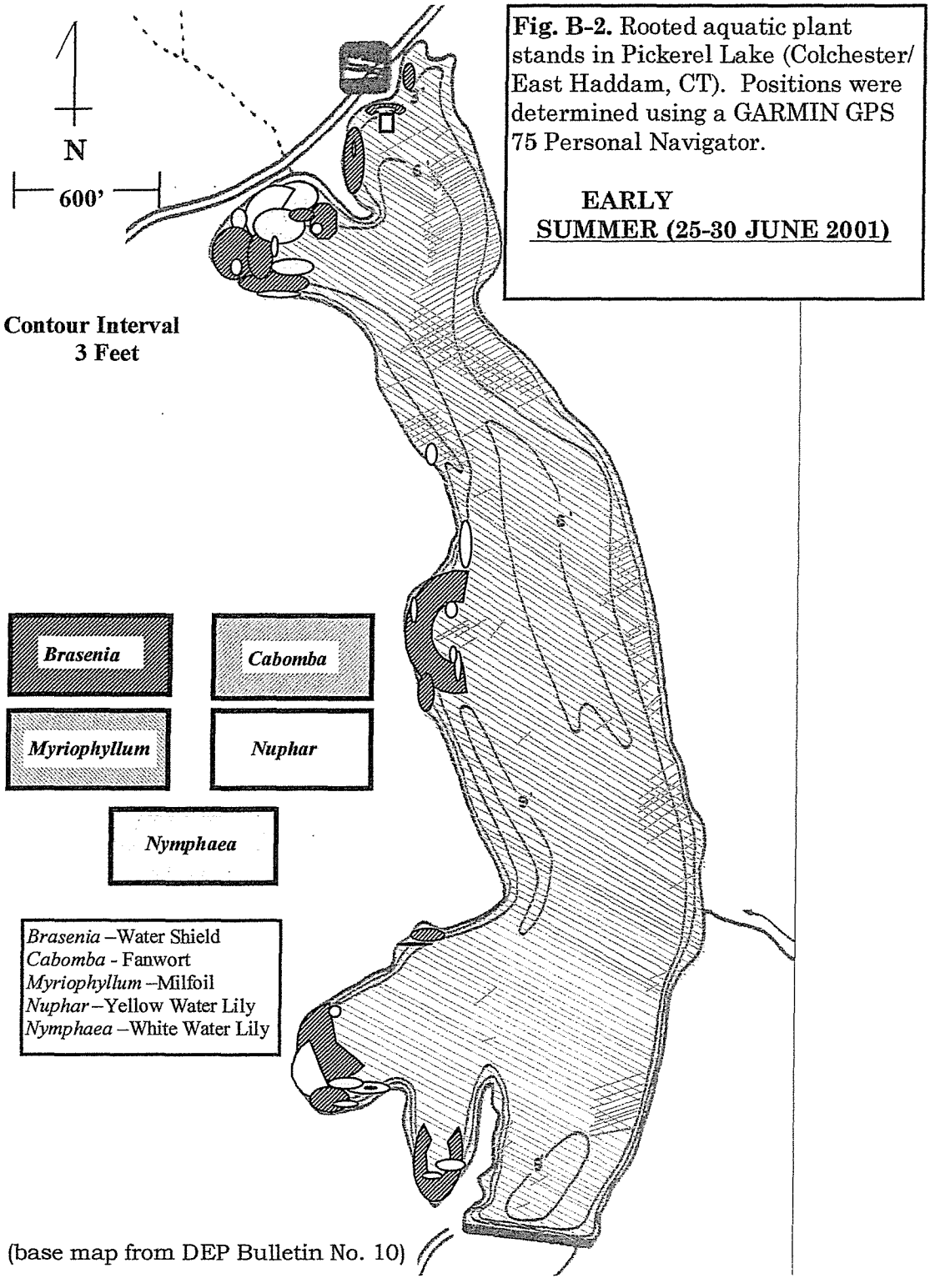


Figure 5. Dopirak Aquatic Plant Distribution Map for Pickerel Lake, Summer 2001.

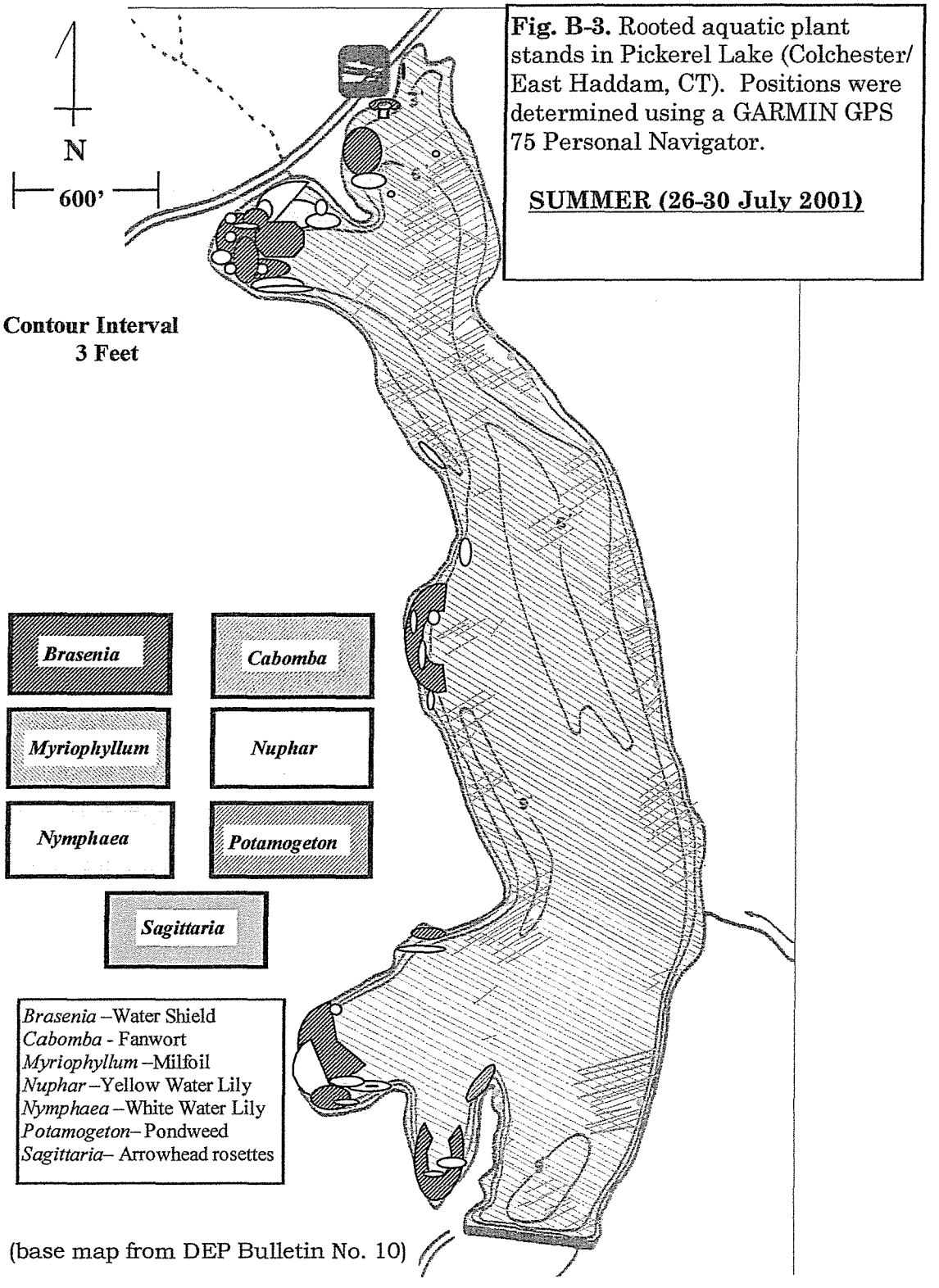
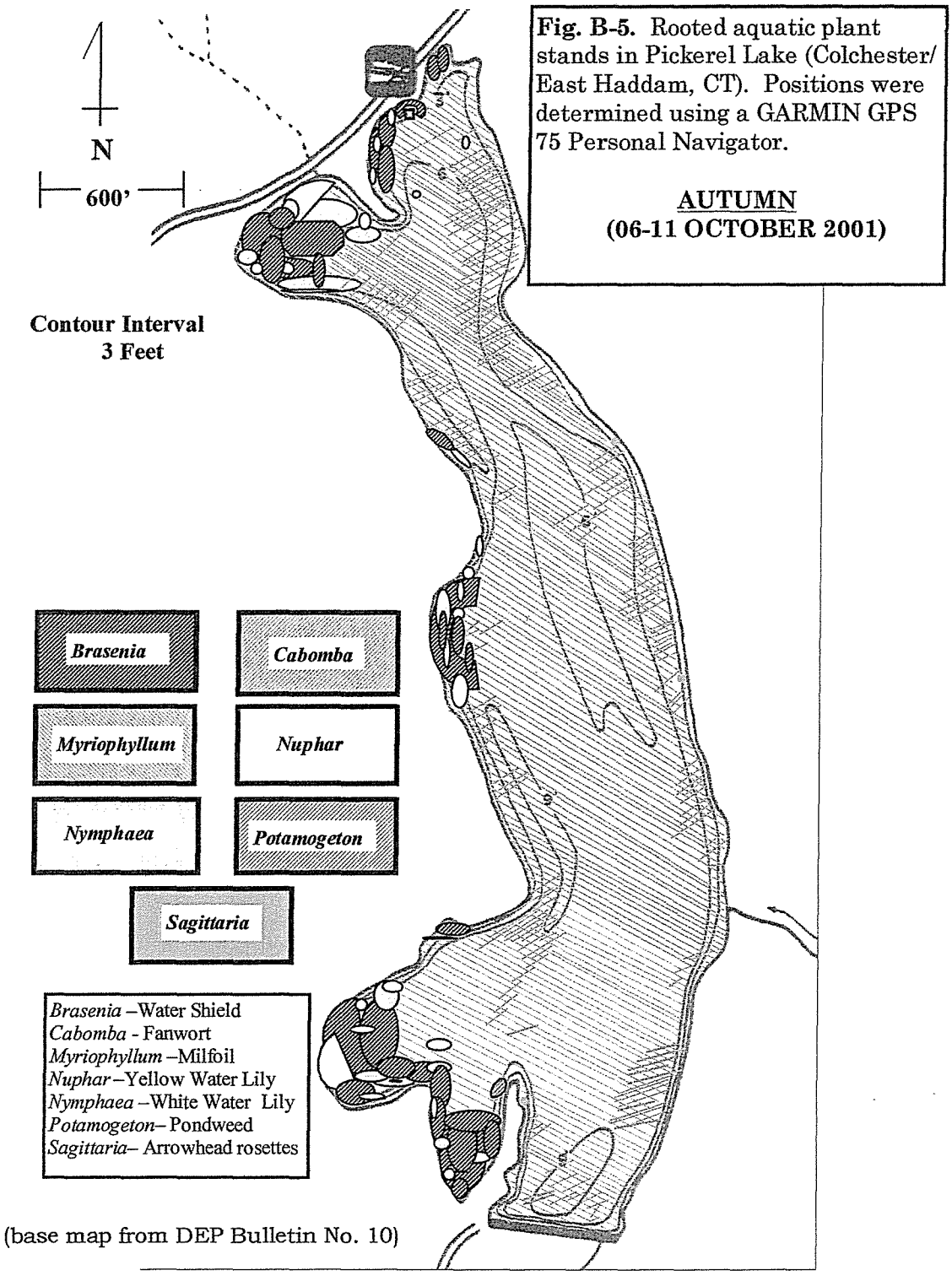


Fig. B-3. Rooted aquatic plant stands in Pickerel Lake (Colchester/ East Haddam, CT). Positions were determined using a GARMIN GPS 75 Personal Navigator.

SUMMER (26-30 July 2001)

Figure 6. Dopirak Aquatic Plant Distribution Map for Pickerel Lake, Fall 2001.



2003 - 2004

The survey of the aquatic plants conducted during this study agreed with data collected by Dopirak in 2001. The lake had complete coverage of aquatic plants (**Figure 7**). A series of transects was used to characterize the water depths, and bottom type (**Figure 8**). Almost the entirety of the deeper areas of the lake, >4 feet, were covered with milfoil which formed a dense canopy at about 6 feet above the bottom. In areas where the water was 6 feet deep or less this canopy was located at the water surface, "topping out", or forming a weed mat on the surface. In areas where the water depths were greater than 6 feet the milfoil canopy generally followed the bottom depth contours such that it was located at between 1 and 3 feet, and as much as 4 feet, below the surface in areas were the water depth was 7 to 9 feet deep. In areas were the water was between 9 and 10 feet deep there did not appear to be any milfoil growing leaving an open area. Bladderwort was found mixed with milfoil throughout the lake.

Fanwort was found mixed in with milfoil and generally did not form solitary beds. Fanwort was abundant along most of the east shore; generally in water shallower than about 6 feet although it could be found at all water depths. At the north end of the lake there were dense beds of fanwort off shore of the boat ramp and in the lake area near the ramp. In that area the fanwort was at its maximum density in the lake. There were prolific stands of fanwort along the western shore and in the south near the dam as well.

The northwestern cove had two extensive beds of water shield that formed a closed canopy over the water surface of about 1.6 acres. Mixed in the water shield were the two water lilies (white and yellow) mostly closer to the north and west shoreline. There were a few small areas where some open water persisted where the two pondweeds could be found. It is

probable that beavers were active in keeping these areas open of milfoil and floating leaved plants. The southwestern cove also had dense complete surface coverage with water shield with water lilies of about 2 acres. There were two small areas where pondweeds were abundant, both were at the tips of the peninsulas that extend from the southern shore. These areas had rocky substrate that may have limited colonization by milfoil and fanwort.

Table 7. Aquatic Plants in Pickerel Lake From 2003 – 2004 Survey.

