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FINAL REPORT

1987

Diagnostic/Feasibility Study

LAKE BOON

Towns of Hudson/Stow, MA

Camp Dresser & McKee

FINAL REPORT

DIAGNOSTIC/FEASIBILITY STUDY

LAKE BOON

Hudson and Stow, Massachusetts

August 1987

Camp Dresser & McKee Inc.
in association with
IEP, Inc.

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SUMMARY

1. Lake Boon is a diverse waterbody with two larger open water basins, and several shallow, vegetated basins. The lake is a well-used recreational resource for the people of Hudson and Stow, supporting a Town bathing beach and swimming, boating, and fishing activity throughout the year.

2. Dense growth of floating leaved and submerged aquatic plants interfere with recreation in the shallow eastern basins of the lake, and shallower areas of the second basin. The primary nuisance species is Camboba, not a native of the area. Water milfoil is another nuisance species present, but it does not appear to have expanded since the DWPC (1981) study. However, it has the potential to expand rapidly.

3. Moderate to high populations of blue-green algae occur during the summer, contributing to borderline transparency problems. Dissolved oxygen is limited in deeper waters during summer stratification, but is not of sufficient magnitude to impact fisheries or phosphorus recycling. No problems with bacterial contamination were noted.

4. Lake Boon has a low flushing rate with limited water inflows due to the large volume of the lake compared to the area of the watershed, and the prevalence of groundwater storage in the watershed area.

5. The major controllable sources of phosphorus from the Lake Boon watershed is surface runoff from shoreline residential properties and nutrient export from shoreline septic systems. The sandy character and high water table of shoreline soils limit their function to attenuate phosphorus.

6. To address the main problem of dense aquatic vegetation and the secondary problem of reducing phosphorus in the water column, various combinations of alternatives were developed. Four options were then evaluated in more detail and the proposed project was then selected.

7. The selected option includes the following components:

   a. One year only contracted hydroraking to provide interim relief from nuisance aquatic vegetation. It may also have limited carryover benefits since hydroraking removes the roots of aquatic vegetation as well as upper portions. This will cost approximately $38,000. If funded by the DEQE Clean Lakes Program at 75%, the Town's share will be $9,500.

   b. The purchase of a medium sized weed harvester to be maintained and operated by the towns of Hudson and Stow on an annual basis. This harvester will cut and remove nuisance aquatic vegetation, improving the recreational potential of Lake Boon. The weed harvester will cost about $50,000, of which $12,500 is the Towns' share. Annual costs, which are not fundable under the Clean Lakes Program, will be approximately $18,000.

   c. The implementation of a watershed management plan to include a septic system pumping program; revisions to the Towns' by-laws on cesspool conversion; and a public education program. This portion of the project is vital to the preservation of Lake Boon. Without it, the lake will deteriorate to a "pea soup" condition. This portion of the project will cost $30,000 total, with $7,500 being the Towns' share. There will also be an annual cost of up to $10,000 for the first few years of implementation.

   d. A 3-year monitoring program as required by the DEQE Clean Lakes Program to determine the effectiveness of the project. This is estimated to cost about $50,000 total, of which $12,500 is the Towns' share.

8. The total cost of the project is $168,000 including the state required monitoring program, with the Towns' share $42,000. Annual costs will be an additional $28,000.

9. This project will not return Lake Boon to a "pristine" condition. However, without these preservation efforts, nuisance aquatic vegetation and algae blooms will increase rapidly over the next few years to a point where recreation is severely inhibited. This project should be implemented as soon as possible if the lake is to be preserved.

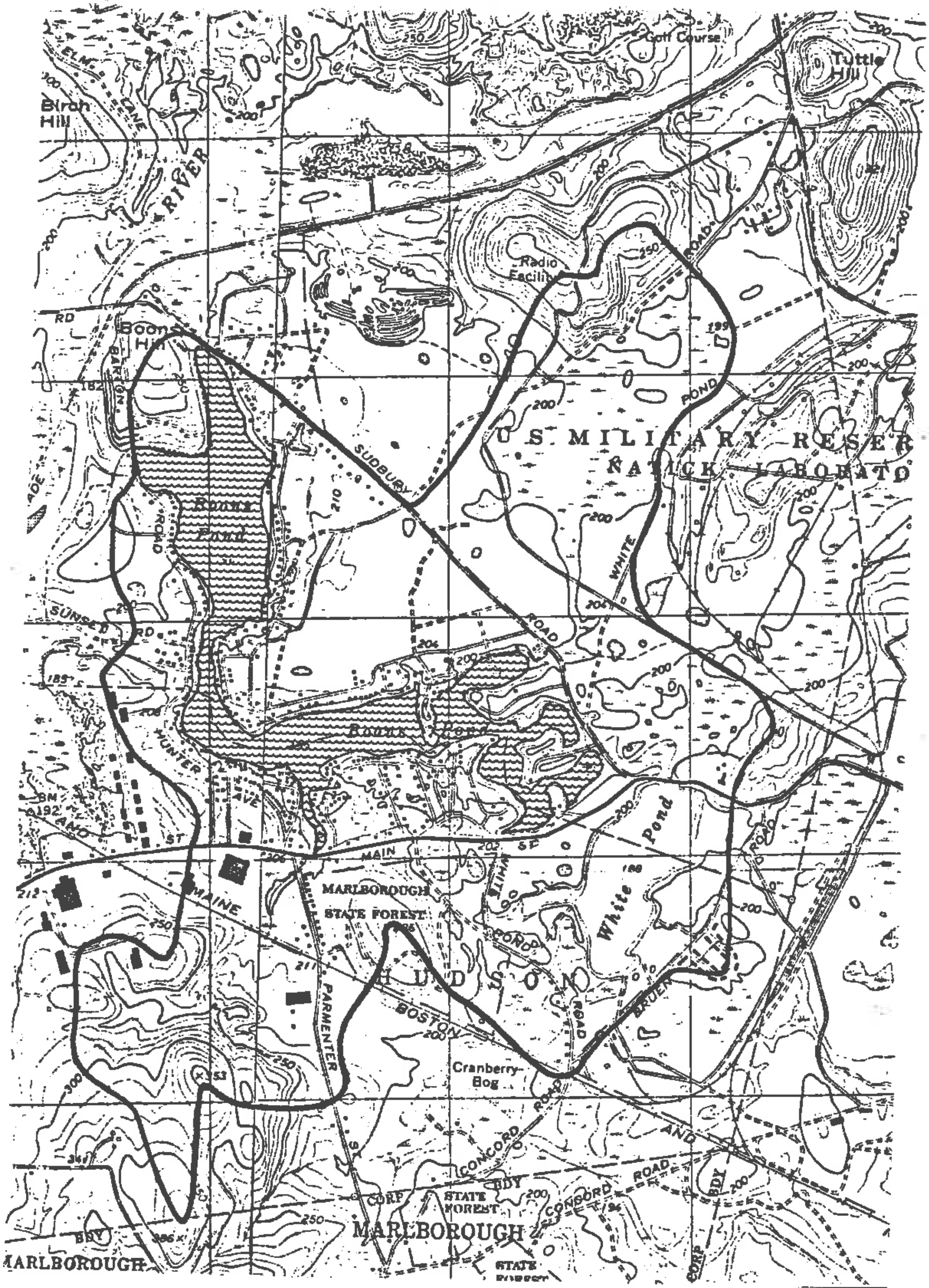
1.0 INTRODUCTION

Lake Boon is located in Hudson and Stow, Massachusetts (Figure 1-1), tributary to the Assabet River. The watershed includes land in the both towns, and is dominated by forest with dense residential development surrounding the lake.

Historically, Lake Boon has been an important recreational resource for the residents of Stow and Hudson--swimming, boating, and fishing are all popular activities. At one time, the cottages surrounding the lake were popular for summer vacations of Boston area residents, however, most have been converted to year-round homes.

In more recent years, the condition of the lake deteriorated because of increased algae and aquatic plant growth, interfering with established recreational pursuits. Initial attempts to control weed growth began in the 1960's with chemical and mechanical controls. These were only marginally successful, and continued problems led to a 1978 study by the Metropolitan Area Planning Commission (MAPC). "A Management Program for Lake Boon: Interim Report" was issued by MAPC in January 1979, and addressed land use and zoning issues in the watershed.

In 1979-1980, the Massachusetts Division of Water Pollution Control (DWPC) conducted a year-long study of the lake. This effort included water quality monitoring, hydrologic and nutrient budgets, and an analysis of potential management/restoration strategies. However, restoration measures for the lake were not fully evaluated. The present study is designed to update the findings of the DWPC study, and to provide a more detailed analysis of feasible restoration techniques. The study began in the summer of 1985, and was partially funded through the Massachusetts Clean Lakes Program (Chapter 628).



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LAKE BOON
DIAGNOSTIC FEASIBILITY STUDY

TOWNS OF HUDSON AND STOW
MASSACHUSETTS

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FIGURE 1-1

WATERSHED DELINEATION

Many of the requirements of the study are technical, and so the use of a considerable amount of technical terminology is necessary. For reference, a glossary of terms is provided in Appendix A. Metric units are required by contract, but English equivalents are given where possible.

2.0 DIAGNOSTIC STUDY

2.1 GENERAL DESCRIPTIONS AND MORPHOMETRY

These descriptions represent subtasks A.3.1.a - g of the substate agreement, and give an overview of the lake and its watershed, as well as forming a basis for further analyses.

2.1.1 LAKE BOON WATERSHED

Lake Boon is a 66 hectare (163 acre) lake located in the Towns of Hudson and Stow. The watershed of Lake Boon includes 684 hectares (1690 acres) and ranges in elevation from 60 meters (190 feet) at the lake to 85 meters (280 feet) at the height of land. The watershed-to-lake area ratio is 10.4:1. This is fairly small and suggests the influence of in-lake processes and low flushing rate in determining the character of the lake. Much of the watershed is characterized by level or slightly sloping, sandy areas with dry oak forests and red maple swamps.

The lake can be divided into several basins for discussion purposes. The first basin is the deepest, northernmost basin, with the outlet exiting on the west side. The second basin is intermediate in depth, located centrally in the lake and watershed. The third and fourth basins, including the "stumps" area, are at the east end of the lake, and consist of shallow areas which were not part of the original lake, but are flooded wetlands added to the lake when the water level was raised in the 1800's.

The outlet is at an earthen dam over which Barton Road passes at the northwest corner of the lake. The structure consists of a 48" wide concrete weir structure with about a three foot drop to a circular corrugated metal culvert, which empties on the west side of Barton Road. Water levels may be adjusted one to three feet by flash boards at the weir. The outlet stream consists of a marsh area, about 200 feet wide, which empties into the Assabet River about 600 feet downstream of the lake outlet.

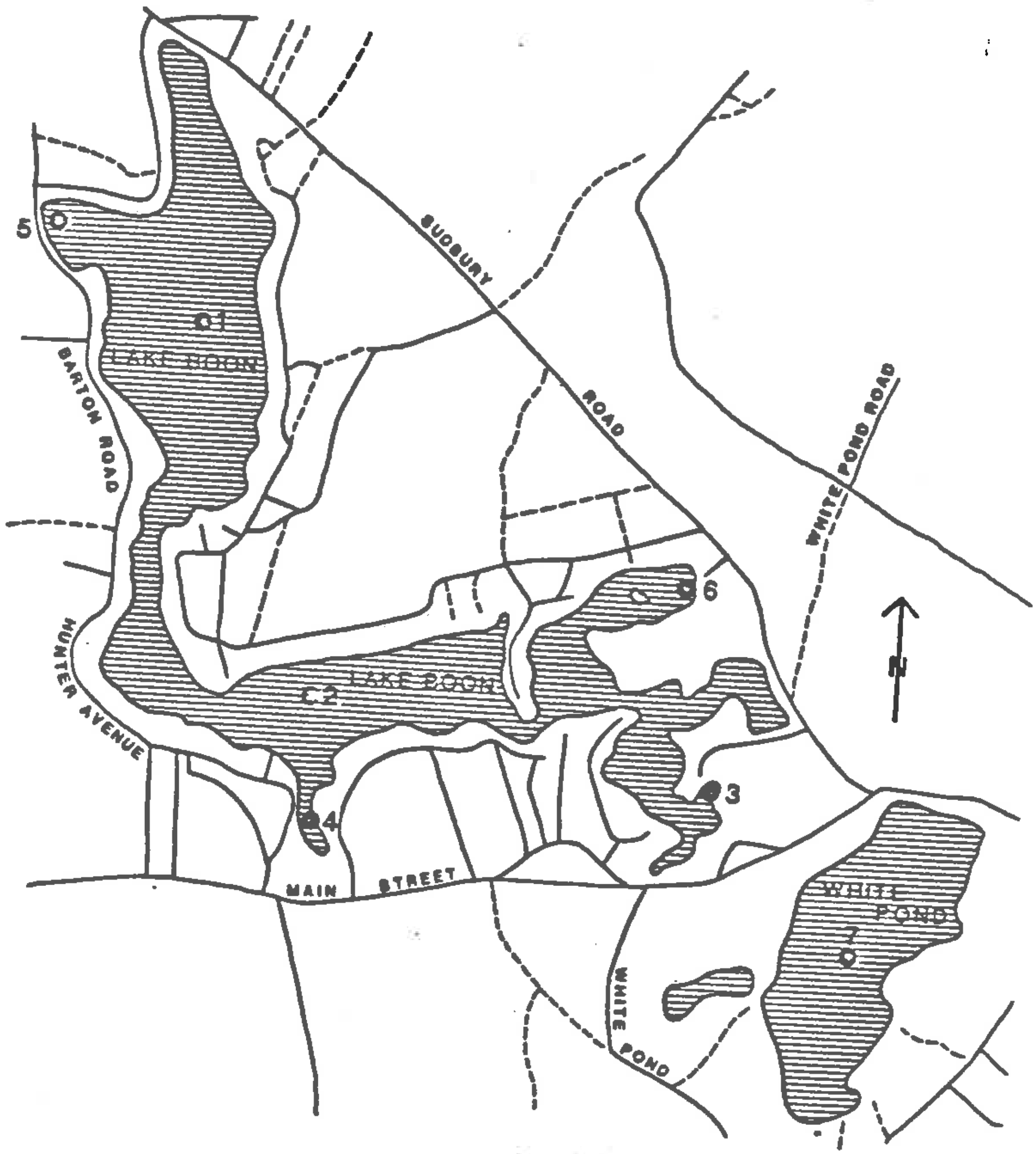
Inlet streams to Lake Boon are remarkably limited, hinting at the importance of groundwater in sustaining the lake. The sampling stations for the lake are shown on Figure 2-1. The largest inlet (sampling station 4) enters the lake in a cove on the south side of the second basin. Two minor inlets that flow only part of the time enter the lake at the east end (stations 3 and 6).

No flow was ever observed during the course of our study at station 6. Given the buried condition of the culvert under Sudbury Road, and the well developed upland vegetation along the "channel" west of Sudbury Road, it is doubtful that surface flows have entered the lake here in recent years. Both stations 3 and 6 drain large wooded swamps upstream of the lake.

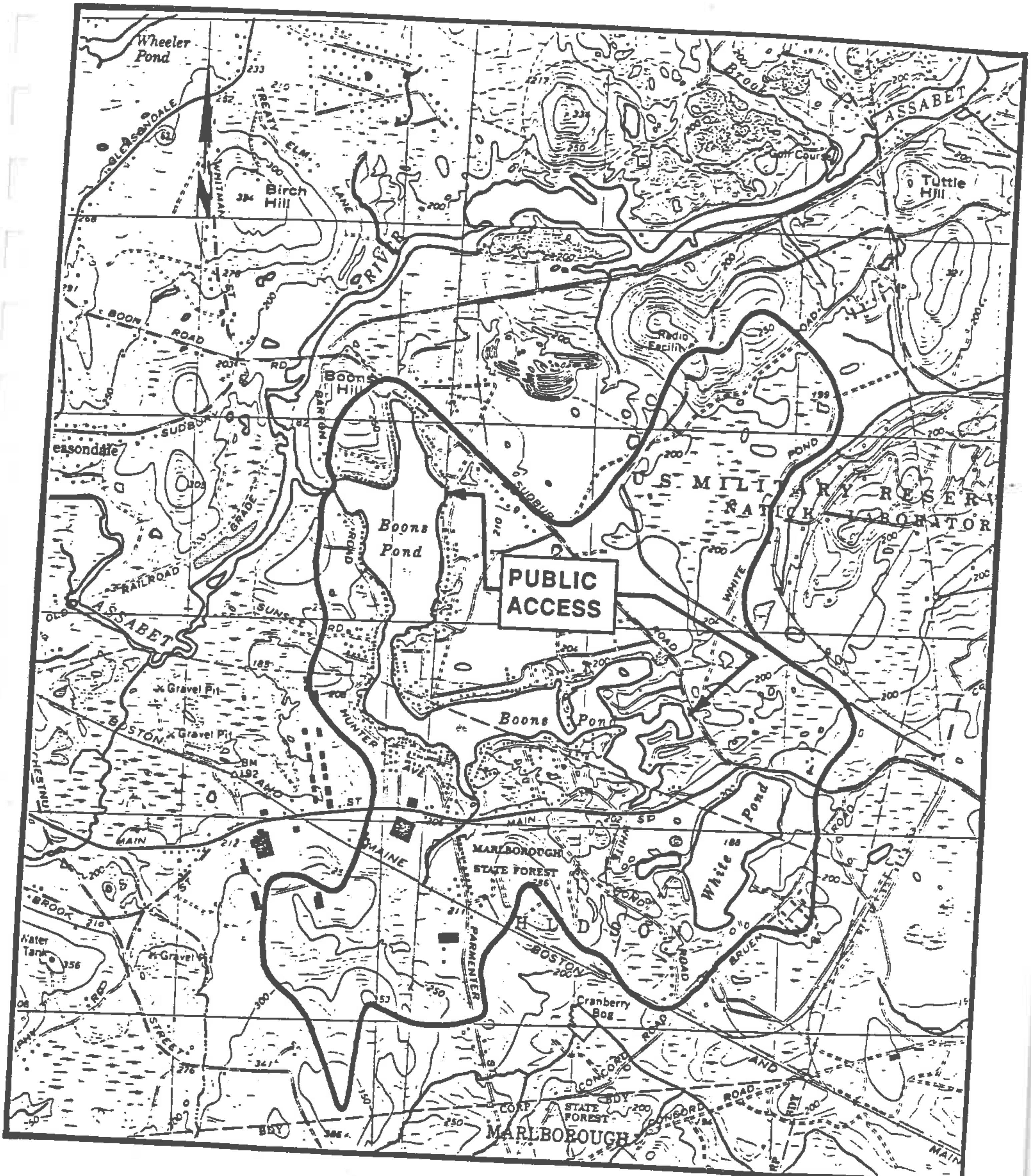
White Pond, a natural kettle hole pond, is located to the southeast of Lake Boon (Figure 2-1) and was sampled during this study (Station 7) because of the potential hydrologic connection between the two water bodies. White Pond has no surface inlets or outlets, and is maintained as a water supply by the Town of Maynard. Although White Pond and its drainage area have been included in the watershed delineation for Lake Boon (DWPC, 1981), it is doubtful that this area contributes water to Lake Boon as discussed in later sections.

2.1.2 PUBLIC ACCESS

Lake Boon has public access at two points as shown on Figure 2-2. One is an unpaved boat ramp located off Sudbury Road in the southeast portion of the lake. Another is the Stow Town beach off Sudbury Road on the east side of Lake Boon, which is also available for public use. The Town beach does not have a formal boat launching area. The



SCALE IN FEET 0 500 1000 2000	**LAKE BOON** DIAGNOSTIC FEASIBILITY STUDY TOWNS OF HUDSON AND STOW MASSACHUSETTS	CAMP DRESSER & McKEE INC. in association with IEP, INC.	**FIGURE 2-1** SAMPLING STATIONS 1985-1986



SCALE IN FEET 0 500 1000 2000	**LAKE BOON** DIAGNOSTIC FEASIBILITY STUDY TOWNS OF HUDSON AND STOW MASSACHUSETTS	CAMP DRESSER & McKEE INC. in association with IEP, INC.	**FIGURE 2-2** PUBLIC ACCESS

previous public boat access off Main Street in Hudson is no longer available since the land is now privately owned. Lake Boon is also accessible from the dam at Barton Road, however, this approach is discouraged by the Town of Stow due to a lack of parking. A private beach club is also located in the northern tip of the lake near Sudbury Road, however, only members can utilize this entrance.

2.1.3 MORPHOMETRY

The bathymetric map, or bottom contour map, shown on Figure 2-3 was generated from field examinations during ice cover in December, 1985. Transects were set up using shoreline features as reference points. Points were selected 15 meters from the shore, then at 50 meter intervals. Water depth was measured by a combination of two methods: an electronic depth sounder in deeper water, and a hand-held weight on the end of a marked rope in shallower depths.

Basin 1 is the deepest basin with a maximum depth of 7.0 meters (23 feet). Basin 2 has a maximum depth of 4.5 meters (15 feet), with the majority being 3 meters (10 feet) or greater. Basin 3 has a maximum depth of 3 meters (10 feet), but most of the basin is less than 2 meters (6 feet) deep. The shallow areas of the lake where aquatic plants grow is very limited in the first basin, but widespread in the eastern basins.

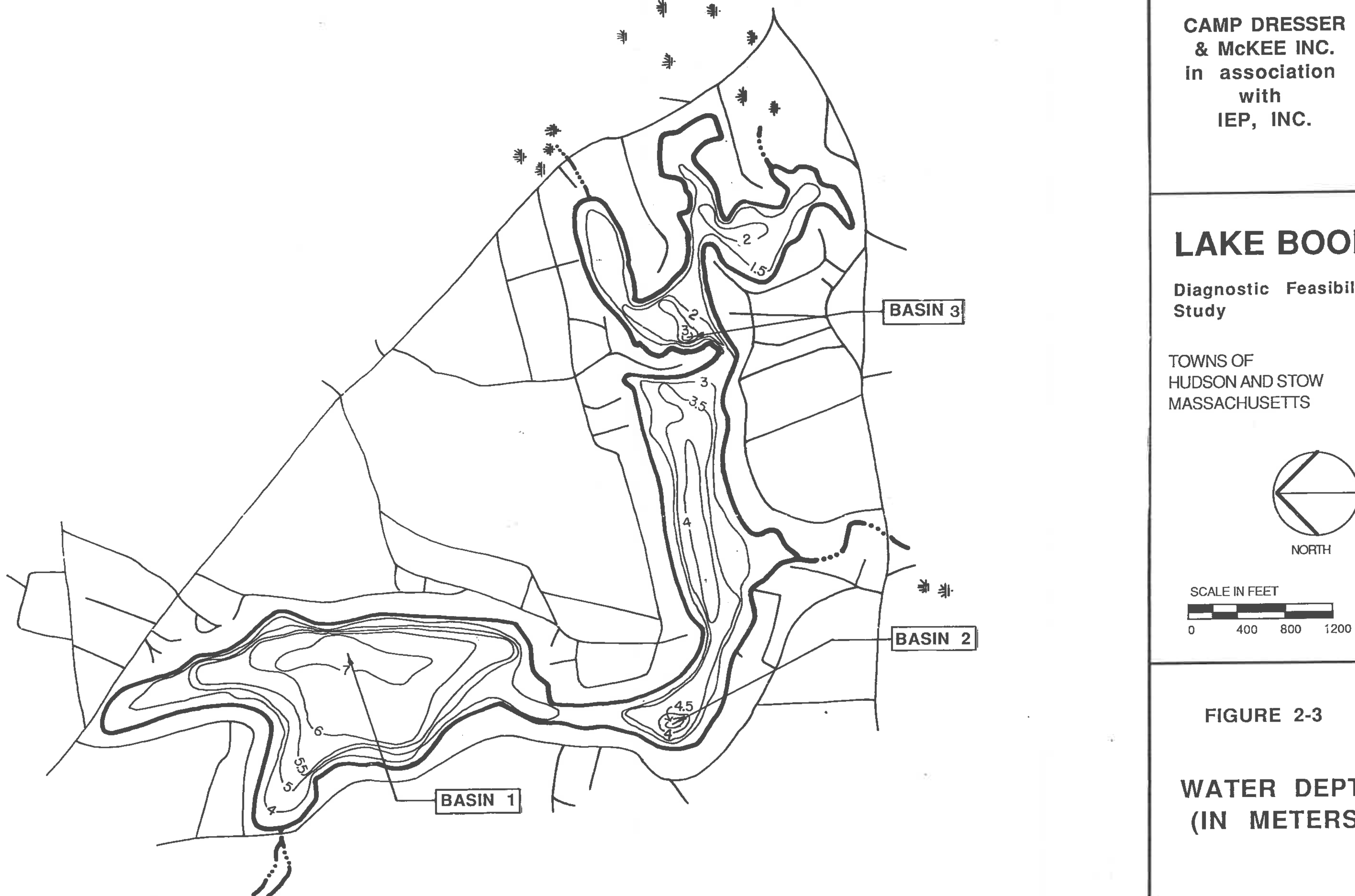
Morphometric parameters (Table 2-1) were calculated from the bathymetric map and from the U.S.G.S. topographic map. These data are comparable to what was found by DWPC in 1981.

2.1.4 HISTORY

According to the Division of Water Pollution Control's 1981 study, Lake Boon was named after Matthew Boon who settled the surrounding

Table 2-1 Morphometric Data

Area	163 acres	66 ha
Maximum Depth feet	23 feet	7.0 m
Mean Depth	10.7 feet	3.3 m
Volume	74,700,000 ft^3	2,110,000 m^3
Watershed Area	1,440 acres	583 ha
Maximum Length	10,300 feet	3,140 m
Maximum Width	1,840 feet	560 m
Shoreline Length	31,300 feet	9,530 m
Development of Shoreline	3.3	
Watershed to Lake Area Ratio	8.8	



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LAKE BOON

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FIGURE 2-3

WATER DEPTH (IN METERS)

land around 1660. Boon lived in the area until 1676 when he was killed near the pond.

In the 1840's, Amory Maynard purchased land on the Assabet River and built a dam for his sawmill. In 1847, Boston searched for water supplies to meet growing population needs. Boon's Pond was procured for this purpose, however it was never used. A payment for the water supply taken was received in the form of a dam built on Bailey's Brook at Barton Road. This action enlarged Boon's Pond into a sizeable lake, now called Lake Boon.

Several summer cottages were built followed by many more as the lake became a center of recreation. Around the turn of the century, the steamer, "Princess" was in operation on the lake, bringing commuters from their summer cottages to nearby railways. Lake Boon was the site of many parties and was used frequently by canoeists and rowboaters.

Although White Pond is located within the Lake Boon watershed, it has no known surface water connection to Lake Boon. No inlets or outlets are known to exist, however, a ground water interaction between the two bodies of water is possible. Prior to 1889, White Pond had a large commercial ice cutting operation functioning on its shores, according to Maynard Town Historian Ralph Sheridan. An ice house was situated next to the pond near an old railroad. In the mid 1880's the Town of Maynard made an application to the Massachusetts legislature to acquire White Pond as a drinking water source to supply the Town's growing population. A bill was passed on May 25, 1888 giving the rights of the pond to the Town of Maynard. By 1889, Maynard's water supply system was completed and use of White Pond began.

In response to the droughts of the 1960's Maynard managed to secure an unused well inside the United States Army Reservation and pumped water from the well into White Pond. In 1965, the Maynard Public Works Department leased the "Quirk Well" off of Old Marlborough Road to use to pump into White Pond. Eventually in 1967 the Town took the well and land around it by eminent domain. Currently a pump house next to White Pond pumps water from the pond which then enters a gravity fed distribution system.

In the 1950's and 1960's the permanent population continued to grow on the shores of Lake Boon. Residents became aware of the increased aquatic plant growth which interfered with recreational activities. Weed control was attempted in small coves with an experimental chemical treatment in the early 1960's. This attempt was unsuccessful and drew objections from residents with drinking water wells on the shore. Next, the Lake Boon Commission purchased a weed harvester and used it several times to cut back the aquatic plant growth. According to Dick Gelpke, who operated the harvester, these attempts were unsuccessful. Inadequacies of the collection device allowed cut plant pieces to float away and reroot. Since the 1960's no aquatic plant management has been attempted.

Current recreational uses at Lake Boon include fishing, swimming, and boating. These activities are pursued at many private beach and dock areas associated with cottages, and a public swimming beach on the first basin. Ice fishing is popular in the winter whereas motor boating and swimming are probably the most popular summer activities.

2.1.5 SOILS AND GEOLOGY

Surficial geology of the Lake Boon watershed is shown in Figure 2-4. The major glacial deposit in the watershed is the outwash plain. This area is characterized by low topography and sandy soils. Infiltration of rainfall on these deposits is high with limited surface runoff. Various other types of stratified sand and gravel deposits are found in the watershed including ice channel fill, kame plain, and kame terrace. These deposits are all coarse-grained with high groundwater potential.

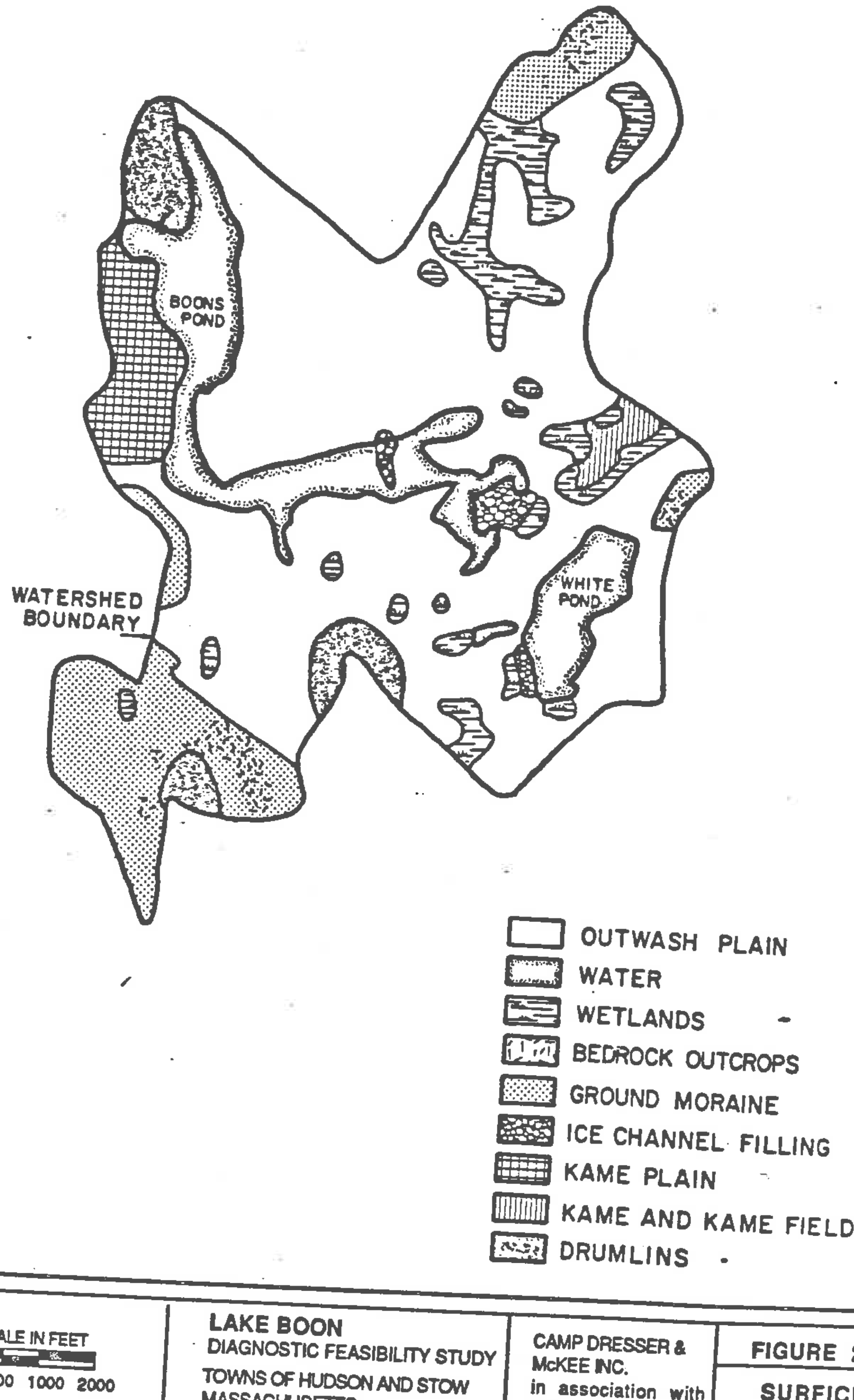

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FIGURE 2-4
SURFICIAL GEOLOGY

Ground moraine and drumlin till deposits are found at the southern edge of the watershed. In contrast to stratified deposits, these deposits are compact and composed of a variety of grain sizes which limit infiltration and increase surface runoff.

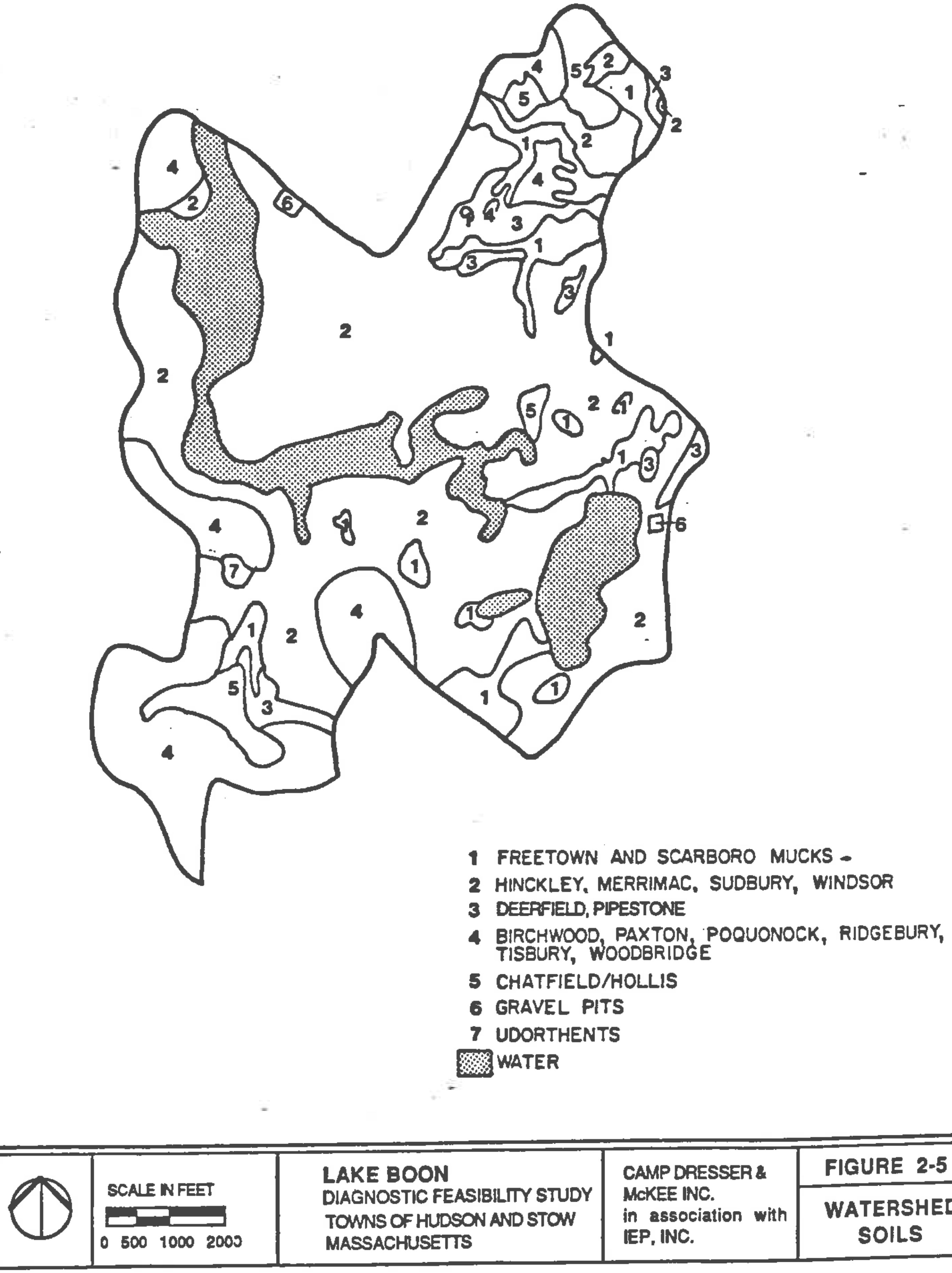
Swamp deposits are found in depressions and along stream valleys in the watershed where partially decayed organic matter has accumulated. These areas are frequently characterized by groundwater discharge.

The dominant soils of the Lake Boon watershed (Figure 2-5, Table 2-2) are Hinckley and Windsor. Hinckley is most prevalent to the north and east of the watershed, while Windsor is found south of the lake. Both of these soil series are well drained to excessively drained sandy soils. Paxton Series is the third most common soil type in the watershed, formed in areas underlain by glacial till. Minor areas of other soil types include two gravel pits, one small filled area, and small pockets of Freetown and Scarboro muck located in the swamps.