Common Name	Habitat	Scientific Name
Water-Willow	Emergent, west side at north and south end coves	*Decodon verticillatus*
Pickerel Weed	Emergent, west side north cove	*Pontederia cordata*
Creeping Bladderwort	Submersed Free Floating, mixed in	*Utricularia gibba*
Large Purple Bladderwort	Submersed Free Floating, mixed in	*Utricularia purpurea*
	Submersed Free Floating, mixed in	*Uticularia gemiscarpa*
Swollen Bladderwort	Submersed Free Floating, mixed in	*Utricularia radiate*
White Water Lily	Floating leaved	*Nymphaea odorata*
Water Shield	Floating leaved	*Brasenia schreberi*
Yellow Water Lily	Floating leaved	*Nuphar variegata*
Fanwort	Submersed	*Cabomba caroliniana*
Water-thread Pondweed	Submersed, west side at north and south end coves	*Potamogeton bicupulatus*
Variable-leaved Milfoil	Submersed	*Myriophyllum heterophyllum X*
Pondweed	Submersed, west side at north and south end coves	*Potamogeton epihydrus*
Tapegrass	Submersed, west side at south end cove	*Valisneria americana*
Aquatic Rush	Submersed, west side at south end cove	*Scirpus subterminalis*

Figure 7. Aquatic Plant Distribution Map From 2003 Survey.

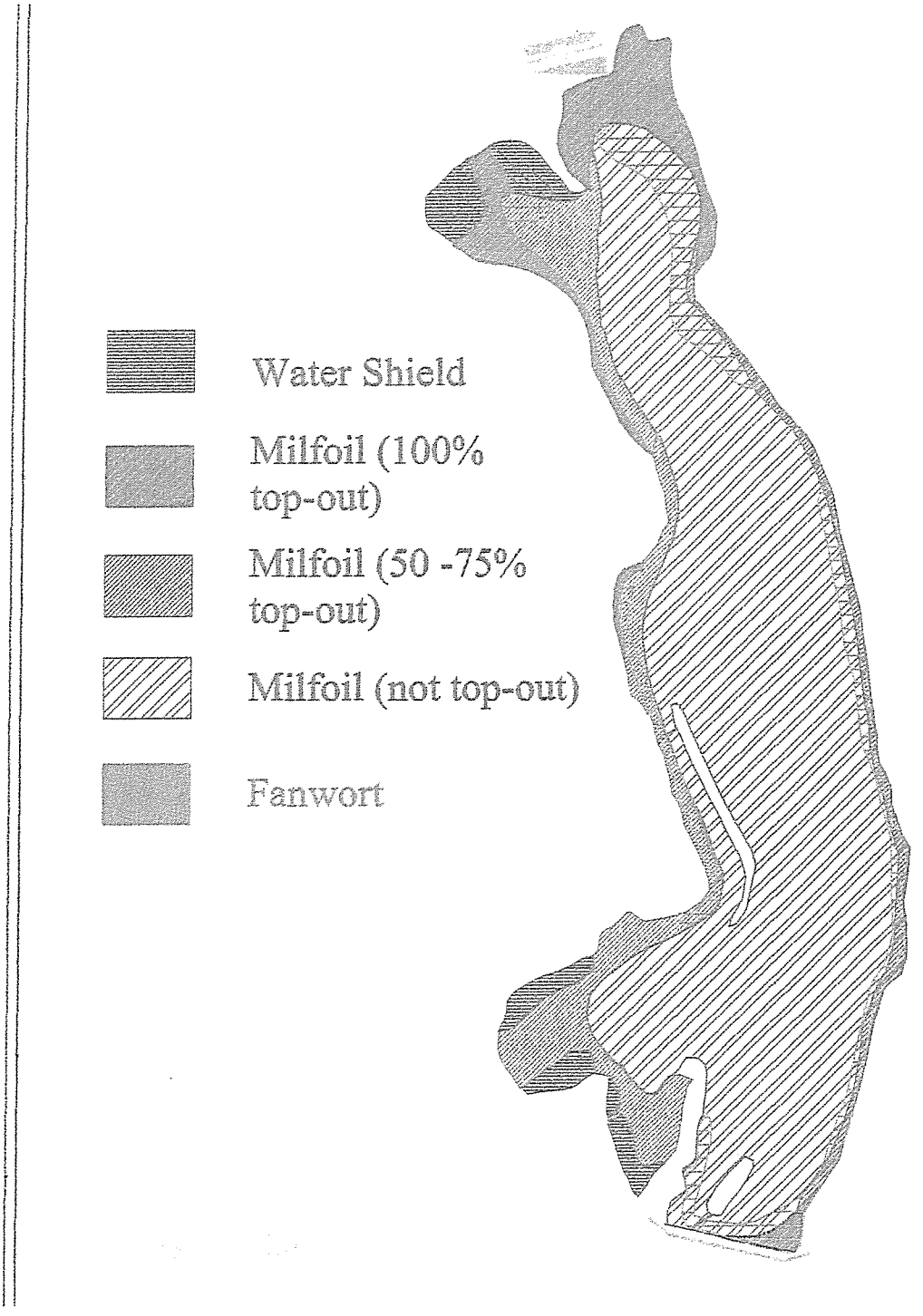
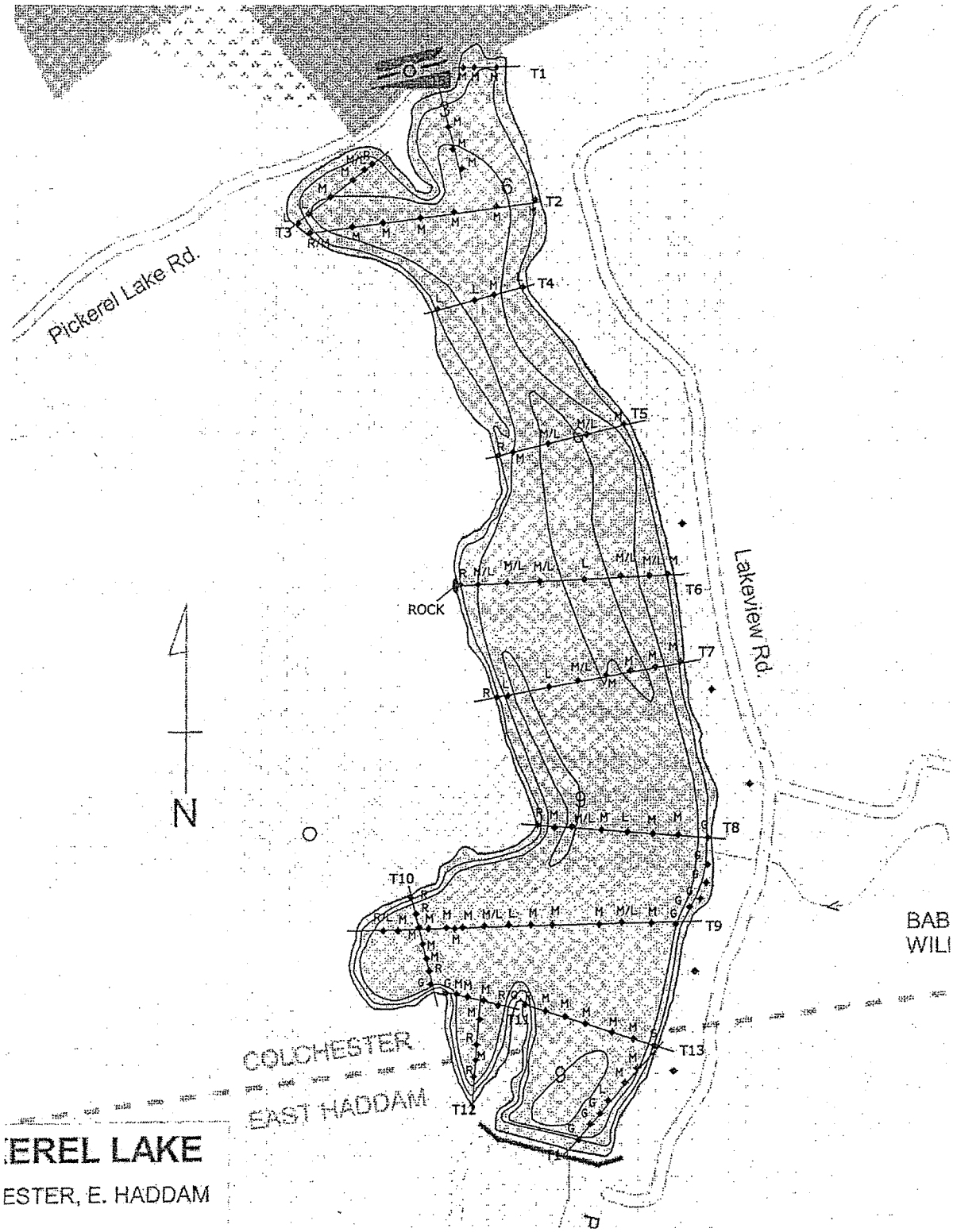


Figure 8. Transects and Observation Points Used During Plant Surveys 2003. Also Shown Are Sediments Types, M = Mud, G = Gravel, R = Rock, L = Loam.



DETAILED DESCRIPTIONS OF AQUATIC PLANT DISTRIBUTION

The water plants generally occur in four major groups characterized by their life form or the way they grow. The four groups are 1) shoreline emergents, such as cattail, 2) floating-leaved plants such as water lilies, 3) submersed plants that reach the surface with a shoot tips, flowers, or small floating leaves, and 4) true submersed plants that don't reach the surface (See Figure 9 for illustration).

Emergent Plants

This group of aquatic plants has their roots and the base of the shoots under water with the remaining portion of the plant above the water. All the leaves, flowers, and fruits are in the air. The emergent plants are limited to very shallow water (< 1 foot) so are typically found close to shore. There are 3 common emergent plant species so far identified at Pickerel Lake pickerelweed, waterwillow, and pipewort which was collected on one occasion from inside the southwest cove. Pickerelweed grows to be a foot or so tall, has large wide leaves and a large spike of purple flowers. The largest bed of these plants is along the northern shore of the northwestern cove.

Waterwillow is a short shrub of long shoots that usually grow close to the water arching out over the water. These plants can actually grow on the water surface due to spongy material in its shoot that provides buoyancy. The plant sends out shoots that float on the water where they can produce additional new shoots. In this way waterwillow can colonize open water areas. The stands of waterwillow in the lake were located on the west shore of the northwestern cove, and along the west shore of the southwestern cove.

Floating Leaved Plants

The floating leaved plants are a collection of three species of plants that have leafs that float on the water surface. Below the water, the plant has a thick root system and stems that grow between the roots and water surface. The three species are white water lily, yellow water lily (spatterdock), and water shield. White water lily has large floating leaves, and a large white flower. Yellow water lily, or spatterdock, also has large floating leaves, but has a yellow flower. The water shield has small oval shaped floating leaves, with a non-descript flower that is generally not seen. The two water lilies are confined to water that is shallow enough for their stems to reach the surface and where the sediments are composed of rich organic muds. Because the plants can expand their distribution by root stock development the coverage by lilies form dense beds of floating leaves over essentially 100 % of the water surface. The water-shield plants can grow in deeper water, up to about 10 feet, but rarely form dense beds at that depth. Ordinarily the dense water-shield beds are in the same water depths as the lilies, between 0 and 3 feet. Water deeper than about 4 feet is generally too deep for the lily-pad development.

Submersed with Floating Leaves and Aerial Shoots Tips

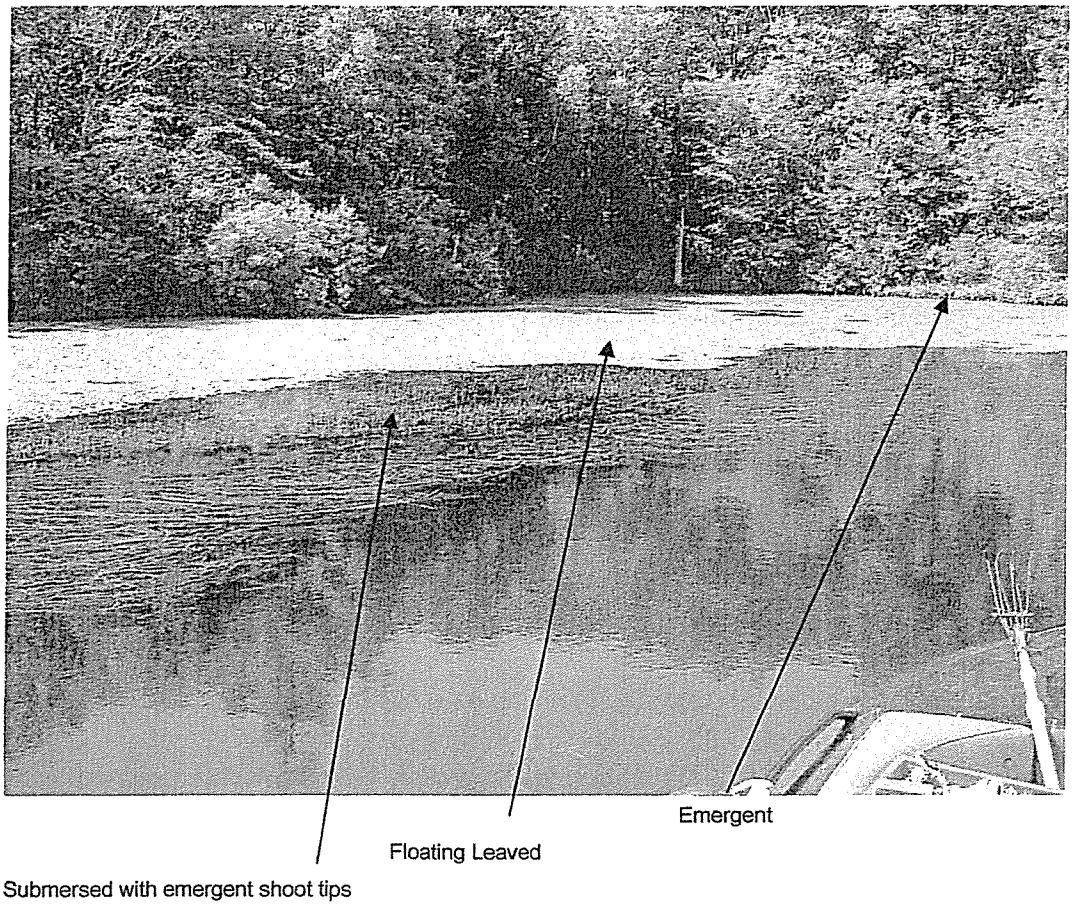
Most of the plants found at Pickerel Lake are in this group of plants. They have a small aerial part of the shoot but all the remaining plant parts are under water. The most prominent example of this type of plant is milfoil, but the bladderworts and fanwort are also of this type. These plants have a either a short emergent spike that bears flowers and fruits or several upper leaves that float on the water surface. Typically, the exposed shoot is only a few inches long. The floating leaves are small, compared to the water lilies. The rest of the plant is under water.

These plants are theoretically limited to water depths of 33 feet due to atmospheric pressure but generally are limited to much shallower depths by light penetration. In clear lakes pondweeds milfoil and fanwort have been found growing down to 20 feet. Usually the densest beds are in water between 5 and 8 feet. In Pickerel Lake poor water clarity appears to be limiting growth of plants to about 9.5 feet.

True Submersed

These plants are completely submersed, that is they have no aerial portion. There were no plants of this type in Pickerel Lake. These plants almost never reach the surface with floating leaves or seed heads.

Figure 9. Photograph of Pickerel Lake Showing Each of the Different Growth Types



MANAGEMENT OPTIONS FOR WEED CONTROL

There are several different types of weed control techniques available to control aquatic plant nuisances. Each has a different approach varying from large-scale methods that affect the entire lake to small-localized methods. Each of the methods is listed here with a brief description of how it works and its feasibility at Pickerel Lake. A summary is given afterward that gives conclusions of this analysis and a table is included that gives approximate cost and other details about each method. In addition a table of all weed management methods is provided in **Appendix 1** comparing the advantages and disadvantages of each method.

Water Level Control

Lake draw-down has been used in Connecticut for many years as a standard cure-all. It is relatively inexpensive; all that is needed is a dam with a spillway with an elevation on the downstream side that is lower then the desired draw-down depth. Then, either the boards are removed or a gate valve is opened, and water is released until the lake level has been drawn down to the desired target depth. The dam at Pickerel Lake is owned by CT DEP. Opening the value at the dam for lake level draw-down is done under contract with CT DEP Eastern District.

The key to a successful draw-down is a prolonged and sustained drying and freezing of the lake bottom that supports nuisance plant growth. A minimum time interval for a sustained draw-down is 6-8 weeks (42 – 56 days) during the winter, with draw-down commencing in early October and refill to commence around the 1st of March.

The ability of this method to control rooted aquatic plants is dependent on several factors. Only those plants that grow in the exposed area will be impacted by the lower water level. Plants that live below the water surface at the draw-down level will not be impacted and may instead increase in range by expanding into the areas cleared by the draw-down. Draw-down success in northern lakes can be limited by an early snow that will insulate the exposed lake sediments reducing freezing of those sediments or if significant groundwater seepage into areas of plant growth will prevent freezing and drying. Even under the best conditions, significant re-infestation may occur from existing seed beds and areas of growth not reached or effected by the draw-down.

Once the draw-down period is over the valve is closed and lake level is returned to normal. Deeper draw-downs will require more water for refilling once the dam is closed. Timing the closing of the valve is important because generally runoff from the drainage basin decreases dramatically after leaf-out at the beginning of May.

The ability of the Pickerel Lake drainage basin to provide enough water to refill the lake has been estimated. The water volumes in each 1 foot of depth in the upper 5 feet of water are shown in Table 8. There is between 22 and 26 million gallons in each water layer. A three foot draw-down would evacuate about 75.6 million gallons.

Table 8. Water Volume Contained in Each 1 Foot of Depth At Pickerel Lake.

Water Depth Range (feet)	Volume (Million Gallons)	Volume (Acre-feet)
0 – 1	26.07	80
1 – 2	25.75	79
2 – 3	23.79	73
3 - 4	23.14	71
4 - 5	21.18	65

Based on a surface area of 82.2 acres

The estimated volume of runoff into Pickerel Lake is based on the size of the water shed and the amount of precipitation that falls during each month. The highest runoff occurs during the wettest months of March and April, runoff is also high between November and February, but beginning in May runoff declines to reach lows during the summer. Using an average effective precipitation of 24.5 inches (the amount of rainfall that becomes runoff) the expected average runoff to the lake would be about 532 million gallons/year. Using monthly percentages generated by USGS long-term rainfall records the expected average monthly runoff to Pickerel Lake is given in Table 9. However, lower than average rainfall could reduce these estimates considerably with each inch of decreased annual rainfall converting into about 22 million gallons less annual runoff. Even given this consideration there should be plenty of runoff during most years for a three foot draw-down to be refilled between February and the end of March.

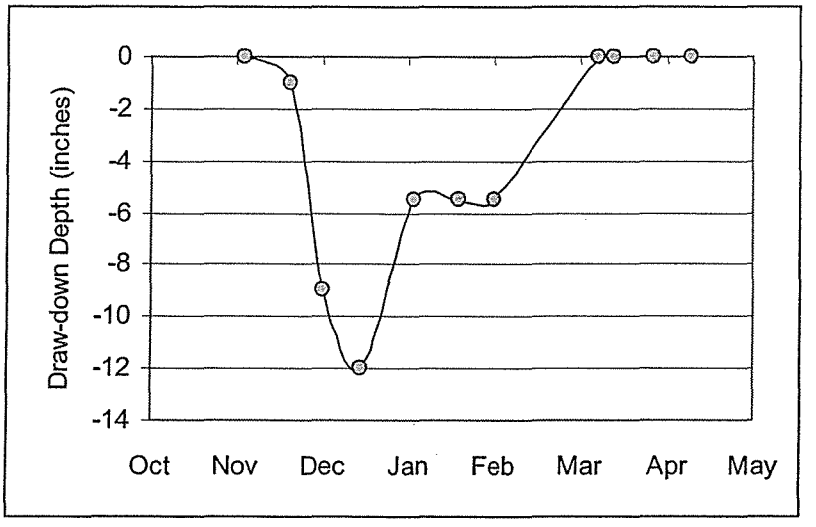
Table 9. Average Monthly Runoff Volumes To Pickerel Lake.

Month	Average Runoff Million Gallons
January	54.0
February	55.3
March	87.8
April	89.9
May	53.8
June	28.5
July	14.0
August	19.6
September	16.6
October	24.0
November	40.9
December	48.5

Given these high runoff volumes a greater problem at Pickerel Lake may be in evacuating the water from the lake and keeping the water level down at the target elevation. A

2 foot lake draw-down was attempted over the winter of 2003 - 2004 but was deemed unsuccessful because the level could not be brought down on account of high rainfalls during December (**Figure 10**). The draw-down was started on November 3, 2003 but stopped on January 9, 2004, by request of the Town of Colchester. The maximum draw-down depth was 12 inches reached in early December for a brief period.

Figure 10. Lake Level Recorded At Pickerel Lake Dam, Winter 2003 – 2004.



Draw-downs may also impact the other organisms living the exposed area. Sometimes this may cause significant harm to the food webs by eliminating invertebrates, insects, mussels, reptiles, amphibians, and snails. The littoral zone is a very productive part of a lake ecosystem that would take several years to recover from one winter of freezing and drying.

One of the principal undesirable effects of draw-down is the potential impacts to fish due to lower dissolved oxygen levels under the ice. Because of the decreased water volume under the ice dissolved oxygen can be depleted faster then would normally occur in the winter. This was tested during the winter of 2003 - 2004 at Pickerel Lake however; the draw-down had been terminated so under ice data did not reflect drawn-down conditions.

Two visits were made to the lake to record oxygen concentrations and water temperatures under the ice at Pickerel Lake. During each visit two sites were visited, one at the north and one at south end of the lake (see **Figure 2**). The temperature, oxygen concentration and percent saturation are given in **Tables 10 and 11.** There were some declines in oxygen under the ice in January but by late February the oxygen levels had become supersaturated, above 100%, probably due to active growth of milfoil, which did look bright green under the ice.

Table 10. Temperature, Oxygen, and Percent Oxygen Saturation At The South Station in Pickerel Lake.

	January 26, 2004			February 27, 2004		
	Temp	Oxygen	Saturation	Temp	Oxygen	Saturation
Depth (ft)	°C	mg/L	%	°C	mg/L	%
0	0.2	13.0	89	2.0	13.4	97
1	0.1	13.1	90	3.7	13.8	104
2	1.2	13.4	95	4.0	13.8	105
3	3.0	12.0	89	4.0	13.8	105
4	3.1	11.6	86	4.0	14.0	107
5	3.7	10.0	76	4.0	14.0	107
6	4.0	9.6	73	4.0	13.8	105
7	4.0	9.2	70	4.0	13.6	104
8	4.0	9.1	69	4.0	13.4	102
9	4.0	9.1	69			
9.5	4.0	5.6	43			

Table 11. Temperature, Oxygen, and Percent Oxygen Saturation At The North Station in Pickerel Lake.

	January 26, 2004			February 27, 2004		
	Temp	Oxygen	Saturation	Temp	Oxygen	Saturation
Depth (ft)	°C	mg/L	%	°C	mg/L	%
1	0.2	13.8	95	4.0	16.0	122
2	2.1	12.1	88	4.0	16.2	124
3	3.1	10.0	74	4.2	16.6	127
4	3.8	7.5	57	4.4	15.0	116
5	4.0	6.2	47	4.9	9.4	73
6	4.0	5.8	44	5.0	8.2	64
7	4.0	5.8	44	5.0	7.8	61
8	4.2	2.8	21	5.0	6.8	53

Additional side affects of draw-downs are; if the sediments where vegetation is removed due to the draw-down are organic the plants may be replaced by filamentous algae the following spring due to the abundant nutrients in the muds, also, draw-down exposes sediments along the lake shore erosion due to rain during the draw-down period which will wash minerals into the lake causing nutrient increases.

Draw-down may also cause the loss of desirable species of plants and increased infestation of draw-down resistant non-desirable plants. One way to reduce the re-infestation from undesirable species is to conduct draw-down only once every 2-3 years. Draw-down is non-selective as it will affect all the plants growing within the exposed areas, good and bad. However, not all species are susceptible to draw-down. **Table 12** shows the effect of draw-down on some common aquatic plants. Generally, plants that grow from seed, like pondweeds are only marginally susceptible if at all. Plants with significant root structures, like water lilies and perennial plants like milfoil are controlled fairly well with draw-down.

Table 12 - Effects of Draw-down on 19 Common Aquatic Plants*

Species that usually increase	alligator weed (*Alternanthera philoxerides*)
	hydrilla (*Hydrilla verticillata*)
	cutgrass (*Leersia oryzoides*)
	bushy pondweed (*Najas flexilis*)
	smartweed (*Polygonum coccineum*)
	leafy pondweed (*Potamogeton epihydrous*)
	softstem bullrush (*Scirpus validus*)
Species that usually decrease	water shield (*Brasenia schreberi*)
	fanwort (*Cabomba caroliniana*)
	coontail (*Ceratophyllum demersum*)
	Brazilian elodea (*Elodea densa*)
	milfoil (*Myriophyllum spp.*)
	southern naiad (*Najas guadalupensis*)
	yellow water lily (*Nuphar spp.*)

	water lily (*Nymphaea odorata*)
	Robbins's pondweed (*Potamogeton robbinsii*)
Species that do not change or have variable response	water hyacinth (*Eichhornia crassipes*)
	elodea (*Elodea canadensis*)
	cattail (*Typha latifolia*)
	Largeleaf pondweed (Potamogeton amplifolius)

* Based on Table from "Restoration and Management of Lakes and Reservoirs" by Cooke et.al. (See references for bibliographic information)

There is a history of draw-down at Pickerel Lake with prior, or historical, draw-down depths being deeper than the 2 or 3 feet proposed now. Reportedly, this was the method that kept the weed manageable. Draw-down still may be a feasible tool to combat near shore growth of milfoil and fanwort. But because the lake has relatively steep sides the surface area of the lake that is potentially controlled by shallow draw-downs is small. The shoreline areas that would be exposed by different draw-down depths are shown in Table 13.

Table 13. Surface Areas Exposed During Each 6 Inch Depth Increment At Pickerel Lake.

Depth Increment	Acres	Cumulative	Acres	Cumulative
0 – 6 (0.0 - 0.5)	1.3	1.3	1.0	1.0
6 – 12 (0.5 – 1)	1.4	2.7	1.0	2.0
12 – 18 (1.0 – 1.5)	1.3	4.0	1.0	3.0
18 – 24 (1.5 – 2.0)	1.3	5.3	1.0	4.0
24 – 30 (2.0 – 2.5)	1.9	7.2	1.10	5.1
30 – 36 (2.5 – 3.0)	2.1	9.3	1.25	6.35
36 – 42 (3.0 – 3.5)	2.3	11.6	1.25	7.6
42 – 48 (3.5 – 4.0)	2.5	14.1	1.7	9.3
48 – 60 (4.0 – 5.0	6.1	20.2	3.2	12.5
60 – 72 (5.0 – 6.0)	10.0	30.2	4.0	16.5

These values are base on the depth contours from the 1959 mapping that was published in the recent lake and pond fisheries guide (Jacobs and O'Donnell 2002). However, water depths recorded during this survey indicate that the lake may be deeper closer to shore than

shown by that map. The new areas shown in the **Table 12**, illustrate that the area of shallow water is small in each 0.5 foot depth increment indicating that draw-down will have a very limited affect on rooted macrophytes in the lake. For a draw-down to have measurable affect on the milfoil it would have to be at least 36 inches

Benthic Barriers

The term benthic refers to the sediment surface so a benthic barrier is a bottom cover or liner that is placed over the plants on the lake bottom. The goal of the barrier is to cut off the light to the plant as well as provide a barrier through which the plant cannot grow. In theory, these barriers work very well, but in practice, a number of shortcomings have limited their use to specific situations. The materials tended to trap gases under them causing them to billow up, or the material did not hold up to long-term exposure to light. Accumulated sediments on top of the barriers allowed for rooting of plants essentially burying the barrier. New porous materials have solved the billowing problem by allowing gases to pass through the barrier but accumulated sediment must still be removed annually.

Benthic barriers are effective in small areas such as dock spaces and swimming beaches to completely terminate plant growth. They are also useful in creating access lanes through areas of dense plant growth. Large areas are not often treated, however, because the cost of the material and installation is high, and maintenance can be problematic. Treating large areas also impacts native or non-target species and can significantly limit habitat for aquatic organisms.

Benthic barriers may provide some limited use at Pickerel Lake where boating lanes are required through, either, water lily beds, or the topped out milfoil near the shore. The price will depend on the areas that would be installed but a basic cost of about $7,500 for a 5,000 square foot area is a general estimate. A covering of 5,000 sq ft would be equal to a 100 x 50 foot long lane. Once the material has been purchased it can be reused for several years. It does require maintenance because new organic sediments can accumulate on its surface providing a medium for new plant growth. Each fall and spring it is recommended that the surface be cleared off. The smaller applications can be removed in the fall and replaced the following spring. It usually works best if the existing plants are removed prior to installation.

Dredging

An analysis of feasibility of dredging Pickerel Lake is covered in Feasibility Study Of The Remediation Of Pickerel Lake by Atlantic Environmental Services (1986) and in Dredging Update To The Feasibility Study Of The Remediation Of Pickerel Lake, by Baystate Environmental Consultants, Inc. (2004). What follows here is brief overview of dredging as a lake weed management tool. The Baystate report is attached to the rear of this report.