The Natick Laboratory Military Reservation is in the north of the watershed. Soil mapping was completed for the reservation in November, 1985 by the U.S. Soil Conservation Service. This portion of the Lake Boon watershed exhibits a great variety of soil types with the mucks and Hinckley soils being the most prevalent. Descriptions and limitations of soils found in the watershed are listed in Table 2-3.

2.1.6 LAND USE

The land use data for the Lake Boon watershed (Table 2-4, Figure 2-6) have been updated from the 1979 Study conducted by the Division of Water Pollution Control. From field checks, it was found that the forested land in the watershed has decreased 8% since 1979 and that residential land has increased by the same amount. Industrial land has also increased along Main Street and Parmenter Street to make up



LAKE BOON DIAGNOSTIC FEASIBILITY STUDY TOWNS OF HUDSON AND STOW MASSACHUSETTS	CAMP DRESSER & McKEE INC. in association with IEP, INC.	**FIGURE 2-5**	**WATERSHED SOILS**

Table 2-2 Lake Boon, Areas of Generalized Soil Types

Soil Types	Acres	Hectares	%
1	132	53	8%
2	90	365	53%
3	50	20	3%
4	284	115	17%
5	95	38	6%
6	4.0	1.6	>1%
7	4.0	1.6	>1%
Water	218	88	13%
Total	1,690	684	100%

Table 2-3 Soils of the Lake Boon Watershed

Soil Name	Hydrologic Class	Texture	Permeability	Location	Potential of Soil for Septic System Use	Reason for Limitation Rating
Birchwood	C	fine sandy loam over sandy loam	rapid surface to slow substratum	two pockets in south of watershed	very low	slow percolation rate, high water table
Chatfield /Hollis	B C/D	friable loam with with rock outcrops	rapid	one pocket Southwest of Marlborough State Forest	medium	depth to rock, slope
Deerfield	B	loamy fine sand over coarse sand	very rapid	one pocket south-west of Marlbo-rough State Forest	low	high water table Poor filter capacity
Freetown Muck	D	decomposed organic material over loamy mineral material	moderate to rapid	small pockets throughout watershed	very low	water table at surface
Gravel Pits		areas of excavation unweathered sand & gravel	none	one in North of Sudbury Road	N/A	N/A
Hinckley	A	gravelly sandy loam over loose stratified sands and gravel	very rapid	Dominant soil North of Boons Pond in watershed	medium to very high	slope
Merrimac	A	friable fine sandy loam over stratified sand	rapid	Pockets in Natick lab reservation	very high	none
Paxton	C	friable sandy loam over firm fine sandy loam	moderate surface to slow sub-stratum	large pockets on outskirts of watershed	very low	slow percolation rate, stony, slope

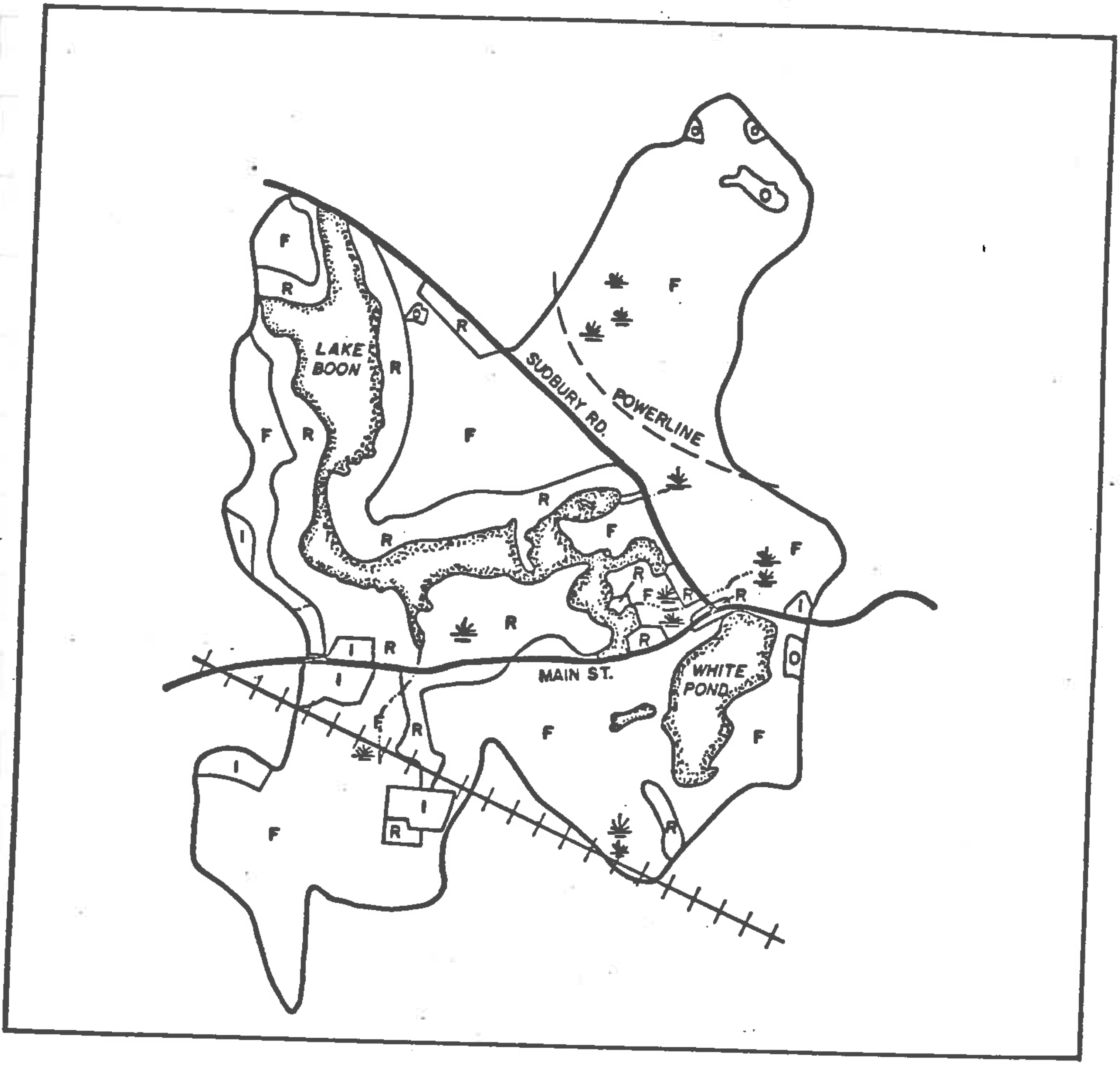
Table 2-3 (continued)

Pipestone	A	loose loamy sand	rapid	one pocket southwest of Marlborough State Forest	high	high water table
Poquonock	C	loose sandy loam over firm sandy loam	rapid surface to slow substratum	one pocket in southwest	very low	slow percolation rate, stony, slope
Ridgebury	C	loose sandy loam over firm sandy loam	rapid surface to slow substratum	one pocket in southwest	very low	slow percolation rate, high water table, stony
Scarboro Muck	D	mucky sandy loam over stratified sand	very rapid	one pocket in south along the Maine & Boston RR	very low	water table at surface
Sudbury	B	fine sandy loam over stratified sand	rapid	pockets in Natick lab reservation	low	high water table
Tisbury	B	friable very fine sandy loam over stratified sand	moderate	pockets in Natick lab reservation	low	high water table
Udorthents		varied (disturbed soils)	rapid to slow	one small pocket in West	variable	variable
Windsor	A	loose loamy fine sand	rapid	dominant soil south of Boons in watershed	medium to very high	slope
Woodbridge	C	loose fine sandy loam overfine sandy loam	moderate surface to slow substratum	along southwest border of watershed	very low	slow percolation rate, high water table slope

Note: soils data adapted from Soil Conservation Service. Application of these data at specific sites is not appropriate without site-specific mapping.

Table 2-4 Lake Boon Land Use

Land Use Type	Area (acre)	(ha)	% of Watershed
Forest	1061	429	63%
Residential	301	122	18%
Industrial	49	20	3%
Wetlands	31	13	2%
Open Land	30	12	1%
Water	218	88	13%
TOTAL	1690	684	100%



F FORESTED
R RESIDENTIAL
I INDUSTRIAL
WETLAND
O OPEN LAND

	SCALE IN FEET 0 50 100 500	LAKE BOON DIAGNOSTIC FEASIBILITY STUDY TOWNS OF HUDSON AND STOW MASSACHUSETTS	CAMP DRESSER & McKEE INC. in association with IEP, INC.	FIGURE 2-6 WATERSHED LAND USE

3% of the total watershed. For a more detailed description of land use, and information about zoning in the watershed area, the reader is referred to DWPC (1981) and MAPC (1979). Non-point source phosphorus loading as estimated from land use is discussed in the nutrient budget section.

2.1.7 WASTEWATER DISPOSAL

Background

The Division of Water Pollution Control, in conjunction with Environmental Devices Corporation, conducted a "septic snooper" survey along the shoreline of Lake Boon in August, 1979. This survey found areas of high inorganic (conductance) background levels along the shore near Pine Point Road, Hunter Avenue, and Worcester Avenue. An area of high organic (flourescence) background concentration was also observed off of Worcester Avenue. Four apparent septic leachate plumes were sampled off Pine Point Road, one of which showed high nutrient concentrations. Five apparent plumes were sampled along Hunter and Worcester Avenues, two of which had elevated nutrient concentrations, and one showed high fecal and total coliform levels.

In all, twenty-seven "plumes" were sampled around the lake, nine of which (33%) were located off of Pine Point Road and Hunter and Worcester Avenues. However, three of these nine "plumes" which showed high Kjeldahl-nitrogen and total phosphorus values may have been caused by bottom sediments (DPWC, 1981).

The Boards of Health in the towns of Hudson and Stow were contacted to obtain available information on septic systems in the vicinity of Lake Boon in their respective towns. Frank Krysa, Health Agent in Hudson, indicated that the Hunter Avenue and Worcester Road areas, in particular, were the worst locations for problems with septic systems. Jack Wallace, Stow Health Agent, related that Pine Point Road was the area with the most complaints about septic systems. Both cited the conversion of older seasonal summer cottages to year-round residences as the predominant reason for problems.

Health Department records on septic system installations, repairs, and written complaints were reviewed in the two towns. In both, the earliest records date back to about 1964. The Stow files revealed that out of about forty houses on Pine Point Road, only four lots had records of septic system installation/repair since 1967, and there were two recorded instances of overflowing systems. Hudson records showed that twenty-two of eighty-six house lots (26%) along Worcester Avenue and Hunter Road had records of installation/repair since 1964. There were no documented septic system failures in the Hudson files.

Assessors maps of the shoreline areas around Lake Boon in Hudson and Stow were obtained to determine the location of house lots within 300 meters of the lake. This information was used to compile a mailing list for the questionnaire that was used to obtain further information on septic systems.

Description and Results of Questionnaire

The septic system survey (See Appendix A) was mailed to property owners and residents around the lake and requested the following information:

1. Address and length of residence
2. Age of house
3. Number of residents
4. Type, age, location and condition of septic system
5. Maintenance procedures and regularity of pumping
6. Problems encountered with the systems
7. Detergent used
8. Source of water
9. Water-related appliances

Of the total of 537 properties identified, about 35% of homeowners responded, (Stow - 40% and Hudson - 30%). The following results are based on the assumption that all the lots have residences on them, whether seasonal or year-round. Although the response is essentially a self-selected sample, the extrapolations provide useful information regarding possible influent sources to Lake Boon.

Of the respondents, 47% pumped their system regularly (Stow 52% and Hudson 40%), 13% never pumped (Stow 12% and Hudson 13%), while 29% only pumped when and if there were problems (Stow 29% and Hudson 29%). 10% of the respondents had new systems and therefore did not pump yet.

This implies that only half of the residents around the lake are adequately maintaining their systems. The remainder deal with their systems when problems occur. However, according to the respondents, only a small percentage (8%) reported any problems with the systems. These problems included odors, back-ups, slow running toilets and drains, and overflowing systems. More than a quarter of the total respondents (27%) have cesspools (Stow 30% and Hudson 23%).

Finally, the questionnaire sought to determine what additives were placed in the septic systems; 24% of respondents use detergents containing phosphates and 32% use commercial preparations in their septic tanks.

The state of repair and efficiency of the septic systems, and the additives placed in the system are important when considering possible sources of contamination of the lake. An estimate of phosphorus loading derived from septic systems is included in the nutrient budget section.

2.2 LIMNOLOGIC DATA

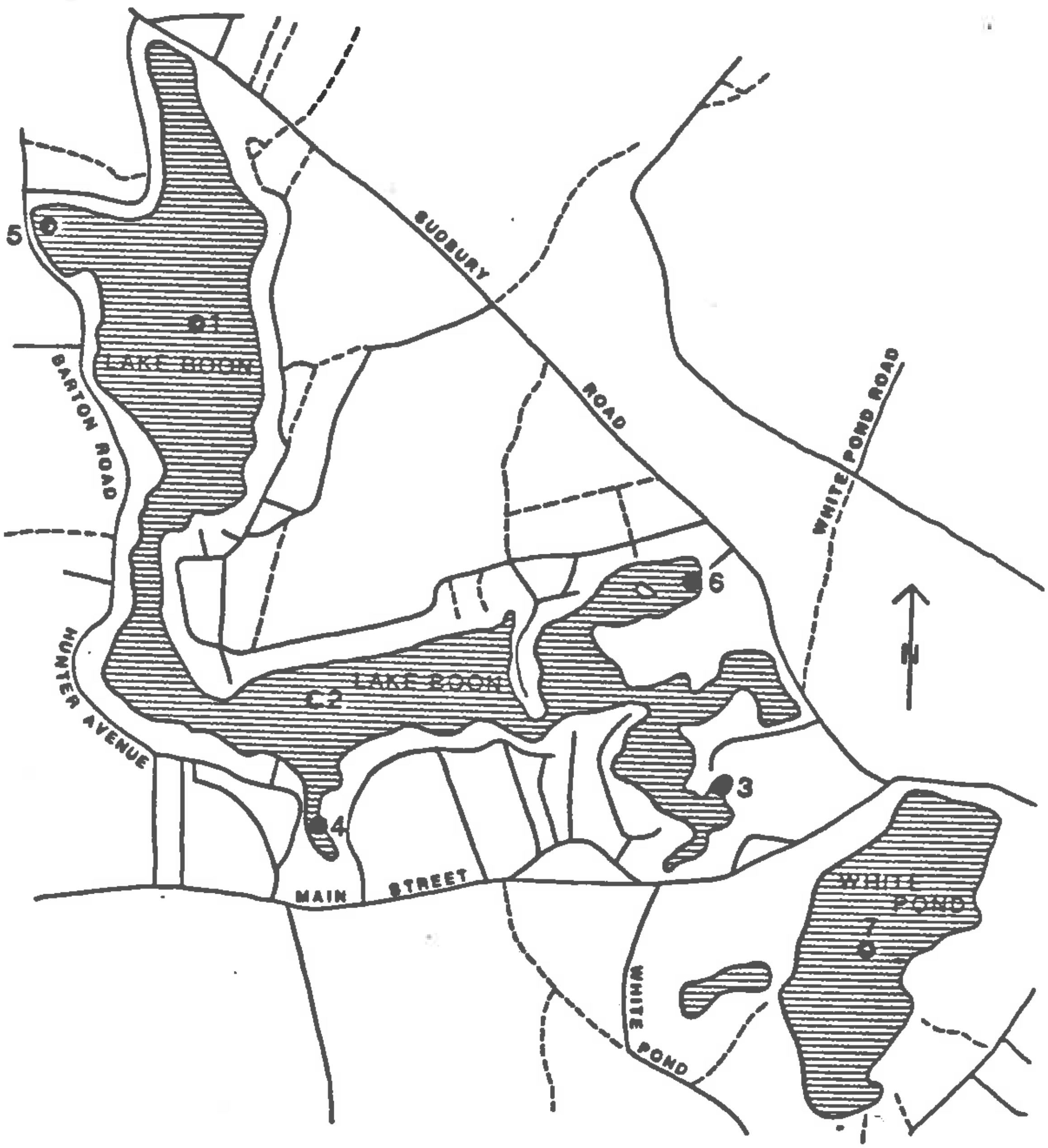
2.2.1 LAKE BOON WATER QUALITY

Water quality was monitored seasonally, over the course of a year during the present study to update and supplement the data collected during the more intensive DWPC (1981) study. Sampling stations (Figure 2-7) were at similar locations for both studies. The results of all analyses are included in Appendix A. A summary of DWPC data is listed in Table 2-5.

Sampling runs were conducted on 10/29/85, 1/28/86, 4/8/86, and 7/29/86. The lab reports may be found in Appendix A. The location and characteristics of each of these stations are described below, followed by a discussion of the data collected.

As shown on Figure 2-7, the in-lake stations in Lake Boon are #1 and #2. The in-lake station in White Pond is #7. White Pond seems to have no surficial inlets or outlets. The wetlands entering the lake were apparently cut off by man-made embankments. Station 1 is six meters deep, Station 2 is 3 meters deep, and Station 7 is ten meters deep. Stations 3, 4 and 6 are inlets, and Station 5 is the outlet. Station 3 is in the southernmost cove of the "stumps" basin of Lake Boon. It flows in from a vast swamp in the U.S. Military Reservation, under Sudbury Road, and then through a red maple swamp to the lake. A new driveway has cut off this inlet where it enters the lake. A culvert was installed to permit drainage, but it was filled in by sand eroding from the driveway. This may impede flow to some degree, although the inlet was dry only during the first sampling round.

Station 4 is located in the southern portion of the second basin. It flows from the Boston and Maine Railroad, under Parmenter Road, and under Main Street into the cove. The stream was generally 6 to 8 feet wide and 2 to 3 inches deep during sampling.