Dredging works as a plant control technique when either, light limitation on growth is imposed through increased water depth, or, when enough soft sediment is removed exposing less hospitable substrates such as gravel or coarse sand. Dredging using suction hoses and SCUBA can be used to remove a target weed species by extracting the whole plant, rootstocks, and seeds. The sediment however is usually returned to the lake.

In order to make the lake deep enough to limit the amount of light reaching the plants sediments have to be removed such that the new depth is greater than the associated light penetration. This limits the use of dredging to areas away from shore because some slope is still necessary at the lake edge. In addition, if water clarity is already very good than the depth required to induce light limitation may be too excessive to be practical.

If the soft sediments that are supporting the nuisance plants are not especially thick it may be possible to create a substrate limitation instead. In this situation the organic mucks are removed leaving coarser material that doesn't support plant growth. It is usually impossible to remove all the muck so some re-growth occurs.

There are several different ways that sediments can be removed:

- Dry excavation, in which the lake is drained to some extant and sediments are dewatered by gravity and or pumping, and removed by conventional excavating equipment such as backhoes, bulldozers, or draglines.
- Wet excavation, in which the lake is not drained, but may be partially drawn down to minimize downstream flows. The sediments are removed by various bucket dredges mounted on cranes or amphibious excavators.
- Hydraulic dredging, requires a substantial amount of water in the lake to float the dredge and provide a transport medium for the sediment. These dredges are typically equipped with a cutter head that loosens sediments that are then mixed with water and transported as a pumped slurry of 80 to 90 % water and 10 to 20% solids through a pipeline that traverses the lake from the dredge to a disposal area.
- Pneumatic dredging is when air pressure is used to pump sediments out of a lake at a higher solids content than hydraulic dredging. This is not widely used in the US and I don't know of any operations of this type in CT.

There are a number of disadvantages to dredging that limit its use. In each case, a site is necessary to contain the sediments that are to be removed. If no local site is available next to the lake, than sediments need to be trucked to an off-site disposal area, usually at great expense. Local sediment containment basins need some type of capability to allow dewatering flows to get back to the lake. Since these flows are turbid and contain nutrients the flows need to either pass through a settling basin or have a flocculent added to remove the turbidity. In the latter case, a NPDES permit would be required, as the discharge would be considered a pollutant. Those flows would have to be monitored and may be treated so as not impact the lake. Dredging itself causes turbidity in the lake and may impact invertebrate populations, non-target species of plants and fish habitats.

Dry excavation tends to be very thorough because the operator can visually observe the results of the work as it happens, and can work in one specific target area. Hydraulic dredging allows for sediment removal without lowering the lake level, and can work in deeper areas that may be inaccessible to land based machines even if the lake was dewatered.

Some limited dredging may have applicability at Pickerel Lake near the areas where boats are launched and where floating leaved plants appear to be causing wetland succession onto the lake surface.

Light Limitation Dyes

Blue dyes are used to limit the light transmission into water and therefore restrict the depth at which rooted plants can grow. These dyes tend to reduce the maximum depth that plants will grow but usually have limited affect in shallow water (< 4 ft deep). The dye has to be replenished based on the flushing rate of the water body to retain its effectiveness. The low light tolerant plants are favored and those that can reach the surface. Because the dyes limit

light penetration there may be some decrease algae photosynthesis in deeper water causing a subsequent increase in deep water oxygen loss. These types of plant controls are not suitable for controlling weeds at Pickerel Lake because they will have no affect on floating leaved species and probably would have only limited affect on milfoil and fanwort and only then after the whole lake is treated with unknown consequences due to the reduction of light penetration to deep water. Dyes are mainly used in small contained ponds and is no recommended or generally permitted for use in large lakes. It is not a viable alternative in Pickerel Lake.

Mechanical Removal

There are several methods of mechanical removal. These are, hand pulling, cutting without collection, harvesting with collection, rototilling, and hydroraking. All of these techniques are similar to mowing your lawn in that they remove plants down to a certain depth, with the exception to hand pulling, which is like weeding your garden, or tilling the soil like rototilling and hydroraking.

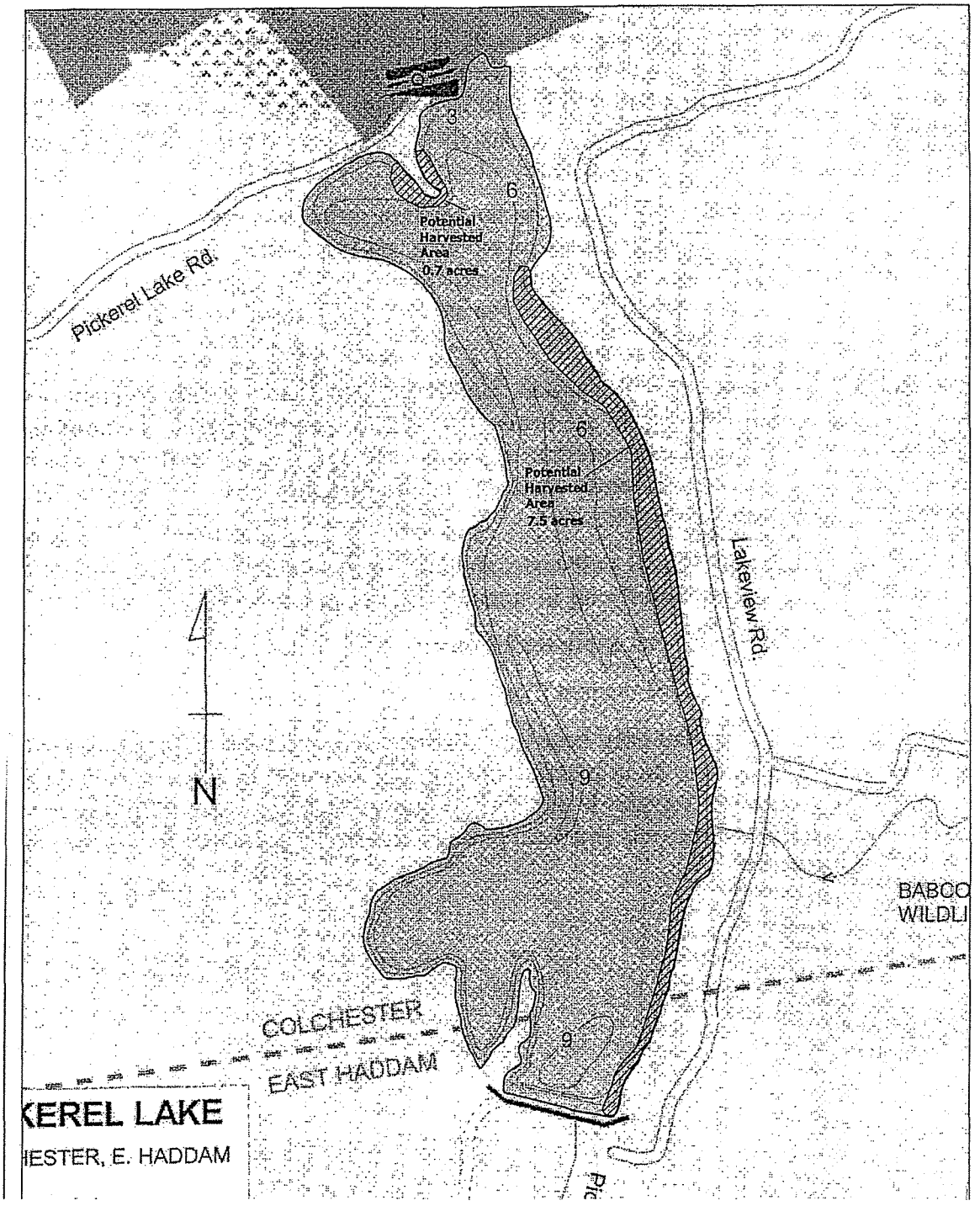
Hand pulling is done by a diver who pulls out the target plants individually. This can be very time consuming but because it is highly selective and is done using a visual operator it can be very effective at controlling target plants in a specific location. Although hand pulling leaves little doubt about whether an individual plant has been removed once the operation is underway it is difficult to keep the area from becoming too turbid to see more plants. Hand pullers have to move to an alternate site until the sediments settle out and the plants can be seen again. Often the site has to be revisited several years in a row in order to insure that all the plants have been removed.

Both cutting and harvesting involve a specialized barge that is fitted with a cutter bar or a cutter bar and a conveyor assemble that retrieves the cut plant material and loads it on the barge. A cutter boat only cuts the plants and leaves the fragments in the lake to be removed by another means or not at all. A harvester collects the cut fragments and transports the material to an off loading site on the shore. In either case, the plant root system and lower shoots are left intake so re-growth is possible and in some case can be so rapid that the area needs re-cutting in a week or two. Cutting or harvesting aggressive colonialist plants such as milfoil is a particularly bad idea because it greatly promotes the spread of these plants into other areas of the lake.

Hydroraking involves the equivalent of a floating backhoe outfitted with a York rake, which looks like a large pitchfork. The tines of the rake are moved through the sediment to rip out thick root masses and associated sediment and debris. A hydrorake can be very effective at removing submerged stumps, water lily root masses, or floating islands. The raking process is not a clean process causing considerable turbidity of the water as well as releasing plant fragments and other debris. Hydroraking is a method that may provide good control of floating leaved weed beds in the cove areas.

Harvesting will cost about $150 / hour with a mobilization fee of between $800 and $1,200. The milfoil is very dense and heavy so may require between 2 and 4 hours to clear each acre or $300 and $600 / acre. There are between 5 and 6 acres maybe up to 10 acres of shore-line along the east side of the lake that could be targeted for harvesting (see **Figure 11**).

Figure 11. Potential Weed Management Zones In Pickerel Lake.



To harvest this area would require about 4 days of harvesting time. However, If the only off-loading site is the state boat ramp at the north end of the lake the time required to travel between the working area and the ramp will short for the north end but steadily increase such that that working down the east shore will become more time intensive with distance from the ramp. It would probably take about 3 weeks to harvest the milfoil from the east shoreline. Figuring about $1,200/day @ 15 days would cost about $18,000. This does not include disposal costs for the harvested plants.

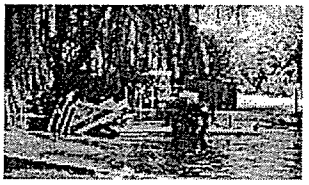
The Pickerel Lake Association could purchase a harvester for permanent use at the lake. The specification sheets for two harvesters are included as **Table 14.** These are large machines that would provide efficient cutting and storage capacity as well as fuel tank and power. These machines are the HM 220 and HM 320 and have costs of $72,900, and $81,000 respectively. A harvester would require an off loading conveyor in order to get the cut weeds onto shore. A trailer conveyor would cost an additional $22,000 for a total cost of $94,900 and $103,000. The freight to have a new machine shipped to CT would be approximately $3,500 that would include the conveyor.

Owning and running a harvester would also require a paid full time operator at say $20/hour for 8 hours for about 12 weeks of the summer for a total of about $12,800 a season. If a volunteer was found that wouldn't mind spending all day on the machine for the summer this cost could be saved. The harvesting would need to be done each year maybe twice in a year so each year the association would have to go through the process of finding an operator as well as procuring insurance and keeping the machine in running order.

Table 14. Specification Sheets For Two Large Aquarius Systems, Inc. Weed Harvesters.

HM-220 AQUATIC PLANT HARVESTER

A popular choice of lake associations, the HM-220 Harvester is the most efficient Harvester available for small to medium sized harvesting projects. Its generous storage capacity of 6,500 pounds results in fewer trips to shore to unload. Highly maneuverable in the water, the HM-220 is also easily transported on land.



The full sized barge style hull of the HM-220 provides more flotation and significantly less draft than other hull designs. This is especially important when working in shallow water and for getting to shore to unload. The diesel engine and hydraulics are platform mounted as far back from the operator as possible for safety, comfort and ease of servicing. The elevated operator platform provides excellent visibility.

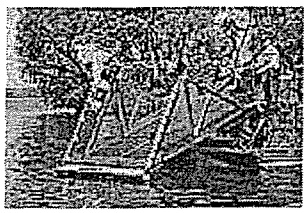
Cutting Width:	5' 0" (1.52 meters)
Cutting Depth:	0 to 5' 6" (0 to 1.68 meters)
Capacity (Volume):	260 cubic feet (7.36 cubic meters)
Capacity (Weight):	6,500 pounds (2,948 kilograms)
Operating Length:	35' 9" (10.90 meters)
Operating Width:	13' 0" (3.96 meters)
Engine Options:	Hatz, Isuzu, Kubota
Hull Style:	full sized barge with state-of-the-art internal reinforcement structure
Hull Material Options:	carbon steel, 304L stainless steel or 316L stainless steel
Conveyor Mesh Options:	standard duty galvanized, heavy duty galvanized, standard duty stainless steel or heavy duty stainless steel
Hydraulic Options:	pressure compensated system or hydrostatic hydraulic system
System Protection:	Engine: low oil level/high temperature shut down; Hydraulics: low level sensor with audible alarm and warning light; Hydraulic Filters: clogged filter sensor with warning light
Control Options:	fingertip control levers, levers & foot pedals or joystick control
Operator & Engine Platform Options:	A full sized platform or two separate platforms
Color Options:	standard light blue or customer's choice
Amenities Available:	sun/rain canopy, underwater viewing camera, am/fm radio w/cassette, hydraulically retractable paddle wheels, life jackets, ring buoy w/50' (15 m) nylon line, first aid kit, navigational safety lighting, high pressure wash down pump w/50' (15 m) rubber hose, fixed fuel tank

Impact Protection: pivoted spring suspension system and pre-compressed shock absorber rods, or gravity swing suspension with pre-compressed shock absorber rods

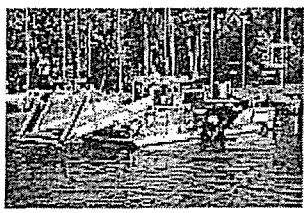
Quality & Safety Features: paddle wheel guards, chain drive guards, safety railings, non-skid decking, fire extinguisher, fully enclosed hydraulic valves, stainless steel hydraulic lines, sound proofing engine enclosure, lockable battery box & storage cabinet/s, lifting eyes, tie down cleats

Compatible Support Equipment: TR-12 Trailer, TRC-12 Trailer Conveyor, TTR-12 Tilt Deck Trailer, S/C-12 Shore Conveyor, T-12 Transport

HM-320 AQUATIC PLANT HARVESTER



A favorite choice of contractors, the HM-320 Harvester was originally designed for companies who provide contract harvesting services. Its standard shipping width of 8' 6" (2.59 m) makes the HM-320 a legal load for over-the-road transportation, eliminating the need for road permits each time the machine is moved to a new location.