SCALE IN FEET 0 500 1000 2000	LAKE BOON DIAGNOSTIC FEASIBILITY STUDY TOWNS OF HUDSON AND STOW MASSACHUSETTS	CAMP DRESSER & McKEE INC. in association with IEP, INC.	FIGURE 2-7 SAMPLING STATIONS 1985-1986

Table 2-5 Lake Boon Water Quality Summary, DWPC, 1979-1980

Parameter	Station					
	1A	1C	2A	2C	4	5
pH						
range	8.6-6.4	7.2-6.6	7.4-6.3	7.6-6.9	6.9-5.6	8.2-6.3
mean	7.3	6.7	7.0	7.1	6.3	7.1
Conductivity						
range	104-85	106-78	102-87	106-92	86-60	100-88
mean	96.5	95.6	95.5	99.5	72	95.2
Chloride						
range	21-18	31-18	31-8.0	22-19	13-7.0	21-19
mean	20	24	20	20	10.4	19.6
Total Hardness						
range	17-14	20-14	17-14	17-15	15-11	17-13
mean	16	16.3	16	16	12.8	15
Total Alkalinity						
range	12-7	15-9	12-8	12-9	15-3	13-7
mean	10	11.6	10.2	10	6.8	10
Total Solids						
range	186-54	180-54	170-44	76-54	98-4	192-50
mean	86.6	85.3	88.6	67.5	62	92
Suspended Solids						
range	2.0-0	10-0	4.0-0	4.5-0	4.0-0	2.5-0
mean	1.0	3.2	1.8	1.6	1.9	1.1
Total Iron						
range	0.10-0.00	0.25-0.00	0.69-0.06	0.35-0.04	0.29-0.05	0.12-0.00
mean	0.06	0.08	0.19	0.17	0.66	0.06
Total Manganese						
range	0.04-0.00	0.49-0.01	0.06-0.00	0.12-0.00	0.24-0.05	0.04-0.00
mean	0.01	0.2	0.03	0.05	0.11	0.02

Table 2-5 Lake Boon (continued)

Parameter	Station					
	1A	1C	2A	2C	4	5
Total Phosphorus						
range	0.10-0.03	0.09-0.00	0.15-0.03	0.07-0.04	0.11-0.02	0.15-0.01
mean	0.06	0.06	0.06	0.05	0.06	0.06
Total Kjeldahl						
range	0.88-0.65	1.3-0.59	0.80-0.48	0.81-0.43	0.74-0.29	0.91-0.37
mean	0.77	0.82	0.64	0.60	0.52	0.58
Nitrate N						
range	0.2-0.0	0.1-0.0	0.1-0.0	0.1-0.00	0.5-0.2	0.6-0.0
mean	0.04	0.06	0.06	0.05	0.38	0.15
Ammonia N						
range	0.12-0.01	0.13-0.00	0.12-0.00	0.20-0.01	0.03-0.00	0.14-0.06
mean	0.06	0.05	0.04	0.12	0.01	0.05
Organic N						
range	0.87-0.53	1.27-0.46	0.75-0.42	0.80-0.23	0.73-0.23	0.84-0.29
mean	0.71	0.76	0.59	0.49	0.51	0.50
Total Coliform						
range	90-<5	-	1600-<5	-	3000-220	740-25
mean	23.3		273.3		985	97.2
Fecal Coliform						
range	<5	-	900-<5	-	880-<5	30-<5
mean	<5		155.0		223.7	8.3
Chlorophyll-A						
range	7.92-1.22	-	8.30-2.08	-	-	-
mean	4.68		4.85			

Table 2-5 Lake Boon (continued)

Parameter	Station					
Secchi disk Transparency						
range	3.4-1.5	-	3.0-1.4	-	-	-
mean	2.6	-	2.0			

Note: All concentrations are mg/l except: pH (std. units), conductivity (umhos/cm), coliform (count per 100 ml), chlorophyll-a (mg/m^3), and Secchi disk (m).

Station 6 is located in the northern cove of the "stumps" basin. The stream comes from a vast swamp in the U.S. Military Reservation, under Sudbury Road, and into the lake. This inlet often had no apparent flow, but did have stagnant water which was rust colored. The muck at the mouth of this inlet was deep (> 1m).

Station 5 is the outlet of the lake, which flows directly into the Assabet River. The outlet structure contains several flash boards that could be useful in partially drawing down the lake.

An evaluation of the data is described below.

Dissolved Oxygen and Temperature

Wide seasonal variations in water temperature influence a variety of biological and chemical water quality parameters including dissolved oxygen. Vertical variation of water temperature is important because temperature influences water density.

During the summer months, increased solar radiation raises the water temperature, especially surface waters. The warmer, less dense layer of water overlays colder, denser waters. Density differences limit mixing of upper and lower layers. In the summer, when water is stratified into layers, low dissolved oxygen concentrations can result due to sediment oxygen demand and lack of oxygen mixing from surface waters.

Extended periods of low oxygen are undesirable biologically and chemically. Aquatic life, including fish require oxygen for life processes. Nutrients can be released from bottom sediments into the water column under low dissolved oxygen conditions, contributing to algae and clarity problems. Also, low dissolved oxygen concentrations can cause offensive odors from hydrogen sulfide production.

Dissolved oxygen measurements and temperature profiles performed at each sampling date for in-lake stations indicate that Lake Boon is well oxygenated during most of the year. Station 1 showed strong thermal stratification during summer months in both studies. At Station 1 at six meters depth, near anoxic (no oxygen) conditions occur during July and August. Station 2 is a much shallower basin (3 m) and strong thermal stratification does not occur. Hypolimnetic oxygen levels generally exceed the 5 mg/l standard guideline in the rest of the year in both studies. In October, overturn had already occurred. In November, DWPC found that mixing had occurrd. During the winter sampling dates the normal pattern of inverse stratification occurred with temperatures increasing with depth. Hypolimnetic oxygen concentrations in January were above the 5 mg/l guideline for Class B waters, implying that adequate oxygen was available for aquatic life during ice cover.

Nutrient Data

Phosphorus and nitrogen are essential elements for growth of algae and plants. Whichever of these is in lesser supply compared to demand is the limiting nutrient, or the nutrient upon which the growth of algae/plants is dependent. In freshwater lakes, phosphorus is usually the limiting nutrient.

Nitrogen occurs in many different forms in water: organic nitrogen, ammonia, nitrate, and nitrite. Sources of nitrogen in a pond are atmospheric from precipitation, nitrogen fixation by algae and inputs from surface and groundwater drainage. Most nitrogen enters lake systems from terrestrial runoff. Nitrogen is a basic element vital to the ecological balance of water. However, large amounts of nitrogen can lead to the proliferation of organisms such as algae.

Kjeldahl-nitrogen is a measure of ammonia and organic nitrogen. Recent sewage contamination, and decay of natural organic matter are sources of Kjeldahl-nitrogen. Organic nitrogen pollution would be suggested by Kjeldahl results greater than 1 mg/l. Organic nitrogen concentrations can be derived by subtracting ammonia values from total Kjeldahl values. No organic nitrogen pollution is evident at Lake Boon from analyses from the present or historical studies.

Ammonia is present naturally in waters due to the biological degradation of organic matter. Larger amounts of ammonia usually do not stimulate excessive growth of aquatic life, but rather lead to toxicity. Fish are especially susceptible to ammonia toxicity, although tolerance varies among species. Concentrations of ammonia greater than 0.02 mg/l can be toxic for freshwater aquatic life (EPA, 1976). Toxicity is dependent on pH as well as other variables such as temperature and ionic strength. Both studies of Lake Boon indicate high ammonia levels, with no pattern of seasonality evident. Although these concentrations are elevated, no evidence of biological toxicity has been noticed with other indexes (algal counts). Ammonia levels of greater than 0.02 mg/l could be attributed to sewage inputs or anoxic conditions, but cannot be directly traced in Lake Boon.

Nitrate and nitrite are important components of the nitrogen cycle. Nitrite is rapidly converted to nitrate during decomposition. Nitrate is the end product of aerobic decomposition of nitrogenous matter and is readily available to plants in this form. Growing plants assimilate nitrate and convert it to protein. Common sources of nitrate are fertilizer, septic leachate, animal waste, automobile exhaust, landfill leachate, natural soil organic matter, and atmospheric fallout.

Large concentrations of nitrate in combination with available phosphorus can lead to nuisance algal blooms and dense macrophyte stands. For domestic water supply 10 mg/l nitrate nitrogen is the maximum recommended concentration for human health, (EPA, 1976). Concentrations of nitrates below 90 mg/l have no adverse effects on warm water fish (EPA, 1976). For eastern Massachusetts, 0.05 mg/l is considered the normal background level (MAPC, 1983). All data from both studies of Lake Boon suggest that nitrate levels are normal for a Massachusetts lake and should not be considered a nitrate toxicity problem.

Total phosphorus ranged from <0.01 to 0.30 mg/L, slightly higher than the ranges found by DWPC in unpolluted Massachusetts lakes, but within the ranges found by CDM in other developed lakes. The greatest concentrations of phosphorus were found at the eastern inlet (#3). Figure 2-8 shows in-lake phosphorus data collected during the two studies.

The most significant form of phosphorus found in lakes is phosphate. Phosphate is a major nutrient required for plant and algal nutrition, however, excessive concentrations can stimulate nuisance growth. Although phosphorus is not the sole cause of cultural eutrophication, it is a key element required by freshwater plants, and generally is present in the least amount relative to demand. An increase in phosphate allows for the utilization by plants of other nutrients already present. The phosphates can enter a lake system from several different sources including: sewage, industrial wastes, detergents, fertilizers, and natural sources (rocks, soil and rain).

As a general guideline for Massachusetts lakes, phosphorus concentrations of greater than 0.025 mg/l can contribute to nuisance aquatic growth (EPA, 1976). Phosphorus analyses are below problem concentrations, however, DWPC data indicate average concentrations near problem levels (Figure 2-7). Whereas much variability is shown in phosphorus concentrations, no seasonal patterns are evident from these data. Inlet stations in FIGURE 2-8 both studies do not indicate that large concentrations of phosphorus are entering the lake system from the tributaries.

In-lake phosphorus concentrations measured during the present study were largely <.01 mg/l, within the range indicating oligotrophic conditions (Wetzel, 1983). However, during the DWPC (1981) study,

Figure 2-8A. Lake Boon Phosphorus (mg/l)
1979-1980

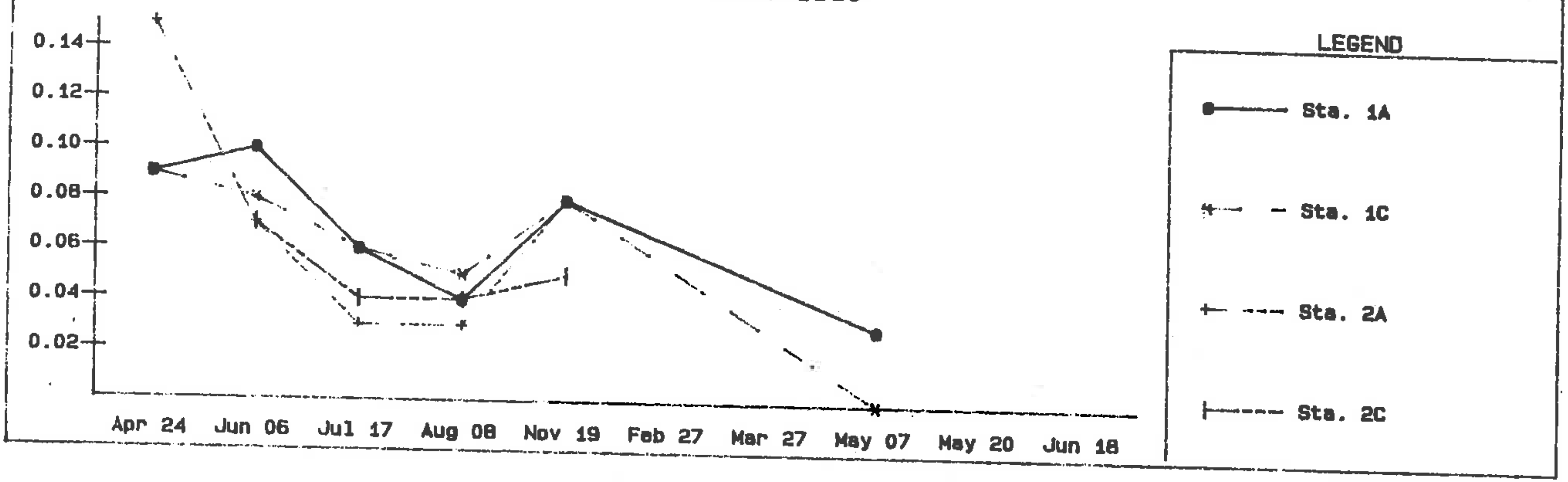
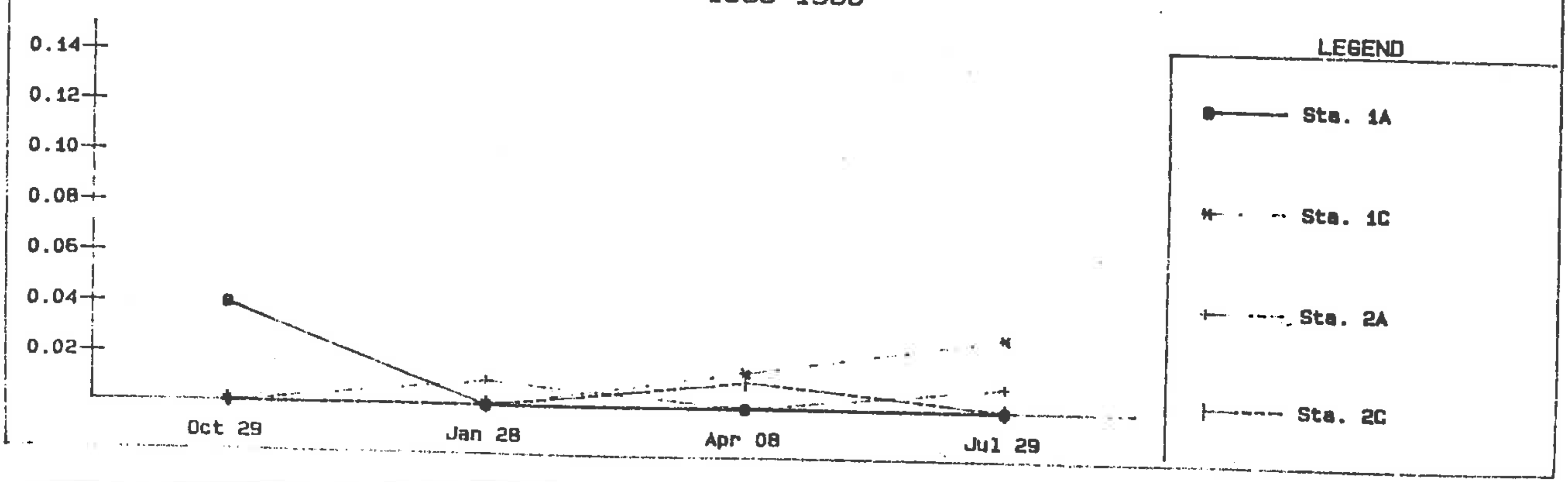


Figure 2-8B. Lake Boon Phosphorus (mg/l)
1985-1986



concentrations of phosphorus averaged 0.06 mg/l, indicative of mesotrophic to eutrophic conditions (Wetzel, 1983). Based on only four sampling rounds, there are insufficient data to conclude that Lake Boon has changed significantly in the five years between the two studies. It is more likely that the four sampling rounds made during the present study are not representative of the in-lake conditions over the whole year and/or meteorologic variability caused the year of study to produce atypical water chemistry (Section 2.3.2).

Iron

Iron is a trace element required by plants and animals to sustain life processes. Algal and plant growth can be limited by insufficient quantities of iron especially under highly alkaline conditions. Iron plays a vital part in oxygen transport in all vertebrates and some invertebrate animals. Some forms of iron precipitate and can be detrimental to fish and other aquatic life when suspended in water. Flocculants can settle on stream or lake bottoms destroying bottom dwelling invertebrates, plants or fish eggs. Flocs can also consolidate to form pavement-like materials.

Sources of iron pollution include industrial wastewaters, mine drainage waters and iron rich groundwaters. Iron concentrations greater than 3.0 mg/l for domestic and 1.0 mg/l for freshwater life are considered high (EPA, 1976). All iron concentrations in both studies are low enough to be of no danger to all forms of aquatic life. Levels of iron greater than 0.5 mg/l are considered high for Massachusetts lakes.

Iron concentrations ranged from <0.02 to 7.2 mg/L, with the highest levels found at stations #3 and #6, the eastern and northern inlets respectively. There was some difference between the concentrations found at the bottom and surface of stations #1 and #2, the in-lake stations, which during the same sampling runs showed some oxygen

which would remain in solution are included in this measurement. All aquatic life must tolerate a range of dissolved solids concentrations in order to survive under natural conditions, but cannot tolerate drastic changes in concentrations. Excessive dissolved solids are objectional in drinking water supplies due to physiological effects and corrosion and encrustation of metallic surfaces.

Dissolved solids concentrations ranged from 25 to 187 mg/L, well within the 15,000 mg/L limit reported by EPA as unsuitable for most freshwater fish. They are also much lower than the EPA's drinking water standard of 250 mg/l (EPA, 1976), and are acceptable ranges without extreme variances for aquatic life in Massachusetts lakes.

The highest concentrations for both suspended and dissolved solids were found in samples collected on July 29, 1986. Turbidity concentrations ranged from <2 (the detection limit) to 32 NTU. Levels were highest at station #6, the northern inlet, and station #3, the eastern inlet. Lowest turbidities were found at station 7, the in-lake White Pond station. In contrast to total and dissolved solids concentrations, the highest turbidities were found during the January sampling run.

Alkalinity and pH

The buffering capacity of water is determined by the alkalinity and reflects the stability of the pond's pH level. The pH and buffering capacity of a body of water have direct effects on aquatic organisms and indirect effects on the toxicity and solubility of other compounds such as metals. A lake with high alkalinity resists changes in pH. Often the alkalinity of a lake is influenced to a large degree by watershed characteristics such as depth of soils and bedrock type.

The Division of Water Pollution Control's 1981 study of Lake Boon water quality found surface alkalinity for Station 1 averaged 10 mg/l and surface Station 2 averaged 10.2 mg/l. Average alkalinities of 9.7 mg/l and 8.6 mg/l were found during this study at Station 1A and Station 2A. A general guideline of alkalinity values considers 20 mg/l to indicate a well buffered lake (EPA, 1976).

Considering inlet stations, alkalinity levels ranged from <1 to 16 mg/L in Lake Boon, below the 20 mg/L (minimum) level criteria used by EPA for aquatic life. This indicates relatively low buffering capacity for the lake and incoming surface streams. In particular, the eastern inlet station (#3), and to a lesser degree the southern inlet station (#4), had very low levels of alkalinity.

The pH value is determined by the concentrations of acids and bases dissolved in water. pH is the measure of the hydrogen ion concentration of a solution on an inverse logarithmic scale ranging from 0-14. A pH of 7 is neutral; less than seven is acidic whereas greater than 7 is alkaline. Most lakes have pH values between 6 and 9. The Division of Water Pollution Control's 1981 study found average pH values for Station 1A, Station 2A, inlet and outlet stations to be 7.3, 7.0, 6.3, and 7.1, respectively. Similar pH concentrations were found during this study. Although alkalinity values indicate low buffering capacity, measurements of pH have fluctuated within the expected natural range, implying that acidification is not currently a problem at Lake Boon. The one pH measurement of 5.7 at Station 2 (Table A1) is by itself insufficient to indicate a pending problem. At these low alkalinity levels, however, LakeBoon is considered susceptible to changes in pH over time.

Chloride and Conductivity

Chloride is one of the major anions in water and sewage. Concentrations of chloride are influential in osmotic balances and ion exchange for aquatic life. Pollution sources, especially road salting, can modify natural concentrations and cause biological disruptions for aquatic organisms.

In urbanized areas, roads are often salted heavily during winter months to keep them free of ice. Chloride levels in Lake Boon indicate that road salting is not presently a pollution problem in this watershed. Concentrations of less than 20 mg/l are low compared to other Massachusetts lakes.

Conductivity is a measure of the ability of water to carry an electric current and is related directly to electrolytes in the water. Dissolved solids are proportional to the conductivity levels. Pollution sources such as road salting and septic systems can increase conductivity levels. Both studies found low conductivity levels compared to other Massachusetts lakes. Lake Boon's low conductivity levels indicate soft water with low levels of dissolved minerals in the water column.

Bacteria

The coliform bacteria group is used as an indicator of potential wastewater contamination. Fecal coliform originate in the intestines of warm blooded animals. Total coliforms include fecal plus non-fecal coliforms which originate in soil and decaying vegetation.

Fecal bacterial counts should not exceed 200/100 ml (EPA, 1976). The more fecal coliforms present, the greater degree of health risks associated with swimming, drinking or shellfishing. The DWPC analyses showed problem levels at Station 2A and the inlet. Elevated fecal coliform levels occurred seasonally at Station 2A with highest counts in July. The inlet station showed high fecal coliform counts throughout the season, however, with a peak in July.

The present study found high fecal counts only during July. On this date the counts were high in all stations whereas previous sampling had not indicated any wide spread bacterial contamination. It is possible that the samples on this date were contaminated during handling, or that the high counts may have been due to storm water runoff. July 29 was the third in four consecutive rainy days. Total coliform analyses from both studies reflect fecal coliform levels. Peaks in total coliform can be attributed to high fecal coliform plus soil bacteria from rain runoff.

Transparency and Chlorophyll-a

Measurements of biological, chemical, and physical parameters describe the environment that influences the trophic condition of Lake Boon. The Secchi disk gives a physical measurement of the depth to which light penetrates the water column. Several factors affect Secchi disk readings including water color, dissolved and particulate matter, phytoplankton (algae) and zooplankton densities, water surface and weather conditions.

Chlorophyll a is a photosynthetic pigment found in all plants. Phytoplankton biomass and productivity can be estimated with this biological assessment. The relationship between chlorophyll a and algal populations and densities aids in understanding nutrient loading in lakes. The water quality of Lake Boon can be best described by comparing Secchi disk, chlorophyll a, algae, turbidity, and dissolved and suspended solids analyses.

Good to fair clarity is implied by Secchi Disk reading at Stations 1 and 2 in both studies. Readings are greater than the state minimum of 4 feet (1.2 m) required for swimming areas (Commonwealth of Massachusetts, 1969) except at Station 2 in the summer, when readings approached the four foot minimum (Figure 2-8). The lowest Secchi disk readings coincide with the highest chlorophyll a results suggesting that reduced transparency is due to increased algal densities.

Chlorophyll a results varied seasonally. In the summer, the peak growth season of algae, chlorophyll a results were high reflecting the high counts of blue green algae. When algal populations were increasing (spring) and decreasing (fall), chlorophyll a results were compared with these environmental trends. The winter brings ice cover to Lake Boon and reduces light to algal populations. Chlorophyll a results reflect these changes. Chlorophyll a peaks of 16 mg/m^3 measured during the present study indicate mesotrophic lake conditions (Wetzel, 1983). The peak concentrations measured during the DWPC (1981) study of 8 mg/m3 are indicative of borderline oligotrophic to mesotrophic conditions. The fact that chlorophyll a peaks measured in 1979-1980 were about half of those measured in 1985-1986 is inconsistent with the lower phosphate concentrations and lower algal densities measured in 1985-1986.

2.2.2 WHITE POND WATER QUALITY

White Pond is well oxygenated throughout the year. Hypolimnetic oxygen concentrations generally exceed 5 mg/l, which is a guideline used to indicate that adequate oxygen is available to support aquatic life and maintain the aesthetic quality of the water (EPA, 1976). Only in January does the dissolved oxygen level approach anoxic conditions. A weak thermal stratification is evident in July, with decreasing temperature with depth. Aquatic life processes have an adequate supply of dissolved oxygen year-round to meet their requirements.

A bathymetric map of the pond was not generated. Only a surface sample was collected at this station and comprehensive temperature/dissolved oxygen profiles were not obtained.

In July excellent water clarity (6m) was noted. Tom Sheridan of Maynard Public Works reported infrequent algae problems. The last incidence of elevated algal populations occurred in 1983 and was treated with copper sulfate. Microscopic examinations indicate that during most of the year algal densities had not reached nuisance proportions.

Species composition can have an influence on water quality. In April algal counts reach a peak due to a bloom of Dinobryon. This armored flagellate can cause a fishy odor and can clog filters or screens (Palmer, 1977). Low densities and the least diversity occurred in January due to low solar radiation and ice cover.

Since White Pond is a public water supply, water quality is particularly important to public health and aesthetic qualities. Maynard Public Works is responsible for maintaining good quality drinking water to Maynard residents. Occasionally turbidity has been a problem after rainstorms, according to Tom Sheridan of Maynard Public Works. However, recent water quality has been high and no in-lake treatments have been conducted since 1983. Treatment in the distribution system consists only of disinfection.

2.2.3 PHYTOPLANKTON

Phytoplankton are non-vascular, free-floating, photosynthetic plants. These microscopic algae incorporate sunlight and nutrients to form plant matter, and exist as single cells, colonies or filaments. Several factors affect distribution and abundance including concentrations of nitrogen and phosphorus, penetration and intensity of light, and turbidity and suspended solids. Figure 2-9 shows transparency of the lake over the study.

Phytoplankton biomass and species composition are the best indications of water quality and trophic conditions (Vollenweider and Kerekas, 1980). Both studies of biological productivity of Lake Boon exhibit similar seasonal trends (Figure 2-10). Elevations in algal cell counts and chlorophyll a occur in July and August and the widest diversity of genera exists simultaneously.

Green algae is prevalent especially Spaerocystis and Chlamydomonas and other pigmented algae including Chrysococcus. A bloom of the blue-green algae Anabaena also occurred. This bloom corresponded with

Figure 2-9A. Lake Boon Transparency (m)
1979-1980

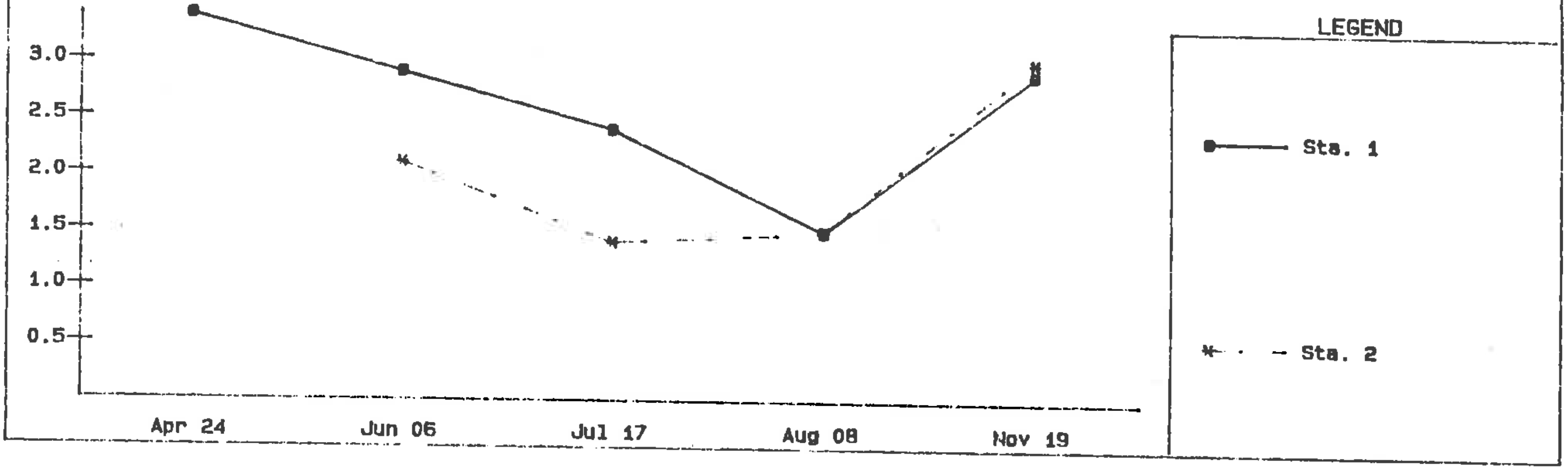


Figure 2-9B. Lake Boon Transparency (m)
1985-1986

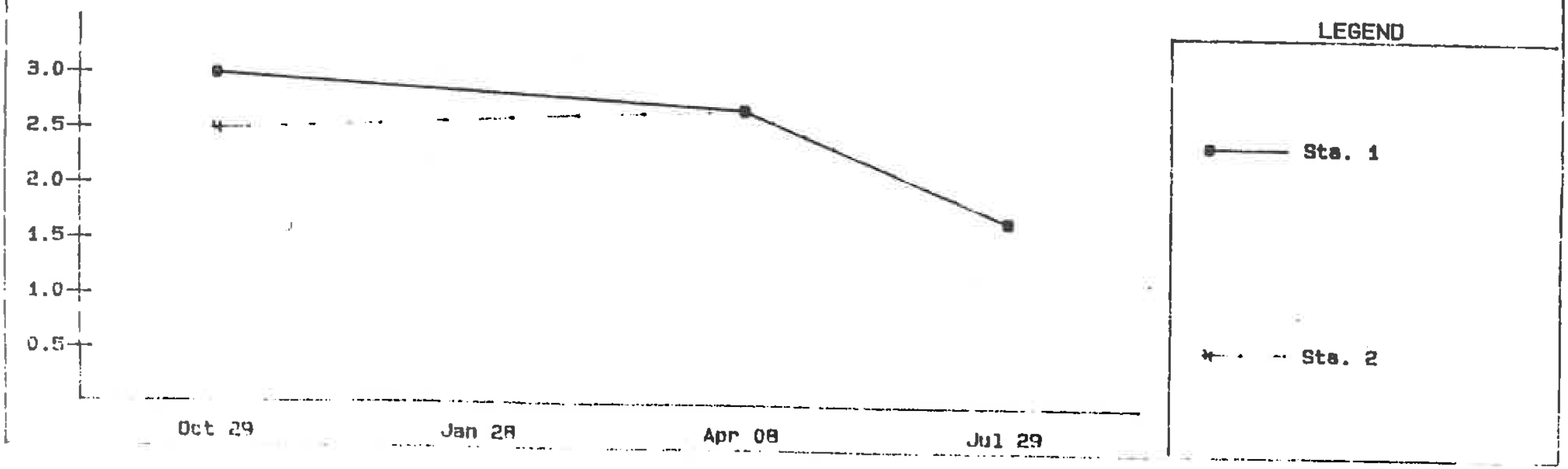


Figure 2-10A. Lake Boon Phytoplankton (cells/ml)
1979-1980

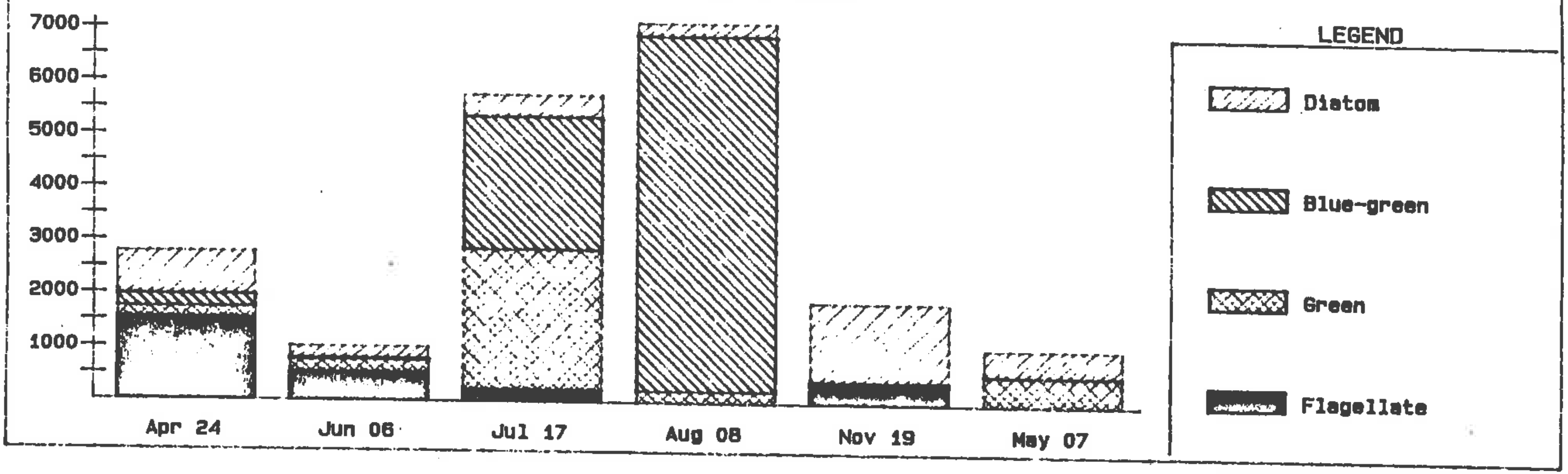
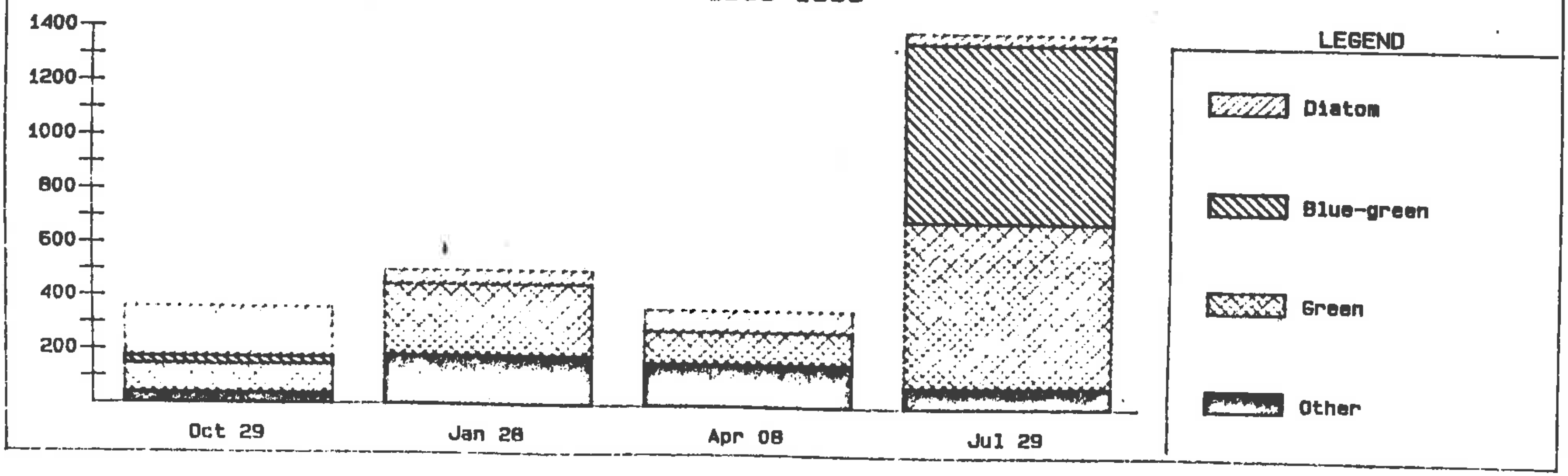


Figure 2-10B. Lake Boon Phytoplankton (cells/ml)
1985-1986



the highest chlorophyll-a and lowest transparency measured during the study. However, no elevation of nutrient concentrations was noted on this date. Blue-green algae can fix nitrogen and are often responsible for objectional odors and tastes. The DWPC data show similar community compositon but some different genera.

In the fall a depression in algal densities, diversities and chlorophyll a occurs which relates to the mixing layers of water. Diatom populations are dominant in the fall, a typical pattern observed in many lakes. Winter brings the least photosynthetic activity of the year due to ice cover and decreased solar radiation. A narrow range of diversity occurs with green algae the most common with frequent diatoms. The spring months bring increasing solar radiation and water temperature which are more favorable conditions for algal populations. Densities and diversity increase with green algae still most dominant.

The dominant algae noted at Lake Boon by the DWPC in 1979 and 1980 were the blue-green algae, Oscillatoria and Choroococcus. Several other phytoplankton also occurred in large numbers including the diatom Tabellaria, a flagellete Uroglenopsis and an unidentified flagellete. These dominant algae did not occur regularly throughout the year, but rather usually as "blooms" or population explosions. In 1985 and 1986, IEP found the dominant phytoplankton genera to be a blue-green alga, Anabaena, and two green algae, Spaerocystis and Gloeocystis. The golden-brown algae Dinobryon also occurred frequently through the year of study. The phytoplankton numbers measured in 1985-1986 were far lower than those measured in 1979-1980. Phytoplankton are useful indicators of lake fertility or trophic condition. Certain genera of algae are indicative of nutrient concentrations in the water body. In both the DWPC and IEP studies, the dominant algae indicate eutrophic conditions (Wetzel, 1983). Blue-green and green algae are commonly found in nutrient rich waters.

2.2.4 AQUATIC VEGETATION

A survey of the aquatic plants growing in Lake Boon was made on August 14, 1986. Figure 2-11 shows the distribution of the plants in the lake; a complete list of plants is included in Table 2-6, along with an estimate of relative abundance of each by basin. The percent coverage of aquatic plants is shown on Figure 2-11A.

In general, the plant species and distribution noted during the present study are similar to that documented by DWPC in 1979. Cabomba is the dominant nuisance species present. This plant is not native to New England, but it has been introduced to many ponds in the region and often grows in dense underwater patches that detract from recreational and wildlife values.