Now available to the general market, the HM-320 Harvester has grown in popularity among municipalities with multiple lakes or ponds to maintain. It comes with a standard 6' wide or optional 7' wide cutting swath, and it can hold 335 cubic feet of plant material on board.

Cutting Width: 6' 0" (1.83 meters); optional 7' 0" (2.13 meters)

Cutting Depth: 0 to 5' 6" (0 to 1.68 meters)

Capacity (Volume): 335 cubic feet (9.49 cubic meters)

Capacity (Weight): 7,025 pounds (3,186 kilograms)

Operating Length: 36' 0" (10.97 meters)

Operating Width: 13' 10" (4.22 meters)

Engine Options: Hatz, Isuzu, Kubota

Hull Style: full sized barge with state-of-the-art internal reinforcement structure

Hull Material Options: carbon steel, 304L stainless steel or 316L stainless steel

Conveyor Mesh Options: standard duty galvanized, heavy duty galvanized, standard duty stainless steel or heavy duty stainless steel

Hydraulic Options: pressure compensated system or hydrostatic hydraulic system

System Protection: Engine: low oil level/high temperature shut down;
Hydraulics: low level sensor with audible alarm and warning light;
Hydraulic Filters: clogged filter sensor with warning light

Control Options:	fingertip control levers, levers & foot pedals or joystick control
Operator & Engine Platform Options:	A full sized platform or two separate platforms
Color Options:	standard light blue or customer's choice
Amenities Available:	sun/rain canopy, underwater viewing camera, am/fm radio w/cassette, hydraulically retractable paddle wheels, life jackets, ring buoy w/50' (15 m) nylon line, first aid kit, navigational safety lighting, high pressure wash down pump w/50' (15 m) rubber hose
Impact Protection:	pivoted spring suspension system and pre-compressed shock absorber rods, or gravity swing suspension with pre-compressed shock absorber rods
Quality & Safety Features:	paddle wheel guards, chain drive guards, safety railings, non-skid decking, fire extinguisher, fully enclosed hydraulic valves, stainless steel hydraulic lines, sound proofing engine enclosure, lockable battery box & storage cabinet/s, lifting eyes, tie down cleats
Compatible Support Equipment:	TR-23 Trailer, TRC-23 Trailer Conveyor, TTR-23 Tilt Deck Trailer, S/C-12 Shore Conveyor, T-12 Transport

A harvester could also be used to skim up the milfoil "floaters". These are fragments of milfoil shoots that have come loose from the root stocks and float to the surface. Once at the surface these fragments are blown by prevailing winds into coves and along the shoreline. It seems that due to southerly winds during the summer these fragments end up along the east shore and at the northern end making the boat ramp almost unusable. On the July 13, 2003 there was about 100 feet of accumulated floating fragments massed against the northern shore.

Herbicides

Chemicals to control weeds and algae have been used for many years, and other than drawdown is probably the most widely used of all weed control methods. It has only been recently that the other techniques have gained acceptance.

There are only seven active ingredients currently approved for use in aquatic herbicides in USA today.

- COPPER SULFATE Copper products are not usually used for control of rooted plants, instead they are used as a herbicide against algae; both filamentous and planktonic. Copper can be used in conjunction with other herbicides to render them more affective if the plants have a dense growth of attached algae on their surfaces. The copper kills the attached algae so the herbicide can be affective against the plants.

  This is likely going to be the case for herbicides targeted for milfoil at Pickerel Lake because the milfoil had thick accumulations of filamentous algae.

- ENDOTHALL is a contact herbicide, attacking plants at the point of contact. Only the part of the plant that it contacts with will be affected. The roots will not be impacted so re-growth and recovery can be expected. The herbicide acts quickly against the leaves and shoots causing accumulation of large amounts of dead plant material on the sediment surface, which in turn can cause oxygen loss. There are use restrictions on the label against using it in drinking water supply reservoirs, although there shouldn't be toxicity impacts to other lake fauna.

  Endothall is usually applied for control of pondweed and may not work against milfoil but has shown limited efficacy against fanwort. However, it is a contact herbicide which means that annual treatments will be needed.

- DIQUAT is another fast acting contact herbicide. Again, there is a domestic water use restriction and it is not used in water supplies. This herbicide can be toxic to invertebrates, fish, and other animals. Because contact herbicides do not affect the roots and buried seeds re-growth is probably certain.

  Similar to Endothall, Diquat is a contact herbicide that will affect milfoil only during the season of its application.

- GLYPHOSATE is another contact herbicide. It is typically used against emergents and floating leaved plants but not against submersed species.

  This is a very affective herbicide against water lilies and water shield and could be used to clear choked coves of floating leaved plants at Pickerel Lake.

- 2,4-D is a systemic herbicide meaning that it is absorbed by the roots and incorporated into the whole plant. This herbicide has been in use for over 30 years, and has shown to be very effective against Milfoil. The herbicide can be used in either liquid or solid form so the area of treatment can be very well controlled. 2,4-D has variable toxicity to fish, and the label restricts its use in water used for drinking water supply or other domestic uses, or for irrigation or watering of livestock.

  This herbicide would be affective against the milfoil in Pickerel Lake but the label negates use in lakes where domestic wells are within 100 feet of the shoreline. A special permit would be necessary and would probably require reference to Bashan Lake where 2,4-D (Navigate) has been used to control milfoil for the last 5 years.

- FLURIDONE is another systemic herbicide introduced in 1979 becoming widespread since the mid 1980's. Fluridone has proven to be very affective against milfoil and some of the other invasive aquatic plants. The herbicide comes in both a liquid and a slow release pellet allowing for both spot treatments and whole lake treatments. The herbicide has low toxicity to other organisms. The use of the liquid fluridone does require a 40 day contact period during which lake outflow should be minimized. Sometimes the needed level of fluridone has to be bumped up because of dilution and flushing out of the lake.

  This herbicide will be affective against the fanwort and may have some impact on the milfoil. Because it is a systemic it will show more than one year of control.

- TRICLOPER is a new herbicide on the market similar to 2,4-D in that it is absorbed into the plant and causes metabolic changes in growth process. It targets dicots such as milfoil and fanwort but there is only limited field trial information about use against fanwort so its efficacy is not well known.

Tricloper has potential for use against the fanwort and possibly the milfoil in Pickerel Lake.

An application of the systemic herbicide Fluridone to control fanwort would likely be made in the early part of the year probably May when the plant is newly growing. The application would need to be monitored to ensure that the desired concentration of Fluridone remains in the lake. Because flushing will dilute the concentration in the water a bump up treatment is sometimes needed part way through the duration of 40 days. Maintaining necessary concentration can be augmented by first lowering the lake by a foot or so to ensure that flushing does not occur during the early stage of the application.

A treatment of Pickerel Lake with Fluridone would likely cost $ 35,000 to 40,000 and would provide at least two years of control of fanwort.

The systemic herbicide 2,4-D could be used selectively along the east shore to control milfoil near the lake front homes but label restrictions preclude use where domestic wells are located within 100 feet of the shore line. The contact herbicide Diquate could be used affectively against the milfoil and does not have similar label restrictions. Although it is a contact herbicide annual treatments are probably necessary although there may be some carry over into the next year. For either case the application of herbicide to Pickerel Lake would cost between $250 and $350 per treated acre. In the case of the east shore of the lake where milfoil

could be found maybe $5 / fish. There would be a shipping charge attached to this either way. The stocked fish would be between 10 & 12 inches in length. A modification would need to be made at the outlet so fish would not be able to get out of the lake. This would need a DEP Dam Safety Permit and probably not be approved for the actual dam face but an alternate screening either above or below the dam.

The use of grass carp has been intensively studied at Ball Pond in New Fairfield CT, but the results of that study were not ready for inclusion into this report. It is strongly recommended that prior to stocking with grass carp that the results from Ball Pond be reviewed first.

Summary Of Applicable Management Options At Pickerel Lake

Each of the methods that show some feasibility at Pickerel Lake is summarized here with a comparison given in **Table 15.**

Water Level Control

Winter water level draw-down exposes minimal surface areas until at least a 3 foot lowering is achieved. Because milfoil and fanwort were found throughout the lake a draw-down of only a few feet will have little over-all control of the weeds in the lake affecting only the near shore areas. Although this method will probably show good control over the plants in the exposed areas, the high lake flushing rate means it may be hard to keep the water level low during the winter and under ice oxygen concentrations have not been totally verified during a draw-down yet.

Benthic Barriers

Bottom Barriers work very well in small localized areas like near docks, beaches and swim/boat lanes. These have applicability if only a few select areas are required to be maintained as open water. The material is expensive but only needs to be purchased once, although it does require maintenance.

Dredging

Dredging would be expensive at an estimated cost of $3.4 million. Although it would make the lake deeper it may not have any affect on the shoreline plant beds. The deeper water area does not appear to cause serious impairment problems currently.

Mechanical Removal

Weed Harvesting could be performed on the shallow beds of milfoil along the east shore, probably requiring two cuttings each season. The costs would be modest but there may be significantly more fragmentation of fanwort than currently occurs. Milfoil already appears to have spread to its limit in the lake but harvesting could increase the plant density in the cut areas. A harvester could be used to scoop up milfoil "floaters" that accumulate along the shoreline.

Herbicides

Contact herbicides are feasible if a limited shoreline application is used. Diquate, which would be applied to control the milfoil and fanwort, would need to be used on an annual basis. Systemic herbicides such as 2,4-D, would provide control for longer periods of time but have use restrictions that will make obtaining a permit less certain. Fluridone will provide lake-wide of fanwort, but will probably not have much affect on the milfoil. However, it might be prudent to

reduce the fanwort in the lake prior to, or in conjunction with, other weed treatment attempts because any newly available open areas created by other methods will be colonized by fanwort.

Biological Introductions

Grass Carp is feasible and may be permitted by the State DEP Fisheries Division. There would probably be a period of study associated with the stocking so that a proper assessment can be made of the water quality and resident fisheries conditions before and after stocking. Prior to stocking grass carp the Ball Pond study results should be reviewed in detail. Nutrient re-cycling may be increased in the lake water which could lead to algae blooms.

Table 15. Summary of Weed Management Approaches.

	Period of Operation	Cost	Affective area	Longevity
Drawdown	Winter	$ 960 - $ 1,920 Based on 20-40 hrs @ $48/hr	Limited to shallow water < 3 feet deep	Maybe one or two years
Bottom Barrier	Summer	$ 7,500 for 5,000 sq. ft.	Boating lanes only	Several years
Harvesting	Summer	$ 10,000 – $ 18,000	10 acres	Annual
Dredging	Summer (6+ years)	$ 3.4 million	50 acres to 13 feet, 320,000 cubic yards	Many years
Herbicides	Summer	Contact = $ 4,500 Systemic = $ 35,000- $ 40,000	Contact 10 acres Fluridone = whole lake	Contact = annual Systemic = 2-4 years
Grass Carp	5+- years / stocking	~ $ 9,000 maybe lower	Whole lake	After 5 years consumption tapers off

LITERATURE CITATIONS

Atlantic Environmental Services, Inc. 1986. Feasibility Study of The Remediation of Pickerel Lake, Colchester/East Haddam, Connecticut,

Cook G. Dennis, E.B. Welch, S.A. Peterson, and P.R. Newroth. 1986. Restoration and Management of Lakes and Reservoirs. Butterworth Pub. MA.

CT DEP. 1987. A Guide to Lakes and Ponds of Connecticut, an Interim Report

CT DEP. Bureau of Water Management. 1992. Trophic Classifications of Forty-nine Connecticut Lakes, Hartford.

Dopirak, William J. Jr. 2002. Analysis of Macrophyte Interactions in a Eutrophic Lake and in Experimental Microcosms, Masters Thesis Central Connecticut State University.

Les, D.H. & L. Mehrhoff. 1999. Introduction Of Nonindigenous Aquatic Vascular Plants In Southern New England: A Historical Perspective. Bio. Invas. 1:281-300.

State Board of Fisheries and Game 1959, A Fisheries Survey of Lakes and Ponds of Connecticut, Hartford.

USGS. 1995. Water-Quality Characteristics of Selected Public Recreational Lakes and Ponds in Connecticut.

APPENDIX 1

Management Options For The Control Of Rooted Aquatic Plants.