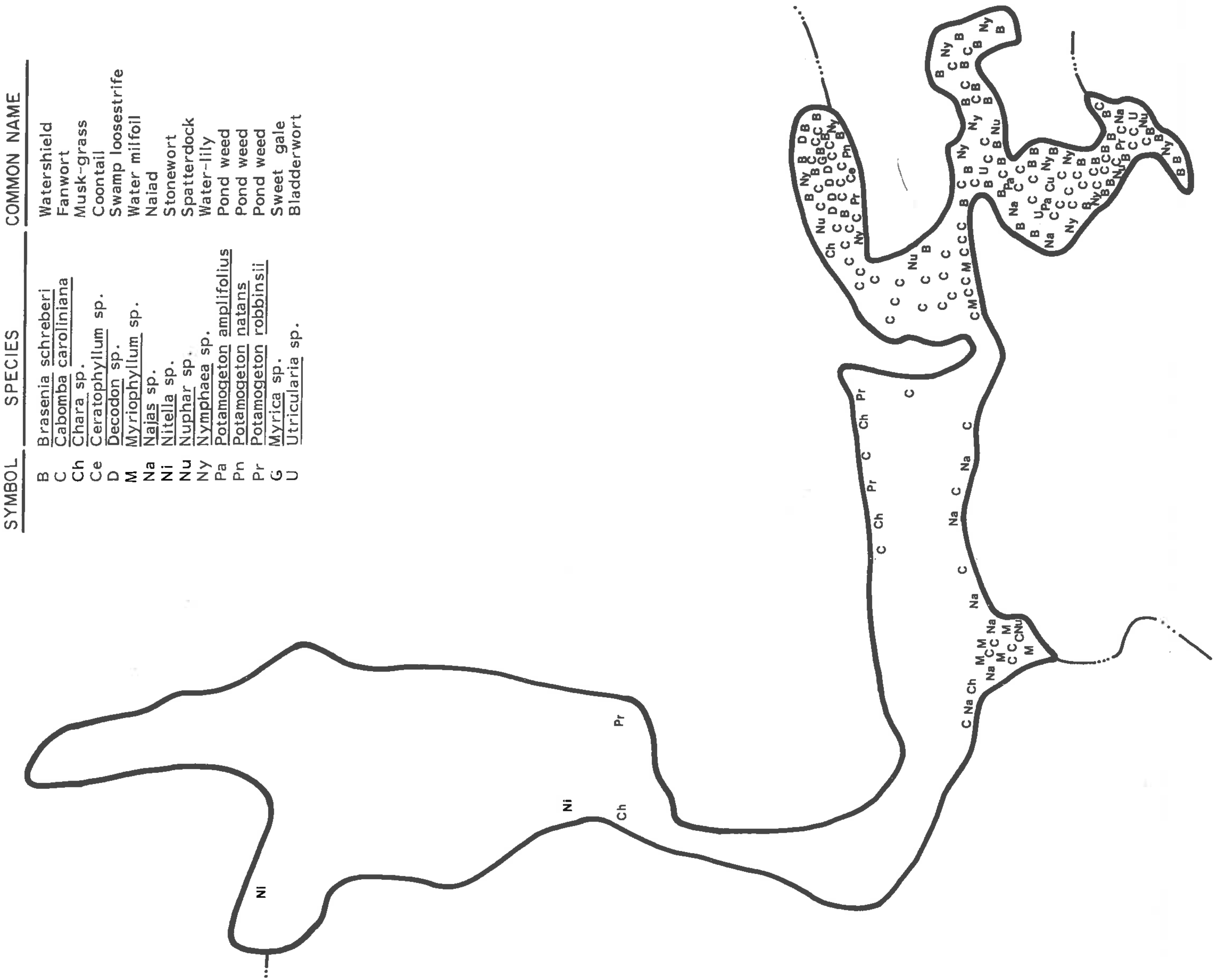
Cabomba is dominant in the third and fourth basins of the lake, whereas it has not been found in the first basin. Growth in the second basin appears to be highly variable from year to year. This year, Cabomba is fairly sparse in the second basin except in the cove near Station 4 (Figure 2-11). Growth was more evenly spread throughout the basin in 1979, and was noted in the central parts of the basin during the water sampling round in October, 1985.

A second potential nuisance species found in Lake Boon is water milfoil Myriophyllum heterophyllum. The only dense patch found in 1986 was in the cove near the inlet at Station 4. Other than this area, water milfoil does not seem to have expanded its coverage since the 1979 survey.

Aquatic plant growth in the third and fourth basins is dense, consisting of Cabomba along with native floating-leaved species such as yellow and white waterlily and watershield. These species commonly form dense patches in shallow ponds in New England, especially in areas of flooded wetlands, which is the case with this portion of Lake Boon. Unlike some of the introduced species, the

KEY

SYMBOL	SPECIES	COMMON NAME
B	*Brasenia schreberi*	Watershield
C	*Cabomba caroliniana*	Fanwort
Ch	*Chara* sp.	Musk-grass
Ce	*Ceratophyllum* sp.	Coontail
D	*Decodon* sp.	Swamp loosestrife
M	*Myriophyllum* sp.	Water milfoil
Na	*Najas* sp.	Naiad
Ni	*Nitella* sp.	Stonewort
Nu	*Nuphar* sp.	Spatterdock
Ny	*Nymphaea* sp.	Water-lily
Pa	*Potamogeton amplifolius*	Pond weed
Pn	*Potamogeton natans*	Pond weed
Pr	*Potamogeton robbinsii*	Pond weed
G	*Myrica* sp.	Sweet gale
U	*Utricularia* sp.	Bladderwort



CAMP DRESSER & McKEE INC.
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IEP, INC.

LAKE BOON

Diagnostic Feasibility Study

TOWNS OF HUDSON AND STOW MASSACHUSETTS

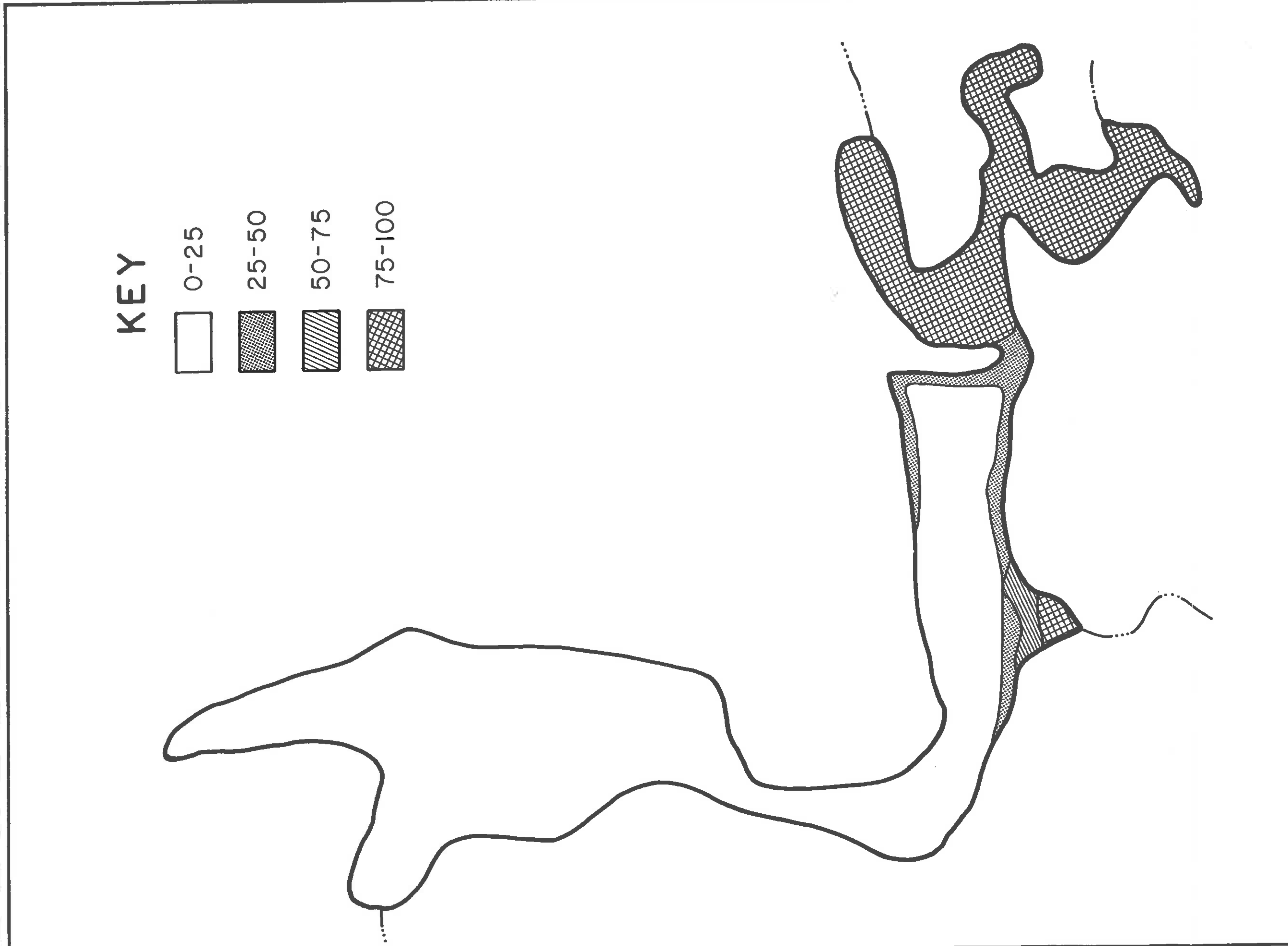
NORTH

SCALE IN FEET

0 620 1240

FIGURE 2-11

AQUATIC PLANT DISTRIBUTION
August 14,1986



CAMP DRESSER & McKEE INC. in association with IEP, INC.

LAKE BOON

Diagnostic Feasibility Study

TOWNS OF HUDSON AND STOW MASSACHUSETTS

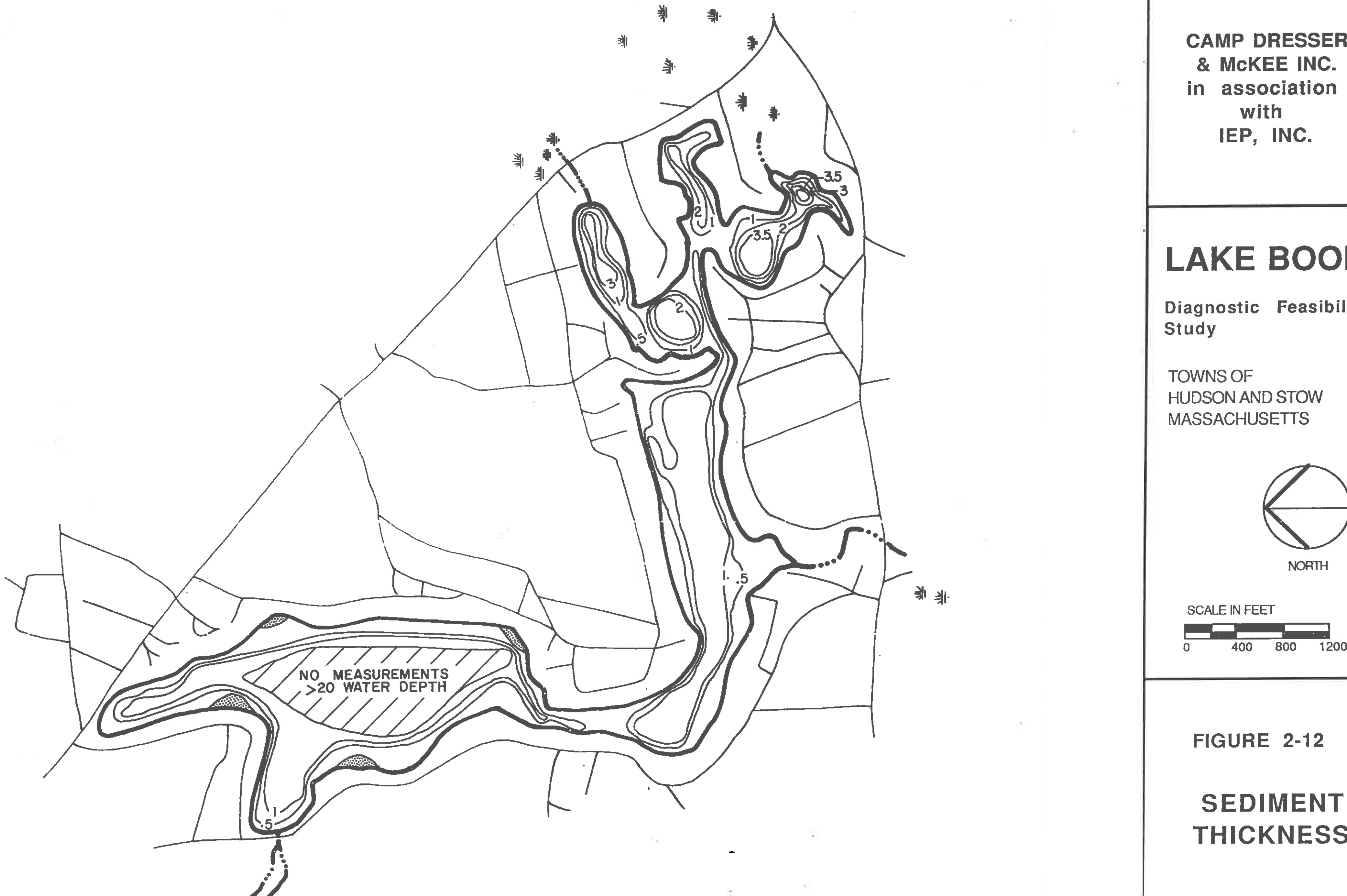
NORTH

SCALE IN FEET

0 310 620 930

FIGURE 2-11A

AQUATIC VEGETATION PERCENT COVERAGE



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LAKE BOON

Diagnostic Feasibility Study

TOWNS OF
HUDSON AND STOW
MASSACHUSETTS

FIGURE 2-12

SEDIMENT THICKNESS

wildlife value of these species is fairly high as they are important sources of food for waterfowl and cover for fish (Martin et al, 1951).

Macrophyte growth in the first basin is sparse, dominated by Nitella, a macroscopic form of algae. At present, growth in this basin does not appear to present a problem for recreation as it is sparse and low, confined to within a foot or so of the pond bottom.

2.2.5 SEDIMENT SAMPLING

Sediment thickness measurements were made at all test holes where measured water depth was twenty feet or less. Most shoreline areas of the first and second basins showed little or no accumulated sediment, with an exposed clean sand and gravel substrate (Figure 2-12). The eastern basins contain up to 12 feet (3.5 meters) or more thickness of organic peat. These deposits are characteristic of wetland soils which most likely formed before the region was flooded by raising the dam in the 1800's. Little or no evidence of recent sedimentation was noted.

On April 8, 1986, two sediment samples were collected with an Eckmann dredge. One sample was collected at each of the two in-lake stations and sent to the laboratory for analysis. The tests were chosen to characterize the sediment in terms of nutrient content, organic material, and heavy metal pollutants which would affect the potential for dredging or removal of sediment from Lake Boon.

Several indices were used to put the results from Lake Boon into perspective. The Clarke Number (CN) is a standard index (McGinn, 1981) used to evaluate concentrations of metals. This number represents the average concentration of an element in the earth's crust. Local variations within a factor of two or three can be expected at specific sites. Sediments generally contain concentrations less than the Clarke Number as they are composed of

Table 2-6 Lake Boon, Aquatic Macrophyte Survey

Genus/Species	Common Name	Occurrence by Basin 1	2	3 & 4
Brasenia schreberi	Watershield			D
Cabomba caroliniana	Fanwort		D	D
Chara sp.	Musk-grass	O	C	O
Ceratophyllum sp.	Coontail			O
Decodon sp.	Swamp Loosestrife			C
Myriophyllum sp.	Water Milfoil		D	O
Najas sp.	Naiad		D	O
Nitella sp.	Stonewort	D		
Nuphar sp.	Spatterdock		O	O
Nymphaea sp.	Water-lily			D
Potomogeton amplifolius	Pondweed			O
Potomogeton natans	Pondweed			O
Potomogeton robbinsii	Pondweed	O	O	O
Utricularia sp.	Bladderwort			C

D = Dominant C = Common O = Occasional both mineral and organic matter. On the other hand, concentrations in great excess of the Clarke Number can indicate pollution.

DWPC (1978) has developed criteria for sediment chemistry to be used in evaluating, and permitting proposed dredging projects. These criteria consider both physical (Class A, B and C) and metal pollutant (Class 1, 2, and 3) parameters. Finally, data from other lakes in Massachusetts surveyed by DWPC can be used to put these results into perspective.

Total volatile solids is a physical parameter which describes the portion of sediment composed of organic material, primarily decaying plant remains. DWPC classifies sediment with >10% volatile solids as high in organic material. Generally, wetland soils have >10% organic material, whereas upland soils have <10%. The Lake Boon samples would therefore be considered to be high in organic matter (Table 6).

Components of decaying organic material include phosphorus and nitrogen which are primary plant nutrients. Total phosphate in the Lake Boon samples is low compared to an average of 1073 mg/kg for sediment samples collected from Massachusetts lakes (DWPC, 1981a) whereas total nitrogen is above the average of 11,000 mg/kg. The nutrient content of this sediment becomes imporant when dissolved oxygen levels in bottom waters are low creating favorable conditions for nutrient release. At Lake Boon, there is potential for this process.

Oil and grease averaged 4840 mg/kg or 0.48%. This is considered low by the DWPC classification (<0.5% constitutes category A sediment) and does not indicate any problems at Lake Boon with this parameter.

The concentration of metals in the samples would place these sediments in Class 3, requiring strict controls on dredging and disposal of these sediments. Analyses for chromium, iron, manganese, and mercury all revealed low concentrations compared to DWPC standards and the Clarke Number (Table 2-7). Copper, nickel, vanadium, and zinc were detected at moderate levels. Elevated levels of arsenic, cadmium, and lead were noted.

Lead levels were comparable to those found by DWPC in Lake Boon in 1979 and, while elevated above the Clarke Number, are comparable to levels detected in other lakes in the Commonwealth (Table 2-7). As this appears to be a regional phenomenon, it may reflect fallout of lead from atmospheric pollution and runoff from street areas.

Arsenic concentrations were seven times higher in 1986 then in 1979 (DWPC, 1979). However, the only known potential source for this contamination is the chemical treatment of the lake in the 1960's which likely included sodium arsenate. Cadmium levels were 12 to 275 times higher in 1986 then in 1979. No new source of this contamination was identified in the watershed.

Metal concentrations quoted in this discussion represent total metal concentration in the sediment. These numbers do not reflect, and cannot be used to evaluate toxicity. A large portion of the metals contained in sediments are bound to the sediment particles, or insoluble forms. Therefore an EP-toxicity test would yield lower concentrations than a total metals test.