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
Physical Controls 1) Benthic barriers	♦ Mat of variable composition laid on bottom of target area, preventing plant growth ♦ Can cover area for as little as several months or permanently ♦ Maintenance improves effectiveness ♦ Not often intended for use in large areas, usually applied around docks, in boating lanes, and in swimming areas	♦ Highly flexible control ♦ Reduces turbidity from soft bottoms ♦ Can cover undesirable substrate ♦ Can improve fish habitat by creating edge effects	♦ May cause anoxia at sediment-water interface ♦ May limit benthic invertebrates ♦ Non-selective interference with plants in target area ♦ May inhibit spawning/feeding by some fish species
1.a) Porous or loose-weave synthetic materials	♦ Laid on bottom and usually anchored by sparse weights or stakes ♦ Removed and cleaned or flipped and repositioned at least once per year for maximum effectiveness	♦ Allows some escape of gases which may build up underneath ♦ Panels may be flipped in place or removed for relatively easy cleaning or repositioning	♦ Allows some growth through pores ♦ Gas may still build up underneath in some cases, lifting barrier from bottom
1.b) Non-porous or sheet synthetic materials	♦ Laid on bottom and anchored by many stakes, anchors or weights, or by layer of sand ♦ Not typically removed, but may be swept or "blown" clean periodically	♦ Prevents all plant growth until buried by sediment ♦ Minimizes interaction of sediment and water column	♦ Gas build up may cause barrier to float upwards ♦ Strong anchoring makes removal difficult and can hinder maintenance

1.c) Sediments of a desirable composition	♦ Sediments may be added on top of existing sediments or plants. ♦ Use of sand or clay can limit plant growths and alter sediment-water interactions. ♦ Sediments can be applied from the surface or suction dredged from below muck layer (reverse layering technique)	♦ Plant biomass can be buried ♦ Seed banks can be buried deeper ♦ Sediment can be made less hospitable to plant growths ♦ Nutrient release from sediments may be reduced ♦ Surface sediment can be made more appealing to human users ♦ Reverse layering requires no addition or removal of sediment	♦ Lake depth may decline ♦ Sediments may sink into or mix with underlying muck ♦ Permitting for added sediment may be difficult ♦ Addition of sediment may cause initial turbidity increase ♦ New sediment may contain nutrients or other contaminants ♦ Generally too expensive for large scale application
2) Dredging	♦ Sediment is physically removed by wet or dry excavation, with deposition in a containment area for dewatering/disposal ♦ Dredging can be applied on a limited basis, but is most often a major restructuring of a severely impacted system ♦ Plants and seed beds are removed and re-growth can be limited by light and/or substrate limitation	♦ Plant removal with some flexibility ♦ Increases water depth ♦ Can reduce pollutant reserves ♦ Can reduce sediment oxygen demand ♦ Can improve spawning habitat for many fish species ♦ Allows complete renovation of aquatic ecosystem	♦ Temporarily removes benthic invertebrates ♦ May create turbidity ♦ May eliminate fish community (complete dry dredging only) ♦ Possible impacts from containment area discharge ♦ Possible impacts from dredged material disposal ♦ Interference with recreation or other uses during dredging ♦ Usually very expensive
2.a) "Dry" excavation	♦ Lake drained or lowered to maximum extent practical ♦ Target material dried to maximum extent possible ♦ Conventional excavation equipment used to remove sediments	♦ Tends to facilitate a very thorough effort ♦ May allow drying of sediments prior to removal ♦ Allows use of less specialized equipment	♦ Eliminates most aquatic biota unless a portion left undrained ♦ Eliminates lake use during dredging

2.b) "Wet" excavation	♦ Lake level may be lowered, but sediments not substantially dewatered ♦ Draglines, bucket dredges, or long-reach backhoes used to remove sediment	♦ Requires least preparation time or effort, tends to be least cost dredging approach ♦ May allow use of easily acquired equipment ♦ May preserve most aquatic biota	♦ Usually creates extreme turbidity ♦ Tends to result in sediment deposition in surrounding area ♦ Normally requires intermediate containment area to dry sediments prior to hauling ♦ May cause severe disruption of ecological function ♦ Usually eliminates most lake uses during dredging
2.c) Hydraulic removal	♦ Lake level not reduced ♦ Suction or cutterhead dredges create slurry which is hydraulically pumped to containment area ♦ Slurry is dewatered; sediment retained, water discharged	♦ Creates minimal turbidity and limits impact on biota ♦ Can allow some lake uses during dredging ♦ Allows removal with limited access or shoreline disturbance	♦ Often leaves some sediment behind ♦ Cannot handle extremely coarse or debris-laden materials ♦ Requires sophisticated and more expensive containment area ♦ Requires overflow discharge from containment area
3) Dyes and surface covers	♦ Water-soluble dye is mixed with lake water, thereby limiting light penetration and inhibiting plant growth ♦ Dyes remain in solution until washed out of system. ♦ Opaque sheet material applied to water surface	♦ Light limit on plant growth without high turbidity or great depth ♦ May achieve some control of algae as well ♦ May achieve some selectivity for species tolerant of low light	♦ May not control peripheral or shallow water rooted plants ♦ May cause thermal stratification in shallow ponds ♦ May facilitate anoxia at sediment interface with water ♦ Covers inhibit gas exchange with atmosphere

4) Mechanical removal	♦ Plants reduced by mechanical means, possibly with disturbance of soils ♦ Collected plants may be placed on shore for composting or other disposal ♦ Wide range of techniques employed, from manual to highly mechanized ♦ Application once or twice per year usually needed	♦ Highly flexible control ♦ May remove other debris ♦ Can balance habitat and recreational needs	♦ Possible impacts on aquatic fauna ♦ Non-selective removal of plants in treated area ♦ Possible spread of undesirable species by fragmentation ♦ Possible generation of turbidity
4.a) Hand pulling	♦ Plants uprooted by hand ("weeding") and preferably removed	♦ Highly selective technique	♦ Labor intensive
4.b) Cutting (without collection)	♦ Plants cut in place above roots without being harvested	♦ Generally efficient and less expensive than complete harvesting	♦ Leaves root systems and part of plant for re-growth ♦ Leaves cut vegetation to decay or to re-root ♦ Not selective within applied area
4.c) Harvesting (with collection)	♦ Plants cut at depth of 2-10 ft and collected for removal from lake	♦ Allows plant removal on greater scale	♦ Limited depth of operation ♦ Usually leaves fragments which may re-root and spread infestation ♦ May impact lake fauna ♦ Not selective within applied area ♦ More expensive than cutting
4.d) Rototilling	♦ Plants, root systems, and surrounding sediment disturbed with mechanical blades	♦ Can thoroughly disrupt entire plant	♦ Usually leaves fragments which may re-root and spread infestation ♦ May impact lake fauna ♦ Not selective within applied area ♦ Creates substantial turbidity ♦ More expensive than harvesting

4.e) Hydroraking	♦ Plants, root systems and surrounding sediment and debris disturbed with mechanical rake, part of material usually collected and removed from lake	♦ Can thoroughly disrupt entire plant ♦ Also allows removal of stumps or other obstructions	♦ Usually leaves fragments which may re-root and spread infestation ♦ May impact lake fauna ♦ Not selective within applied area ♦ Creates substantial turbidity ♦ More expensive than harvesting
5) Water level control	♦ Lowering or raising the water level to create an inhospitable environment for some or all aquatic plants ♦ Disrupts plant life cycle by dessication, freezing, or light limitation	♦ Requires only outlet control to affect large area ♦ Provides widespread control in increments of water depth ♦ Complements certain other techniques (dredging, flushing)	♦ Potential issues with water supply ♦ Potential issues with flooding ♦ Potential impacts to non-target flora and fauna
5.a) Drawdown	♦ Lowering of water over winter period allows desiccation, freezing, and physical disruption of plants, roots and seed beds ♦ Timing and duration of exposure and degree of dewatering are critical aspects ♦ Variable species tolerance to drawdown; emergent species and seed-bearers are less affected ♦ Most effective on annual to once/3 yr. basis	♦ Control with some flexibility ♦ Opportunity for shoreline clean-up/structure repair ♦ Flood control utility ♦ Impacts vegetative propagation species with limited impact to seed producing populations	♦ Possible impacts on contiguous emergent wetlands ♦ Possible effects on overwintering reptiles and amphibians ♦ Possible impairment of well production ♦ Reduction in potential water supply and fire fighting capacity ♦ Alteration of downstream flows ♦ Possible overwinter water level variation ♦ Possible shoreline erosion and slumping ♦ May result in greater nutrient availability for algae

5.b) Flooding	♦ Higher water level in the spring can inhibit seed germination and plant growth ♦ Higher flows which are normally associated with elevated water levels can flush seed and plant fragments from system	♦ Where water is available, this can be an inexpensive technique ♦ Plant growth need not be eliminated, merely retarded or delayed ♦ Timing of water level control can selectively favor certain desirable species	♦ Water for raising the level may not be available ♦ Potential peripheral flooding ♦ Possible downstream impacts ♦ Many species may not be affected, and some may be benefitted ♦ Algal nuisances may increase where nutrients are available
Chemical controls 6) Herbicides	♦ Liquid or pelletized herbicides applied to target area or to plants directly ♦ Contact or systemic poisons kill plants or limit growth ♦ Typically requires application every 1-5 yrs	♦ Wide range of control is possible ♦ May be able to selectively eliminate species ♦ May achieve some algae control as well	♦ Possible toxicity to non-target species of plants/animals ♦ Possible downstream impacts; may affect non-target areas within pond ♦ Restrictions of water use for varying time after treatment ♦ Increased oxygen demand from decaying vegetation ♦ Possible recycling of nutrients to allow other growths
6.a) Forms of copper	♦ Contact herbicide ♦ Cellular toxicant, suspected membrane transport disruption ♦ Applied as wide variety of liquid or granular formulations, often in conjunction with polymers or other herbicides	♦ Moderately effective control of some submersed plant species ♦ More often an algal control agent	♦ Toxic to aquatic fauna as a function of concentration, formulation, and ambient water chemistry ♦ Ineffective at colder temperatures ♦ Copper ion persistent; accumulates in sediments or moves downstream

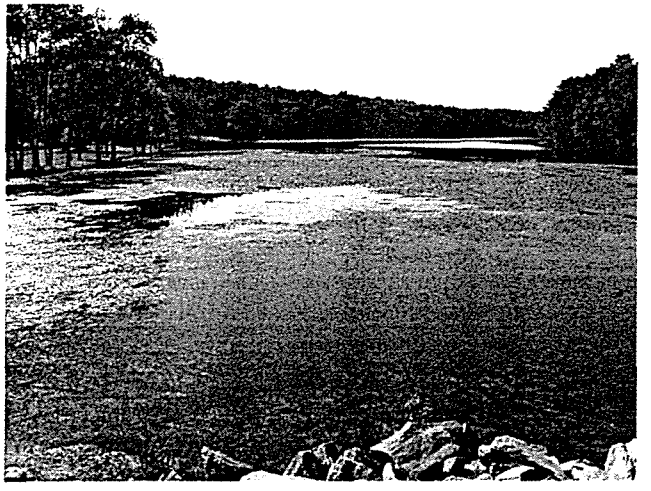
6.b) Forms of endothall (7-oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid)	♦ Contact herbicide with limited translocation potential ♦ Membrane-active chemical which inhibits protein synthesis ♦ Causes structural deterioration ♦ Applied as liquid or granules	♦ Moderate control of some emersed plant species, moderately to highly effective control of floating and submersed species ♦ Limited toxicity to fish at recommended dosages ♦ Rapid action	♦ Non-selective in treated area ♦ Toxic to aquatic fauna (varying degrees by formulation) ♦ Time delays on use for water supply, agriculture and recreation ♦ Safety hazards for applicators
6.c) Forms of diquat (6,7-dihydropyrido [1,2-2',1'-c] pyrazinediium dibromide)	♦ Contact herbicide ♦ Absorbed by foliage but not roots ♦ Strong oxidant; disrupts most cellular functions ♦ Applied as a liquid, sometimes in conjunction with copper	♦ Moderate control of some emersed plant species, moderately to highly effective control of floating or submersed species ♦ Limited toxicity to fish at recommended dosages ♦ Rapid action	♦ Non-selective in treated area ♦ Toxic to zooplankton at recommended dosage ♦ Inactivated by suspended particles; ineffective in muddy waters ♦ Time delays on use for water supply, agriculture and recreation
6.d) Forms of glyphosate (N-[phosphonomethyl glycine)	♦ Contact herbicide ♦ Absorbed through foliage, disrupts enzyme formation and function in uncertain manner ♦ Applied as liquid spray	♦ Moderately to highly effective control of emersed and floating plant species ♦ Can be used selectively, based on application to individual plants ♦ Rapid action ♦ Low toxicity to aquatic fauna at recommended dosages ♦ No time delays for use of treated water	♦ Non-selective in treated area ♦ Inactivation by suspended particles; ineffective in muddy waters ♦ Not for use within 0.5 miles of potable water intakes ♦ Highly corrosive; storage precautions necessary

6.e) Forms of 2,4-D (2,4-dichlorophenoxyl acetic acid)	♦ Systemic herbicide ♦ Readily absorbed and translocated throughout plant ♦ Inhibits cell division in new tissue, stimulates growth in older tissue, resulting in gradual cell disruption ♦ Applied as liquid or granules, frequently as part of more complex formulations, preferably during early growth phase of plants	♦ Moderately to highly effective control of a variety of emersed, floating and submersed plants ♦ Can achieve some selectivity through application timing and concentration ♦ Fairly fast action	♦ Variable toxicity to aquatic fauna, depending upon formulation and ambient water chemistry ♦ Time delays for use of treated water for agriculture and recreation ♦ Not for use in water supplies
6.f) Forms of fluridone (1-methyl-3-phenyl-5-[-3-{trifluoromethyl} phenyl]-4[IH]-pyridinone)	♦ Systemic herbicide ♦ Inhibits carotenoid pigment synthesis and impacts photosynthesis ♦ Best applied as liquid or granules during early growth phase of plants	♦ Can be used selectively, based on concentration ♦ Gradual deterioration of affected plants limits impact on oxygen level (BOD) ♦ Effective against several difficult-to-control species ♦ Low toxicity to aquatic fauna	♦ Impacts on non-target plant species possible at higher doses ♦ Extremely soluble and mixable; difficult to perform partial lake treatments ♦ Requires extended contact time
6.g Forms of triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid)	♦ Systemic herbicide, registered for experimental aquatic use by cooperators in selected areas only at this time ♦ Readily absorbed by foliage, translocated throughout plant ♦ Disrupts enzyme systems specific to plants ♦ Applied as liquid spray or subsurface injected liquid	♦ Effectively controls many floating and submersed plant species ♦ Can be used selectively, more effective against dicot plant species, including many nuisance species ♦ Effective against several difficult-to-control species ♦ Low toxicity to aquatic fauna ♦ Fast action	♦ Impacts on non-target plant species possible at higher doses ♦ Current time delay of 30 days on consumption of fish from treated areas ♦ Necessary restrictions on use of treated water for supply or recreation not yet certain

Biological Controls			
7) Biological introductions	♦ Fish, insects or pathogens which feed on or parasitize plants are added to system to affect control ♦ The most commonly used organism is the grass carp, but the larvae of several insects have been used more recently, and viruses are being tested	♦ Provides potentially continuing control with one treatment ♦ Harnesses biological interactions to produce desired conditions ♦ May produce potentially useful fish biomass as an end product	♦ Typically involves introduction of non-native species ♦ Effects may not be controllable ♦ Plant selectivity may not match desired target species ♦ May adversely affect indigenous species
7.a) Herbivorous fish	♦ Sterile juveniles stocked at density which allows control over multiple years ♦ Growth of individuals offsets losses or may increase herbivorous pressure	♦ May greatly reduce plant biomass in single season ♦ May provide multiple years of control from single stocking ♦ Sterility intended to prevent population perpetuation and allow later adjustments	♦ May eliminate all plant biomass, or impact non-target species more than target forms ♦ Funnels energy into largely unused fish biomass and algae ♦ May drastically alter habitat ♦ May escape to new habitats upstream or downstream ♦ May not always be sterile; population control uncertain
7.b) Herbivorous insects	♦ Larvae or adults stocked at density intended to allow control with limited growth ♦ Intended to selectively control target species ♦ Milfoil weevil is best known, but still experimental	♦ Involves species native to region, or even targeted lake ♦ Expected to have no negative effect on non-target species ♦ May facilitate longer term control with limited management	♦ Population ecology suggests incomplete control likely ♦ Oscillating cycle of control and re-growth likely ♦ Predation by fish may complicate control ♦ Other lake management actions may interfere with success

7.c) Fungal/bacterial/viral pathogens	♦ Inoculum used to seed lake or target plant patch ♦ Growth of pathogen population expected to achieve control over target species	♦ May be highly species specific ♦ May provide substantial control after minimal inoculation effort	♦ Largely experimental; effectiveness and longevity of control not well known ♦ Infection ecology suggests incomplete control likely ♦ Possible side effects not well understood
7.d) Selective plantings	♦ Establishment of plant assemblage resistant to undesirable species ♦ Plants introduced as seeds, cuttings or whole plants	♦ Can restore native assemblage ♦ Can encourage assemblage most suitable to lake uses ♦ Supplements targeted species removal techniques	♦ Largely experimental at this time; few well documented cases ♦ Nuisance species may eventually outcompete established assemblage ♦ Introduced species may become nuisances

DREDGING UPDATE
TO THE
FEASIBILITY STUDY OF THE
REMEDIATION OF
PICKEREL LAKE
IN THE
TOWN OF COLCHESTER



SUBMITTED TO:

MS. ALICIA L. WATSON
TOWN OF COLCHESTER

PREPARED BY:

BAYSTATE ENVIRONMENTAL CONSULTANTS, INC.

JULY 26, 2004

BAYSTATE ENVIRONMENTAL CONSULTANTS INC.

Civil Engineers
Environmental Scientists

July 26, 2004

Ms. Alicia L. Watson
Wetlands Enforcement Officer
Town of Colchester
127 Norwich Avenue
Colchester, CT 06415

RE: Pickerel Lake Remediation Update
Colchester, Connecticut
BEC File No. 03-0313P

Dear Alicia:

The Feasibility Study of the Remediation of Pickerel Lake, Colchester/East Haddam CT was prepared for CDEP by Atlantic Environmental Services in 1986. By means of this report Baystate Environmental Consultants, Inc. (BEC) of East Hartford, CT is submitting its' findings as detailed in our contract with the Town executed April 27, 2004. The contract Scope of Services is limited to a review of the lake dredging component of the prior 1986 study with an update of cost information. Although prepared as a stand alone document this report is a limited evaluation of one option in lake management. This report should be reviewed within the context of the larger evaluation being prepared by Northeast Aquatic Research and in fact may best be inserted as an appendix to that document.

Since the date of the original study on Pickerel Lake, BEC has been involved in the successful restoration dredging of over twenty lakes or ponds in both Connecticut and Massachusetts. In addition our firm has been under contract with CDEP almost continuously in regard to the restoration of Silver Lake in Berlin/Meriden the largest lake dredging project in the Northeast. Construction on that project was initiated in mid 1993, and is now through its' third dredging phase. That project has several similarities to the effort proposed at Pickerel and as such this update is based to a large degree upon the lessons learned at that project, as well as others, over the intervening years.

If in your review you have any questions regarding our findings, please feel free to contact me. Thank-you for this opportunity to have helped on this environmental lake improvement project.

Very truly yours,

BEC, Inc.

Harry R. Jones, P.E.
Principal

290 Roberts Street
Suite 207
East Hartford, CT 06108
Tel (860) 289-8541
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Other Office:
East Longmeadow, MA

An Equal Opportunity Employer

Introduction

The Feasibility Study of the Remediation of Pickerel Lake, Colchester/East Haddam CT was prepared for CDEP by Atlantic Environmental Services in 1986. The purpose of this report is to update those findings and costs that relate to the dredging of Pickerel Lake as of 2004.

For ease of review this update has been sub-divided into five subtopics related to the dredging of Pickerel Lake, namely:

- General Setting
- Sediments
- Dredging Program
- Dredging Methodology
- Cost and Timeline

Each sub-topic was then divided into time settings, 1986 and 2004. The 1986 section reiterates the findings of the prior report whereas the 2004 section offers updated findings based upon today's general knowledge and our lake and pond dredging experiences over the intervening 18 years.

General Setting

1986: Pickerel Lake is an 88.6 acre impoundment in Colchester and East Haddam with an average depth of six feet. There was then an extensive growth of aquatic plants in the lake which interfered with recreation usage of the waterbody. A State Boat Launch was identified at the northern end of the lake in Colchester with an earthen dam at the southern end in East Haddam. The 890 acre watershed was generally forested with sparse residential development with a state forest north of the lake.

2004: A windshield survey and review of current GIS state wide mapping indicates that the conditions from 1986 have changed only marginally since then. Also several neighbors living on the lake along Lakeview Drive confirmed that the extensive lake vegetation virtually prohibits recreational usage of the lake during the summer months. Extensive macrophyte beds were observed in the shallow cove areas. The interest in this update is itself an indication that the unsatisfactory conditions documented in 1986 have little changed over the past 18 years.

Sediments

1986: A fairly extensive bathymetric survey was undertaken of the entire lake to determine water depths with a resultant Bathymetric Map incorporated into the 1986 report. The substrate of the lake bottom was identified as an organic rich peat like material varying in thickness from five to twenty-eight feet deep. Sediment samples were chemically tested and concentrated levels were reported below EPA permissible levels.

Several lake cross sections were reproduced in the report. The sediment type and depths suggests that the historic context of this lake is that of a prior peat bog that was flooded in the second half of the nineteenth century with the construction of the lake's dam.

2004: There is little reason to suggest that these survey and laboratory findings would be significantly changed over the past 18 years, and as a result, new mapping and testing was excluded from this update. The sediments described were principally the original bog and not the result of extensive new sediment deposition from the watershed. Although some deposition has probably entered the pond from the tributaries over the intervening years the volume is insignificant compared to that of the bog.

These sediments are quite similar to those at the 151 acre Silver Lake in Berlin/Meriden which also is a prior peat bog that was flooded. That lake is currently being dredged as part of that lake's management by CDEP with BEC providing consulting services. Two photographic pages regarding Silver Lake are appended to this report. Another parallel project is Milford Pond in Massachusetts. This pond was a prior cedar swamp that was flooded with a small dam along the Charles River. BEC has just completed an Environmental Assessment for an Aquatic Habitat Restoration by the US Army Corps of Engineers.

Dredging Program

1986: Dredging was recognized as a lake management alternative that "is the most permanent method of weed control available". The report proposes a dredging program over three quarters of the lake, leaving intact most of the two northern coves and the south west cove. The two depth options were proposed, one dredging to 13 feet with 485,000 CY of material removed and the other to 16 feet with 758,000 CY removed. With the 13 foot option 85 to 90% of the material removed would be from the organic peat layer with the remainder from the underlying "hard" strata.

2004: Dredging remains a viable weed control lake management option which has been utilized successful on numerous lakes in Southern New England. Current active lake dredging projects in Connecticut which BEC is aware of include Silver Lake in Meriden/Berlin, Pine Lake and Birge Lake in Bristol, Freshwater Pond in Enfield and Valley Falls Pond in Vernon. All of these waterbodies have experienced in filling from sediments and extensive aquatic vegetation.

Although a viable lake management option, dredging is expensive, and as such the extent of dredging is a design consideration that should be given further review. The 1986 program extended dredging to the western shoreline along the main body of the lake. Since residences are clustered about the eastern shoreline it may be cost effectively prudent to reduce the aerial extent by excluding an approximate 200 foot width along the western shoreline from the dredge program. Shallow shoreline areas can provide

important fisheries habitat. Such an approach has been implemented at Silver Lake. In addition, working with fisheries personnel at CDEP, that program was designed in a saw tooth fashion to enhance fish habitat and structure and at the same time reduce the overall quantity of sediment being removed. Also as part of the Milford Pond study, the Corps of Engineers required an incremental analysis to quantify the habitat benefits associated with dredging and to guide the dredge limits of that project. That proposed project dredges 45 acres of that 120 acre pond, about 3/8th of the aerial coverage.

Also BEC sees little value in removing materials at the dam with the exception of the spillway area in the south east corner of the lake. Figure 1 illustrates the 1986 limits and the suggested program. As shown 55 percent of the lake would be dredged with resultant open water feature just less than 50 acres.

Silver Lake was dredged to a maximum depth of 13 feet, the first phase completed in September of 1995. Although macrophyte vegetation has re-established itself in the dredged areas, a healthy desired occurrence, it has not reached the surface and recreational access on the lake has been significantly improved. As such BEC does not believe the second option of a 16 foot depth is cost effective and proposes that the dredge program not exceed 13 feet.

Finally, the program at Silver Lake essentially dredges to 13 feet or to hard bottom, the mineral based strata below the organic peat. Therefore the approximate 10% of mineral based strata proposed to be removed in the original program could also be eliminated.

If such recommendations were incorporated into the project; the dredge volume with a 13 foot maximum depth would be reduced from the previous reported 485,000 CY to about 320,000 CY, an approximate one third reduction in the overall program. The final program volume should certainly be subject to review, debate and revision but for purposes of this report, the 320,000 CY value will be used.

Dredging Methodology

1986: Three dredging methods were reviewed in the report, namely conventional excavation with a lake drawdown, hydraulic dredging, and use of a dragline bucket from a barge. Recognized disadvantages with conventional excavation is the need to entirely drain the lake, killing the entire fish population, potentially impacting adjacent wetlands and shallow home wells, and the need to operate equipment on the top of the very soft remaining peak layer (lower than 13 feet). Hydraulic dredging requires a containment basin site in which dredge spoils may dewater. A Potentail five acre site was identified west of the dam. The dragline methodology was noted to have the disadvantage of increased lake turbidity.

2004: Hydraulic dredging is the recommended methodology to dredge Pickerel Lake. Although conventional excavation of lakes is often utilized and continues to be a viable alternative, it is usually confined to smaller lakes or ponds all of which have a "hard" mineral based substrate upon which to operate equipment. A photographic page

regarding the dredging of Freshwater Pond in Enfield, is appended to the report, shows equipment operating on a hard bottom. Low pressure excavation equipment is available but truck access would be limited to the edge of the drawn down lake, thus necessitating costly double handling of materials. Also impacts to adjacent residential wells was a serious complication to a dam reconstruction project in Vernon when that lake was drained. As such, that issue cannot be dismissed at Pickerel Lake. Dragline operations can create extensive turbidity problems and in all probability could not be permitted. Even so, the multiple materials handling aspect of this methodology would most probably make the choice cost prohibited.

Both Silver lake and Milford Pond were proposed to be dredged hydraulically as both are flooded peat bogs without "hard" bottoms on which to operate conventional equipment. Silver Lake's overall program will remove approximately three quarters of a million yards of soft sediments. To date about 450,000 yards have been removed by pumping dredge spoils into two containment basins with a storage volume of 190,000 CY. The basins, as well as a finishing "floc" basin, occupy 17 acres of land.

An approximate eight acre site at the west end of the dam extends to the backside of the closed East Haddam landfill. The site is still heavily wooded. Pending results of a topographical, wetland survey and a basin design, BEC estimates a containment basin that could hold upwards of 75,000 to 90,000 CY could be constructed on this site, along with a small flocculation (secondary treatment) basin. In addition potential groundwater impacts to the landfill will need to be assessed.

For a dredging program to ultimately remove 320,000 CY at Pickerel Lake, four dredging phases will be required with an assumed containment basin of 80,000, CY. After each of the first three phases, the containment basin will need to be emptied in order to prepare for the next dredging phase. Silver Lake, on a larger scale has completed three dredge phases over the past ten years. Disposal has been bid out to contractors twice over the past decade with a third contract currently being prepared. The material has been resold to landfills for closing and cover purposes and to potting soil companies. The dredged Pickerel Lake peat material would probably be very similar to that from Silver Lake. Although the material has some value and reuse potential, it is not sufficient to offset transportation costs.

At Milford Pond, a suitable containment basin site could not be identified. Therefore the proposed operation has been modified with pumping to a mechanical dewatering process based upon belt filter press technology which utilize a much smaller area. This is a fairly new option, which although successfully applied to one lake in Massachusetts is significantly more expensive than the basin option.

Cost and Timeline

1986: Table 1 in the report summarized project costs and timelines for three optional methods of sediment removal. As reported these are:

Option A- Dragline with mats, lake empty

1. Removal and use by nursery company	$1.32M over 4 years
2. Removal and offsite disposal	$6.89M over 2 years
Option B- Dragline from barge and offsite disposal	$13.28M over 1.6 years
Option C- Hydraulic dredging	$7.27M over 7 years

2004: Based upon the experiences at Silver Lake, nursery companies could be interested in the dredge materials for possible reuse as a potting soil or for landscaping purposes. However, nurseries have never directly bid on the Silver Lake project, even just a contract to empty the dried basins. They are looking for suitable materials to be brought to their own facilities and as such option A (1) in BEC's opinion is not a viable alternative. Likewise, Option B is not recommended due to permitting issues and its costs. Considering the potential environmental impacts, permit needs and our prior experience BEC recommends that hydraulic dredging (Option C) be selected as the proposed methodology.

Project phasing could follow very closely to that experienced at Silver Lake which included the construction of the containment basin, several phases of the lake dredging with basin cleanout contracts between each dredge phase. A final restoration of the basin site should also be anticipated.

The Silver Lake containment basin was initially contracted in 1993 for $521,000 and provided storage of 190,000 CY's. A basin of 80,000 CY's is estimated to cost $300,000 in 2004 dollars, assuming similar conditions.

Three phases of dredging at Silver Lake have been completed between 1995 and 2003. Based upon the prior Silver Lake bid pricing in 2004 dollars, the estimated cost factor recommended for Pickerel Lake is $4.25/CY or $340,000 per 80,000 CY.

The clean out of the basins at Silver Lake were completed twice at an average cost in 2004 dollars of $1.20/CY of dried sediment. The dried sediment approximates 70% of the in-lake volume. The cleanout of 56,000 CY's remaining from the 80,000 CY's in-lake would cost about $70,000, again in $2004 dollars.

Final restoration is assumed to cost $50,000 in 2004 dollars.

Since the program is proposed to be phased over a number of years, an inflation factor should also be anticipated. A five percent per year factor is suggested. Design permitting and management costs are estimated at 20% of construction costs and a contingency factor of 25% is recommended for budgeting purposes. The projected program and cost summary is as follows assuming a project initiation in 2005.