2.3 HYDROLOGIC AND NUTRIENT BUDGETS

2.3.1 HYDROLOGIC BUDGET

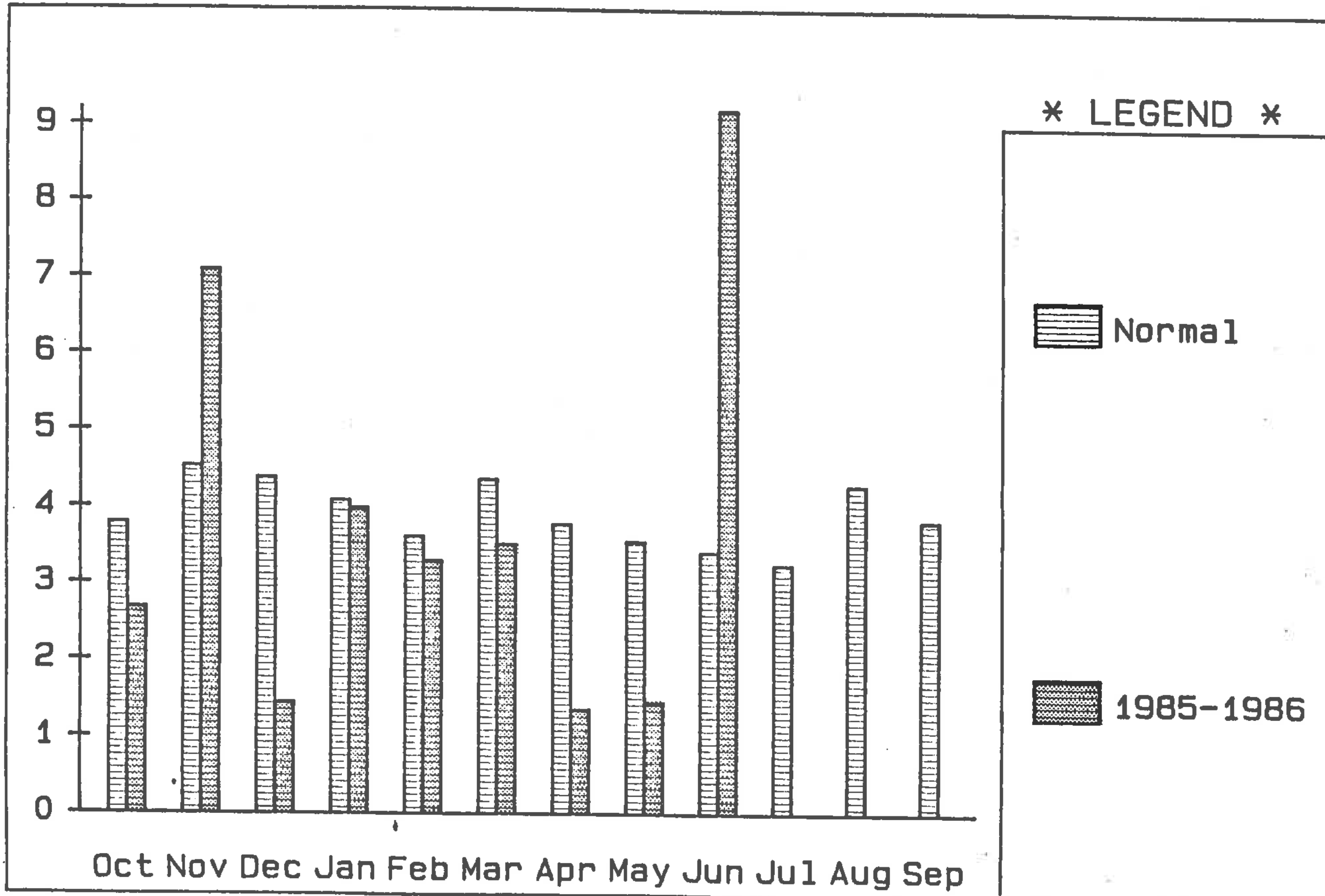
DWPC (1981) calculated an average annual hydrologic budget for Lake Boon based on local precipitation data, regional evaporation rates, and stream gaging on the Assabet River at Maynard (Table 2-8). Precipitation for the year is shown on Figure 2-13.

Table 2-7 Sediment Analyses, Lake Boon
(concentrations in mg/kg, dry weight, except where noted)

	Station 1	Station 2	DWPC Classification	Clarke Number	DWPC Average
Total Volatile Solids (%)	20.2	32.5	C		
Total Phosphate (mg/l)	309	492			1073
Total Kjeldahl-nitrogen (mg/l)	23,680	18,760			9792
Oil and Grease	4,200	5,480	A		
Arsenic	66	74	3		
Cadmium	550	49	3	0.1	3.4
Copper	115	110	2	55	191
Chromium	54	33	1	100	42
Iron	45,000	16,000		56,000	35,388
Manganese	440	710		950	854
Lead	390	410	3	12.5	287
Nickel	48	66	2		
Vanadium	130	<16	2		
Mercury	0.14	0.20	1		
Zinc	320	470	2	70	310

Table 2-8 Lake Boon, Hydrologic Budget (DWPC, 1981)

INPUTS	million gallons/year	million cubic meters/year
Runoff (mostly ground water)	802	3.03
Direct Precipitation	184	0.70
TOTAL	986	3.73
OUTPUTS		
Outflow	873	3.30
Evaporation (potential)	125	0.47
TOTAL	998	3.77



LAKE BOON DIAGNOSTIC FEASIBILITY STUDY TOWNS OF HUDSON AND STOW MASSACHUSETTS	CAMP DRESSER & McKEE INC. In association with IEP, INC.	FIGURE 2-13 PRECIPITATION (INCHES)

Although seepage meters were used to assess groundwater flow into the lake (DWPC, 1981), they did not provide sufficient data to allow an estimate of the percent of runoff as groundwater flow.

As groundwater monitoring was not part of the present study, we still do not have a good estimate of this number. However, the geology of the watershed and field observations indicate that the vast majority of runoff to Lake Boon is groundwater; stream flow is limited.

The average annual outflow from the lake was found to be 3.7 cubic feet per second (cfs) (DWPC, 1981). Based on this flow, and the volume of the lake, the retention time is 0.57 years and the flushing rate is 1.8 times per year. This means, if Lake Boon were empty, on the average it would take 220 days to fill. This low flushing rate reflects the large size of the lake in relation to its watershed.

This flushing rate would be even lower if the White Pond area were not contributory to the Lake Boon watershed. About 190-195 million gallons of water are pumped out of White Pond per year to augment Maynard's water supply (Sheridan, personal communication.). Due to pumping and meteorologic variations the water level of White Pond ranges from 183.5 feet to about 190 feet above sea level, whereas Lake Boon's water surface is about 186 feet above sea level.

Given this pumping rate, the similar elevations of the two water bodies and the lack of an outlet on White Pond, it is doubtful that seepage from White Pond enters Lake Boon. In fact, it is likely that groundwater flows toward White Pond along its entire perimeter. In this case, the Lake Boon watershed is 583 hectares (1440 acres). Adjusting the hydrologic budget yields an average annual outflow of 3.2 cfs, and a flushing rate of 1.4 times per year. In any case, it is clear that the flushing rate for Lake Boon is very low and this will be a critical factor in planning lake management.

Precipitation data from the year of the DWPC study and long-term (30) year) normals (NOAA, 1982) are shown in Figure 2-13. Review of these records shows that over the long term, precipitation is spaced evenly °through the year, but on any given year, precipitation may be very unevenly distributed. Based on the meteorologic conditions of our year of study, a hydrologic budget was calculated (Table 2-9).

Total runoff from the watershed was calculated by comparing drainage areas with the Nashoba Brook watershed in Acton, for which discharge data were available. The Nashoba Brook watershed was chosen because it is most like the Lake Boon watershed in terms of geology, size, and land-use of the areas gauged by U.S.G.S. (Wandle and Fontaine, 1984). Groundwater inputs to Lake Boon were calculated based on the geology of the watershed (Figure 2-4), and assuming a recharge rate of 6 inches per year for till areas, and 15 inches per year for sand and gravel areas. It was also assumed that all groundwater discharge from the watershed entered the lake; in other words, no groundwater passes beneath the lake. In actuality, some unknown amount of groundwater probably does not enter the lake, and this estimate should be considered to be on the high side.

In order to present the groundwater budget on a monthly basis it was assumed that groundwater inputs were evenly spaced through the year. This is probably a fair assumption as groundwater flows are somewhat buffered from short-term meteorologic fluctuations. The final hydrologic input, direct precipitation, was calculated by multiplying the lake area by the depth of precipitation each month.

Hydrologic outputs from the lake include flow through the outlet structure, evaporation and seepage. Seepage was assumed to occur only in the vicinity of the outlet, and based on that limited area would be orders of magnitude less than the other budget components. Evaporation rates were estimated using mean monthly temperature data available for Bedford (NOAA, 1985, 1986), and the Thornthwaite method (Dunne and Leopold, 1978). Even though this method is meant to estimate

Table 2-9 Lake Boon, Year of Study Hydrologic Budget (millions of gallons)

	Surface Runoff	Ground-water	Direct Precipitation	Total In	Evaporation	Outflow	Total Out
1985							
October	3.4	37.7	11.9	53.0	7.9	45.1	53.0
November	82.3	37.7	31.4	151.4	4.1	137.3	141.4
December	31.4	37.7	6.4	75.5	0.0	75.5	75.5
1986							
January	59.3	37.7	17.7	114.7	0.0	114.7	114.7
February	37.2	37.7	14.6	89.5	0.0	89.5	89.5
March	118.0	37.7	15.6	171.3	2.3	169.0	171.3
April	15.5	37.7	6.0	67.3	7.1	60.2	67.3
May	0.0	37.7	6.4	38.3	12.1	26.2	38.3
June	0.0	37.7	40.8	104.8	14.8	90.0	104.8
July	0.0	37.7	20.8	65.5	18.4	47.1	65.5
August	0.0	37.7	10.4	40.9	16.8	24.1	40.9
September	0.0	37.7	3.9	13.2	13.2	0.0	13.2
TOTAL	347.1	452.4	185.9	985.4	96.7	888.7	985.4

evapotranspiration on land areas, it yields total evaporation rates similar to published regional averages for lakes. Evaporation in central Massachusetts lakes averages 27 inches per year (Dunne and Leopold, 1978).

Outflow was calculated as the difference between total inflow and evaporation, assuming that there were no changes in the water level in Lake Boon during the year of study. Outflow was also measured during the water quality sampling rounds. Measured outflows were 2.25 cfs in October, 3.10 cfs for April, and 2.35 cfs for July. Whereas these values are in poor agreement with the estimated values, instantaneous stream flow can be expected to vary greatly from the monthly mean.

Whereas 90% of the hydrologic outputs were outflow from the culvert at Barton Street, inflows were more evenly distributed between groundwater (46%), surface runoff (35%), and direct precipitation (19%). Comparison of the total inflow with the lake volume yielded a flushing rate of 1.8 times per year, or a retention time of 0.57 years (207 days). This flushing rate is somewhat higher than the rate calculated for the time period during the DWPC (1981) study. This may in part explain the lower nutrient concentrations in-lake in 1985-1986 compared to 1979-1980. Also, there was little snow accumulation and low spring time precipitation during the present study, limiting the high spring runoff period.

2.3.2 NUTRIENT BUDGET

An average annual nutrient budget for Lake Boon was calculated using loading coefficients and the land use of Lake Boon's watershed. This method assumes that the phosphorus export to the lake can be predicted by the type of land use in the watershed (EPA, 1980a). Based on land use in the Lake Boon watershed, 219 kg/yr of phosphorus are introduced to the lake (Table 2-10). Due to year to year variability because of meteorologic conditions and error in this type of method, a low and

Table 2-10 Lake Boon, Nutrient Budget

A) Non-Point Source Loading

Land Use	-Phosphorus Loading (kg/yr)- Low	Most Likely	High	% Watershed	% Loading
Residential	42	51	71	18	23
Industrial	21	53	60	3	24
Forest/Wetlands	37	73	110	65	34
Open Land	3	9	16	1	4
Atmospheric*	20	33	79	13	15
TOTAL	123	219	336	100%	100%

B) Septic System Loading

No inputs	0	kg/yr
Most likely**	375	kg/yr
Worst case	1500	kg/yr

C) Internal Release 6.5 kg/yr

*accounts for direct precipitation onto waterbodies
**assumes 75% attenuation of phosphorus by soils

high estimate of the nutrient loading is shown along with the most likely value.

The above estimates account for non-point source loading to the lake, i.e. diffuse runoff through groundwater and stream flow. Potential point sources of phosphorus to Lake Boon include all of the septic systems within 100 m from the lake. Under ideal conditions, soils attentuate all of the phosphorus in septic effluent before it reaches the lake. However, with systems less than 100 m from the lake, poor soil conditions, and aging systems, it is likely that some nutrients do find their way to the lake. This was demonstrated through the septic survey and seepage meter data collected by DWPC (1981).

As a worst case, with no soil attenuation, 1.6 kg per year per person are exported from near-shore septic systems to the lake (EPA, 1980b). Using this number, along with the results of the resident's questionnaire distributed during the present study, it is estimated that a worst case loading from septic systems would be about 1,500 kg/yr (Table 2-11). A "most likely" estimate, assuming 75% efficiency of septic systems, yields 375 kg/yr delivered to the lake. This 75% efficiency is based on knowledge of the soils and septic system history in the Lake Boon area.

Internal recycling of phosphorus may also make this nutrient available for plant and algal growth. Release of phosphorus occurs under anoxic (no oxygen) conditions from decomposition of lake sediment. During summer stratification, near anoxic conditions occurred in the deeper water of Lake Boon (Table A19), and slightly elevated concentrations of phosphorus were noted (Table A11). About 6.5 kg of phosphorus were released, calculated by multiplying the volume of the hypolimnion (bottom layer of the lake) by the difference in concentration of phosphorus in the hypolimnion versus the epilimnion (top layer of the lake). This source of phosphorus to Lake Boon appears to be minor at the present time compared to non-point source and septic inputs (Table 2-10).

Another method of estimating the phosphorus loading is with one of the input-output models which have been developed. These estimate phosphorus loading based on inputs from the watershed and outputs of sedimentation and outflow. The model developed by Vollenweider (1975) is:

$$L = TP\ (Z)\ (S + F)$$

L = phosphorus loading in $mg/m^2/yr$
TP = total phosphorus in-lake in the spring in ug/l
Z = mean depth in meters
S = effluent phosphorus concentration/influent phosphorus concentration
F = flushing rate per year

This model was calibrated for Lake Boon for the spring of 1979 (DWPC 1981), 1980 (DWPC 1981), and 1986 (present study) and yielded loading rates of 635, 159, and 60 kg/yr, respectively. Both the 1980 and 1986 loading estimates based on in-lake phosphorus concentration are low compared to the estimate based on land use. However, the analyses for the 1979 data indicate phosphorus loading levels (635 kg/yr) which are consistent with the most likely phosphorus loading estimated in Table 2-11 (600 kg/yr). Assuming that non-point source loading based on land use is consistent from year to year suggests that substantial septic system contributions occurred in 1979, but not in 1980 or 1986.

A closer look at the meteorologic records from these three years yielded an explanation for the wide variation in in-lake phosphorus levels. The spring is the most critical time of the year for phosphorus loading to New England lakes. Runoff is generally highest because of snowmelt, high groundwater levels, and low evapotranspiration. Phosphorus loading is likewise concentrated in the spring. During the four month period of January to April, total precipitation in the Lake Boon area was 23.4 inches in 1979, 12.4 inches in 1980, and 12.2 inches in 1986, compared to a normal of 15.9

inches. The two springs with lower than normal precipitation were the years that phosphorus concentrations did not indicate input from septic systems. In contrast, in 1979 springtime precipitation was about 50% greater than normal and phosphorus levels in-lake suggest a substantial contribution from shoreline septic systems. A high water table and high water level in-lake enhance leaching of nutrients from shoreline disposal areas during these conditions.

2.3.3 TROPHIC STATUS

Basic measurements of biological, chemical and physical parameters describe the environment that influences the trophic condition of Lake Boon. Lakes are classified into categories or trophic states by depth, concentrations of dissolved oxygen and nutrients, transparency (water clarity), and biological productivity. Oligotrophic lakes have high transparency, low nutrient concentrations, little sediment accumulation, and are well aerated throughout the water column. Mesotrophic lakes have reduced transparency, moderate nutrient concentrations and biological productivity, increasing sediment accumulation, and some oxygen depletion in deep waters especially in late summer and under ice cover. Eutrophic lakes have poor tranparency, excessive nutrients, rapid sediment accumulation and increased biological productivity.

The trophic state of Lake Boon was modeled using a method developed by Dillon and Rigler (1975) which estimates trophic state based on mean depth, phosphorus loading and retention time. This model was calibrated for Lake Boon under four scenarios including:

1) the lake as it would have been under "pristine" conditions with a 100% forested watershed;

2) the lake with present watershed land use and assuming no inputs from septic systems;

3) the lake with present watershed land use and most likely septic loading;

4) the lake with present land use and maximum possible septic loading.

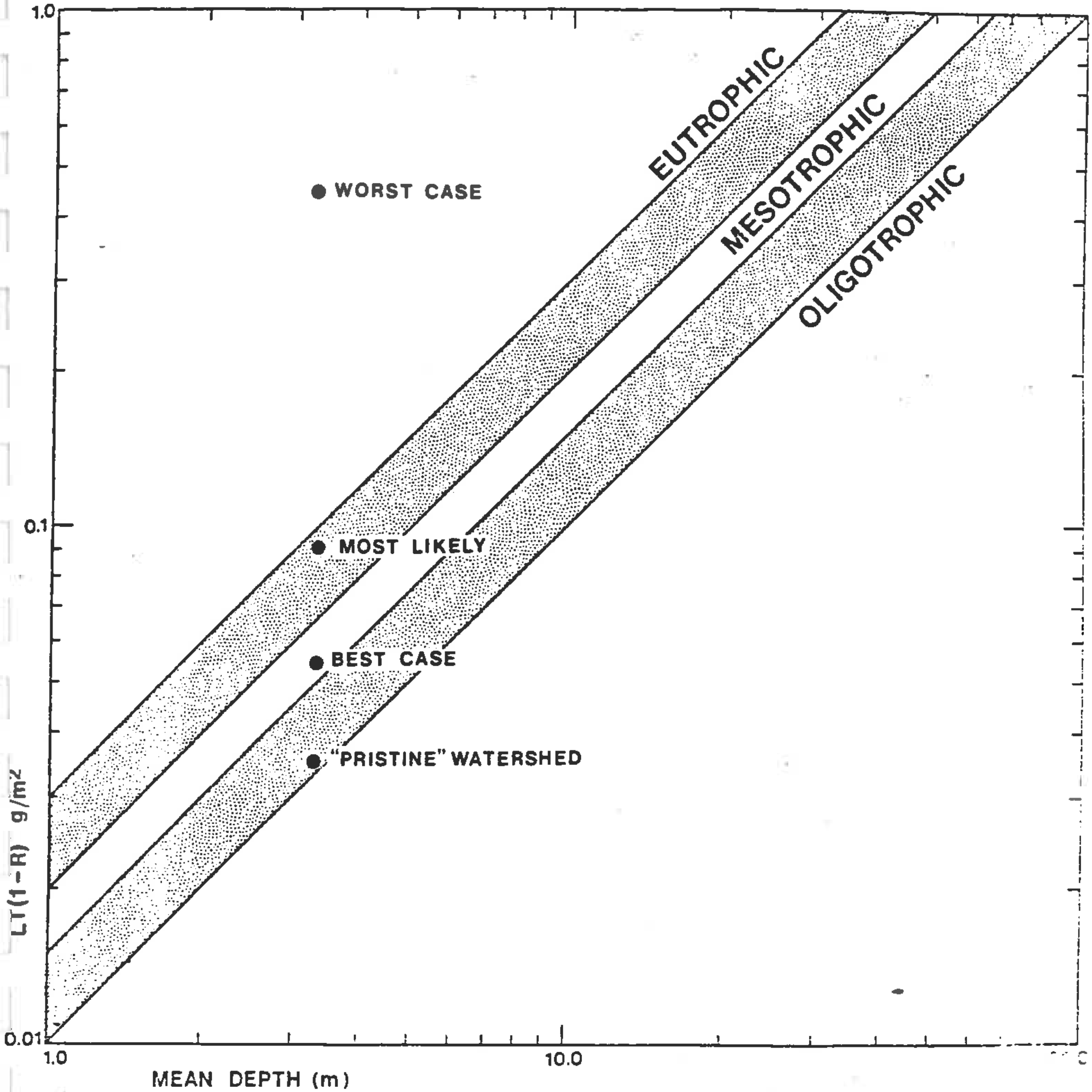
Review of this model shows that at present Lake Boon falls in the borderline mesotrophic to eutrophic range (Figure 2-14). This is in good agreement with observation made during the year of study including:

1) oxygen depletion in the deepest basin in the summer;

2) moderately high algal counts, especially blue-green algae;

3) extensive aquatic plant growth in the shallow basins.