Year	Task	Cost
(2005) 1	Construct Basin Site	$315,000
(2006) 2	Dredge 80,000 CY	375,000
(2007) 3	Clean out Basin	81,000
(2007) 3	Dredge 80,000 CY	394,000
(2008) 4	Clean out Basin	85,000

(2008) 4	Dredge 80,000 CY	413,000
(2009) 5	Clean out Basin	89,000
(2009) 5	Dredge 80,000 CY	434,000
(2010) 6	Restore Basin Site	67,000
Construction Program Subtotal		**$2,253,000**
Design/Permitting/Management @ 20% =		$450,000
		$2,703,000
Contingency @ 25% =		$675,000
		$3,378,000
		Say $3.4M

This is an aggressive schedule with a complete phase of basin clean out and dredging program occurring over twelve months, two years in a row. This could easily extend into another year or two which would increase costs. Also, note that real estate costs associated with use of the containment site are not included in the above estimate. Much more work will need to be performed to identify the containment basin site and to review ownership issues and site restraints.

As previously noted, the hydraulic dredging at Milford Pond is proposed to be conducted utilizing mechanical dewatering technologies in lieu of the more traditional containment basin design. This was chosen at Milford since in fact no suitable site could be located. This new technology that was not known in 1986 is unfortunately a much more expensive

process, and could double the project costs if a containment basin site cannot be secured for Pickerel Lake.

Conclusion

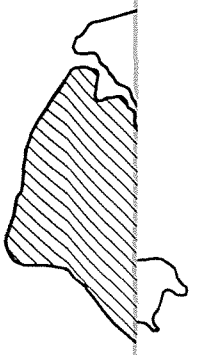
Pickerel Lake continues to experience restricted usage due to the extensive macrophyte growth over most of the lake. Hydraulic dredging is a viable lake management option to increase the open water component of this lake. A program to remove 320,000 CY over about 50 acres is suggested with a maximum depth of 13 feet.

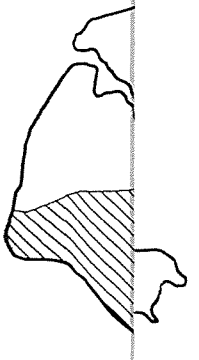
An upland site is required on which to construct a containment basin to dewater the dredged sediments. The previously identified site between the dam and the East Haddam closed landfill is still vacant and is presumed a viable consideration for use. Dried sediments would be removed from the basin after each dredging phase and the site restored at the close of the project.

The estimated cost of such a dredging program is $3.4M and would be phased over six years. The cost could double if in fact a satisfactory containment site could not be secured for use.

If dredging is a selected lake management option, a Conceptual Design Study of Dredging is recommended in which the scope of the project would be better defined, the containment site evaluated and the costs refined. Finally, as a sizable project, funding

sources should be explored at both the state level and possibly the federal level through the Corps of Engineers Section 206 Aquatic Ecosystem Restoration Program.





BAYSTATE ENVIRONMEN
CONSULTANTS INC

Civil Engineers
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Environmental Scier
East Hartford, CT

DREDGING LIMITS
PICKEREL LAKE
COLCHESTER/EAST HADDAM
CONNECTICUT

BEC PROJECT No.	03-0313
SCALE	1"=500'
DATE	JULY 2004
DRAWN BY	SMR
CHECKED BY	HRJ

Freshwater Pond

Client:
Town of Enfield

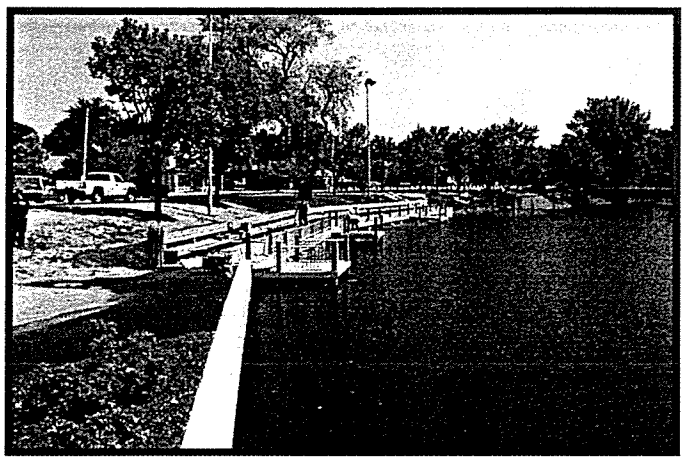
Location:
Enfield, CT

Services:
Diagnostic/Feasibility Study
Park Master Plan
Plans and Specifications
Permitting
Full Time Construction Monitoring

Freshwater Pond Prior to Construction

The Restoration of Freshwater Pond included conventional excavation of pond sediments, improvements to the dam, reconstruction of the adjacent park and construction of a sediment fore bay to facilitate future sediment removal. Public access and use of the pond has been significantly enhanced.

Freshwater Pond, with new public access for fishing and skating



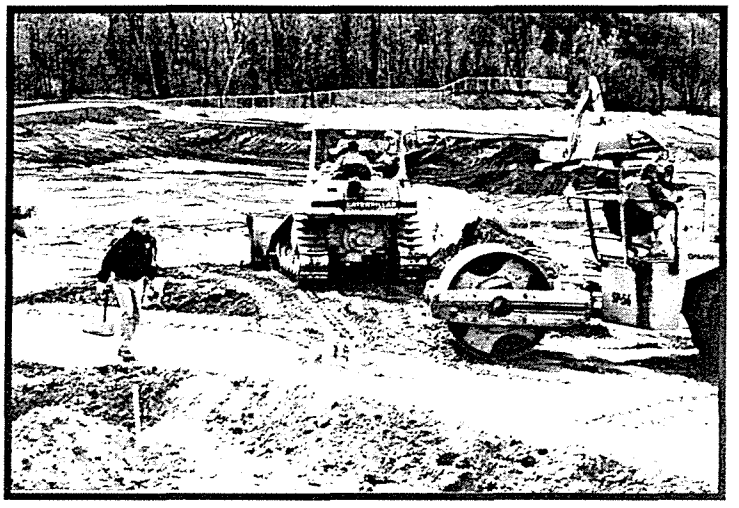
Baystate Environmental Consultants, Inc.
East Longmeadow, MA **East Hartford, CT**

Silver Lake Containment Basin

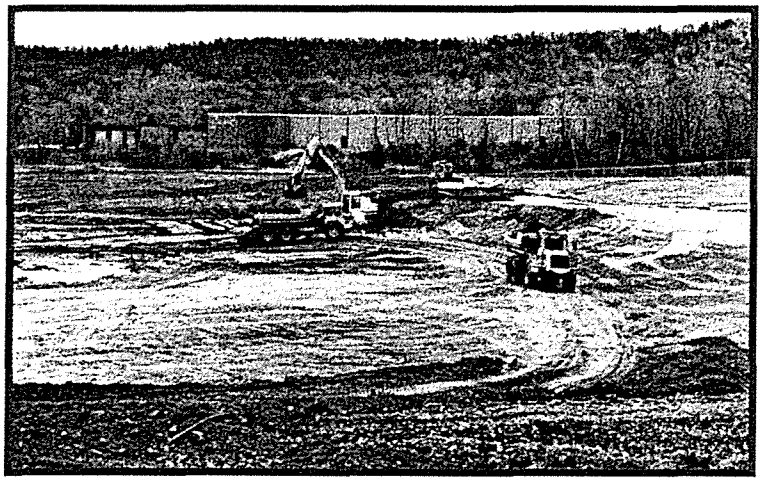
Client:
Connecticut Department of Environmental Protection

Location:
Berlin, CT

Services:
Site Design
Bid Documents
Construction Phase Services

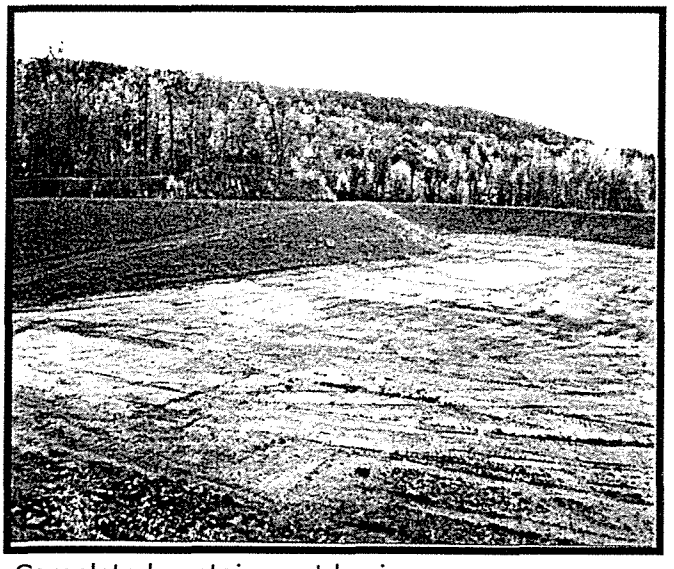


Hydraulic dredge and discharge pipeline at Silver Lake



Basin excavation project designed with balanced cut and fill

The Silver Lake Project included the design and construction of two containment basins with a combined capacity of over 190,000 cubic yards. Also included were a flocculation basin with a 14,000 cubic yard volume, access roads and site security. The design allows for independent operation of each containment basin, accessibility to the lakefront, and also facilitates the application of polymers or other flocculating agents.



Completed containment basin

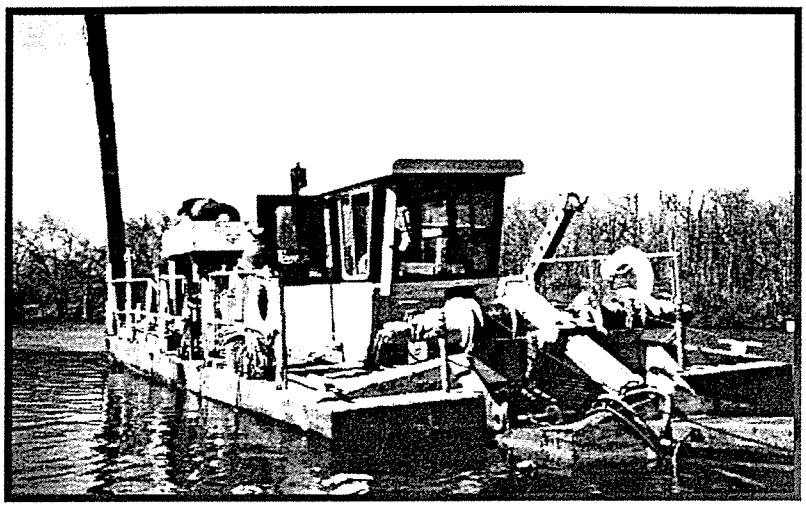
Containment basin after one dredging season

Hydraulic Dredging of Silver Lake

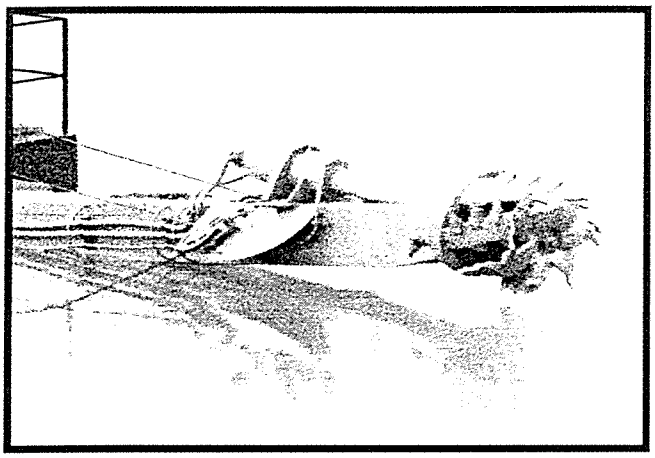
Client:
CT Department of Environmental Protection

Location:
Berlin, CT

Services:
Dredging Design
Permits
Plans & Specifications
Construction Phase Services

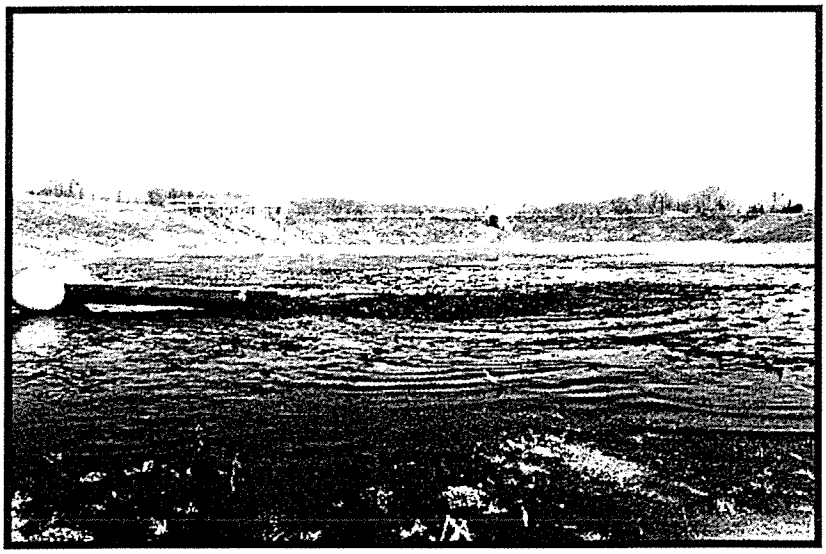


Hydraulic dredge and discharge pipeline at Silver Lake

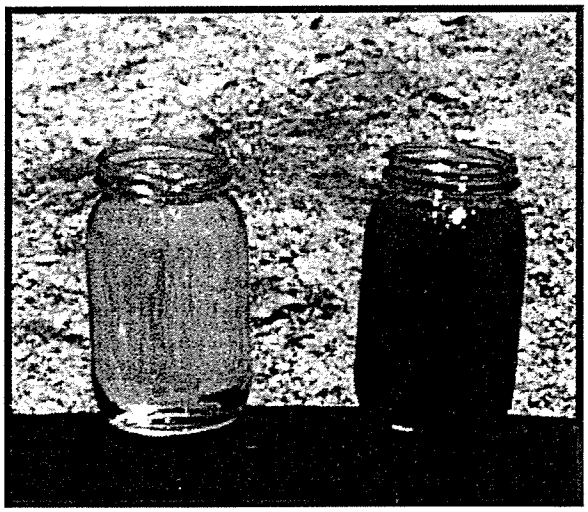


Dredge Cutterhead

- Multi-year program to dredge one half million yards-- largest in New England
- Phases I and II complete at cost of $625,000 with 186,000 cubic yards removed



Dredge containment area



Dredge slurry after chemical treatment