Variations in septic loading will result in a range from highly eutrophic to mesotrophic conditions at Lake Boon. The best estimate of present septic loading puts the lake in the mesotrophic range. However with aging of septic systems and saturation of shoreline soils with phosphorus the loading will over time approach the maximum possible, placing Lake Boon in the highly eutrophic range.



L = AREAL PHOSPHORUS LOADING ($g/m^2/yr$)
R = PHOSPHORUS RETENTION COEFFICIENT (DIMENSIONLESS)
T = HYDRAULIC RETENTION TIME (yr)

LAKE BOON DIAGNOSTIC FEASIBILITY STUDY TOWNS OF HUDSON AND STOW MASSACHUSETTS	CAMP DRESSER &McKEE INC. in association with IEP, INC.	FIGURE 2-14 DILLON/RIGLER TROPHIC STATUS

3.0 FEASIBILITY STUDY

3.1 INTRODUCTION

The primary problem in Lake Boon appears to be aquatic weed growth which interferes with recreation in the lake. The weed growth is heaviest in the upper basin of the lake where depths are shallowest. The shallow depth, along with high nutrient levels in the sediments, seems to be the primary cause of the weed growth. Removal of nutrients from the water column may, over time, reduce the aquatic weed problem. However, it is likely that significant aquatic weed problems will continue unless physical measures are also taken. Secondary problems in Lake Boon include occasional oxygen depletion in the deepest basin of the lake, and occasionally moderate blue green algae counts.

The renovation of Lake Boon is complicated by chemical constituents in the sediments of the lake and by the many shoreline drinking water wells. Specifically, although dredging would appear to be the logical choice of alternatives for the renovation of the lake (by making it deeper), contaminants in the sediments may make dredging difficult. In addition, some other types of lake treatment that might normally be used are not recommended for Lake Boon because of the shallow drinking water wells that surround the lake, many very close to the lakeshore. These wells probably draw water nearly directly from the lake in some cases, and may be indirectly affected by work on the lake.

3.2 TECHNOLOGY IDENTIFICATION AND SCREENING

The full list of possible technologies considered for Lake Boon is shown on Table 3-1. These technologies were evaluated using the following criteria for the first screening:

Effectiveness	- capability to produce desired results
Recreational	- ability to produce desired recreational improvements

TABLE 3-1

TECHNOLOGY SCREENING

ALTERNATIVE	SCREENING FACTORS E	R	I	COMMENTS
Dredging	++	++	--	Cost may prohibit, be hard to implement because of contaminated sediments
Aeration/Mixing	0	0	+	Not effective, eliminate
Hypolimnetic Withdrawal	0	0	+	Not effective, eliminate
Sediment Blanket	+	+	++	Retain
Dilution	+	+	+	Retain
Drawdown	+	+	-	Probably not implementable on large scale due to effects on wells
Weed Harvesting	++	+	+	Retain
Chemical Treatment	+	+	-	Probably not implementable due to effects on wells
Phos. Precipitation	0	0	-	Probably not implementable due to effects on wells
Biological Treatment	0	0	-	Not effective, eliminate
Diversions	0	0	0	Probably not effective, wait for nutrient budget eval.
Treatment of Inflows	0	0	0	Probably not effective, wait for nutrient budget eval.
Sewering	+	+	+	Cost may prohibit
Septic System Modifications	+	+	+	Effectiveness minimal to moderate
Septic System By-Law/Zoning Meas.	+	+	++	Effectiveness minimal to moderate
Erosion Control	+	+	+	Retain
Community Septic Sys.	+	+	0	Effective location may be difficult
Wetlands Treatment	0	0	0	Probably not effective

E = Expected Effectiveness
R = Recreational Improvement or Benefit
I = Implementability

Implementability - ability to be implemented under current regulations and considering physical features of the lake

The matrix analyses, shown on Table 3-1, rates each technology based on (++) highly beneficial or excellent; (+) beneficial or good; (0) ineffective or neutral; (-) adverse or poor. Based on this, several technologies were eliminated or modified as described below.

3.2.1 REASONS FOR REJECTION OF ALTERNATIVE TECHNOLOGIES

The following technologies were eliminated from further consideration based on preliminary information. The reasons for rejection of each technology is also given. A discussion of technologies that have been retained follows in section 3.2.2 "ALTERNATIVES FOR FURTHER CONSIDERATION."

Aeration, Mixing, and Hypolimnetic Withdrawal

The purpose of aeration and mixing is usually to eliminate stratification from a lake, and thus prevent anaerobic conditions at the bottom and the release of phosphorus from the sediments. Similarly, hypolimnetic withdrawal removes the poorer quality water from the bottom of the lake first, discharging it downstream. In Lake Boon, near anoxic conditions occurred in deeper waters during summer stratification, and slightly elevated concentrations of phosphorus were noted. However, this condition is estimated to contribute only about 6.5 kg phosphorus per year, which is a very minor part of the total phosphorus loading. For these reasons, it is not expected that aeration or mixing would be effective at improving water quality in the lake or reducing phosphorus levels. These technologies have therefore been eliminated.

Diversions

The diversion of one or more inlet or stormdrain around a lake is sometimes used if the flushing rate of the lake is too high, or if there is one particularly high phosphorus inflow. In Lake Boon, the eastern inlet, #3, tended to have the highest concentrations of nutrients and could be considered for diversion. However, the overall volume of water contributed by this tributary is relatively minor. Further, the flushing rate of the lake is very low at present, and diversion of some of the flow would result in an even lower flushing rate for the lake. There are also the obvious problems with diversion -- great expense, and displacement of problems downstream.

Treatment of Inflows

The treatment of inflowing streams could be done by one of several methods -- most commonly sedimentation basins or ponds. Actual water treatment, or filtration using drinking water treatment processes, could also be used but is often prohibitively expensive. In general, the inflowing streams to Lake Boon are primarily groundwater-based streams and none have substantial enough flow to warrant treatment.

Drawdown

Drawdown programs are sometimes established in lakes to attempt to control aquatic vegetation. The theory is that overwinter drawdown will freeze and kill the aquatic plants along the shoreline, reducing the problem for the next summer. Although drawdown might be effective in Lake Boon, it is also likely to affect local drinking water wells all around the shoreline of the lake. Many of these are shallow dug wells within a few feet of Lake Boon, and large water level fluctuations in Lake Boon would be likely to affect the performance of these wells. Because of this, drawdown has been eliminated from consideration except as a minimal winter program of 1-2' drawdown for shoreline cleanup.

Chemical Treatment

Chemical treatment is sometimes used both for control of aquatic weeds and algae. Although somewhat effective in the short-term, chemical treatment does not alter the source of the problem. It can also cause increased nutrient problems by the release of nutrients from dead vegetation. Most importantly, however, the use of chemical treatment in Lake Boon is not recommended because of the shoreline drinking water wells. Chemical treatment, including alum treatment to precipitate phosphorus, is eliminated for this reason.

Biological Treatment

There are a number of biological controls that have been used elsewhere, including techniques such as the introduction of weed-eating fish, biomanipulation, and the use of aquatic plant pathogens. However, most of these methods are relatively experimental and probably not applicable to Lake Boon.

For instance, grass carp have been used to control several types of vegetation, but they have not been successful with milfoil which is known to be present in Lake Boon. Assuming that the grass carp would eat Camboba, the milfoil might potentially become an equally serious nuisance. Further, there is no way to contain the fish within the lake, and their migration to other waterways is not desirable.

Biomanipulation includes "lake improvement procedures that alter the food web to favor grazing on algae by zooplankton, or that eliminate fish species that recycle nutrients." (Cooke, et al, 1986.) This might be done by the removal of undesirable fish species and replacement with more desirable species. However, biomanipulation is geared more towards control of algae than aquatic weeds, so it is probably not appropriate for Lake Boon. Similarly, aquatic plant pathogens and insect predators have been developed for certain species of aquatic plants. However, no work has been done on the species that are a problem in Lake Boon. Biological controls will not be considered further in the evaluation for these reasons.

Wetlands Treatment

As with diversion and inflow treatment, wetlands treatment may not be effective because none of the inflowing tributaries contribute a high enough proportion of the flow or pollutants to warrant specific treatment. This technology has been eliminated from further consideration.

Community Septic Systems

Another way to deal with septic systems around Lake Boon would be to construct a community system, collecting wastewater from homes along the shoreline with transfer to a large central septic system for treatment. However, the most significant drawback to this alternative is that there is no potential location for such a facility in the Lake Boon area.

3.2.2 ALTERNATIVES FOR FURTHER CONSIDERATION

As shown on Table 3-2, the technologies that were not eliminated during the first screening were evaluated a second time. In this evaluation, several new factors were considered, including:

- Complexity - difficulty of operation and maintenance
- Flexibility - ability to adapt to changing conditions
- Experience - past success/failure of component options
- Environmental --impacts on terrestrial and aquatic life

In-Lake Restoration Technologies

The primary problem that in-lake technologies must address is aquatic weeds. Algal problems have not been serious to date, although nutrient levels are moderate and the flushing rate of the lake is low indicating a good potential for future algae problems.

Dredging. Although dredging would be a relatively effective technology for Lake Boon, the size of the lake makes complete dredging impractical and

TABLE 3-2

SECOND ALTERNATIVE SCREENING

ALTERNATIVE	C	F	EX	EV	COMMENTS
Dredging	+	-	+	--	Cost prohibitive
Sediment Blanket	-	++	-	++	Could be excellent on limited scale
Dilution	--	-	+	-	Very complex, effects on wells difficult to predict/unplugging specific culverts retained
Weed Harvesting	-	++	++	+	Purchase of harvester cost-effective, but operator would have to be designated
Sewering	--	--	+	+	Very high cost, justification difficult
Septic Modifications	-	+	0	++	Success dependent on local factors
Septic System ByLaw/Zoning Measures	+	+	+	++	Success dependent on enforcement
Erosion Control	+	+	++	++	Success dependent on enforcement
Minimal Drawdown Program	+	+	+	+	Only with very minimal (1-2') drawdown

C = Complexity - difficulty of operation and maintenance
F = Flexibility - ability to adapt to changing conditions
EX = Experience - past success/failure of component options
EV = Environmental - impacts on the environment

a relatively slow flushing rate, which is the time it takes the water in the lake to completely flow through.

Unfortunately, pumping groundwater in large volumes is very expensive and the aquatic weeds in Lake Boon can probably obtain adequate nutrients from the sediments, so dilution may not significantly affect the primary problem in the lake. The effects of large-scale pumping of groundwater on local drinking water wells and groundwater patterns is also not known, and would require extensive investigation prior to implementation.

However, one method specific to Lake Boon that would provide the same type of benefit would be cleaning or reopening the culvert on Sudbury Road and one just north of that. These two culverts are plugged and surface flow does not go through them--instead the water ponds and probably goes through as groundwater flow.

Weed Harvesting. Weed harvesting can be done by one of several methods, but the general idea is to cut and remove aquatic plants from the lake. It has the advantage of good flexibility, in that the area(s) of harvesting can be easily modified, and the harvesting can be done on an as-needed basis. Another advantage is that there is a lot of experience with this method, and it is reliable and well-tested. The environmental impacts are also very minimal, especially when compared with other weed control methods such as dredging. On the negative side, weed harvesting has a relatively high operations and maintenance cost, or annual cost, although this can be minimized over the long-term by the purchase of a harvester. Additionally, weed harvesting is usually required every year, sometimes twice per year.

Hydroraking is another method of physically removing nuisance aquatic vegetation. Unlike a weed harvester which simply cuts the plants with sickle bar type cutters, a Hydro-Rake actually rakes the lake bottom to remove not only the stems and foliage but also the roots. The Hydro-Rake resembles a floating back-hoe with an 8 foot wide York Rake attached to the hoe arm rather than a convential back-hoe bucket. The Hydro-Rake can remove weeds and much in water depth up to 12 feet deep versus a depth difficult to implement. In addition, dredging can cause sediment resuspension and the release of materials adsorbed to the sediments. As a result, dredging may be very difficult to implement at Lake Boon because of the relatively high concentrations of some metals in the sediments. The levels of contaminants in the sediments may make permitting difficult or impossible, and a location for dredge spoils disposal must be found. However, the dredging alternative will be retained to use as a "benchmark" for comparison purposes.

Sediment Cover. As a method to control aquatic weeds, the use of a sediment blanket, or weed barrier, should be considered. The purpose of the sediment cover is to either physically prevent weed growth from the bottom, or to block light penetration to the sediments to prevent weed growth. One commercial type of material is Aquascreen, although several types of filter fabric material have been used for the same application previously. High density 30 mil polyethylene or similar sheets of synthetic material would be placed in shallow areas and anchored with concrete blocks or weights. If solid sheets were used, small holes or ports would have to be provided to vent gases found in the decomposing matter in the sediments. This method has an effect similar to dredging, especially in the shallow water areas.

The advantages are that the sediments are not disturbed, so that the contaminants found in the Lake Boon sediments would not be released into the water column. This technology would also be quite flexible, since the screens could be moved as necessary. Disadvantages are its relatively high expense to treat large areas, and the need for removing or cleaning the screens each year (high complexity). Also, there is relatively little experience with this method.

Dilution. In Lake Boon, dilution could be used to improve water quality by adding large volumes of clean, nutrient-free water. The only available source of clean water is likely to be groundwater pumped from somewhere nearby the lake. This would be likely to improve the trophic status of the lake because it would increase the flushing rate. Presently, the lake has limitation of 5 or 6 feet for a harvester. The Hydro-Rake has no on-board storage therefore each rake-full must either be deposited directly on shore or onto a waiting transport barge. Several years of control have been obtained on vegetation with large tubers such as spatterdock and white lilies. The Hydro-Rake is somewhat less effective on weeds such as water milfoil and pondweed which have small hairlike roots.

Although more effective than weed harvesting, Hydro-Raking is also more expensive, costing between $1,500 and $3,000 per acre depending upon weed and bottom type as well as the disposal system.

Watershed Restoration Technologies

The major problem in Lake Boon is aquatic weeds. Algal problems are secondary and have not been serious. The moderate nutrient levels in the lake are probably the primary cause for algal problems, and the removal of nutrients from the lake could be expected to reduce existing or future problems. However, it is not expected that a reduction in nutrient levels in the water column by itself would significantly affect aquatic weed problems.

Watershed management strategies that reduce nutrients in Lake Boon should therefore not be the only alternatives, but should be combined with in-lake strategies to deal with aquatic weeds more directly. Several watershed restoration strategies are discussed below.

Sewering. As mentioned previously, one of the suspected causes of nutrient loading to the lake is septic systems located on poor soils around the shoreline. To address this problem, one method would be to sewer the area and transport domestic sewage to a wastewater treatment plant. The major advantage of sewering is that septic systems and cesspools can be abandoned and this source of potential pollution is completely removed. However, the placement of sewer lines is very expensive, and in addition, the sewage must be pumped to a wastewater treatment plant of some type with the discharge of treated effluent elsewhere.

The Town of Hudson is partially sewered, but no plans to sewer the Lake Boon area have been made. Stow has no sewers at present. Assuming that all shoreline residences were connected to sewers, then the sewage would still have to be treated somewhere regionally or in a package plant locally. The largest question with this method is the cost- effectiveness of such a large expenditure compared with the benefits of removing a relatively small amount of nutrients from Lake Boon.

Septic System Modifications. An alternative to sewering would be to modify or replace existing septic systems and cesspools. Many of the systems around Lake Boon were installed when the homes were summer homes, and may be undersized for year-round residences. This is currently controlled to some extent through existing by-laws and ordinances, in that modifications or expansions of existing buildings require building permits and are supposed to meet certain septic system requirements. However, this does nothing to address most of the systems surrounding the lake.

In most cases, replacement and cleaning of septic systems is the responsibility of the individual owners. Failing systems are first identified, and then the Board of Health or other responsible agency orders the owner to take corrective measures, whether this means pumping out the system, repairs, or complete replacement.

Unfortunately, it is very difficult to identify undersized or failing systems unless they are actually leaching out onto the ground. When this happens, neighbors may report odor problems, and the failed system is identified this way. If breakout above ground has not occurred, failure or undersizing of the system will go undetected. In the Lake Boon area, this is particularly likely to happen since the soils have high percolation rates, and breakouts are more likely to be seen where the soil has low permeability (high clay content) or hardpan layers. In other words, nutrients from the septic systems surrounding the lake may be leaching into the groundwater and then entering the lake, but if so it is probably because of the high percolation rates rather than actual failure of the systems.

One way to attempt to deal with potentially polluting systems would be to establish a program for pumping the systems regularly.

Septic System Bylaw/Zoning Measures. Some measures are already in place to control septic systems in the watershed, but these pertain only to new systems for the most part. It is much more difficult to control existing systems, however, one method to do so would be through Board of Health powers or new bylaws. First, however, specific systems must be identified, and to do this, drinking water well sampling may be the most effective method. It would have the additional benefit of identifying any public health problems from nitrates, and would define general phosphorus concentrations in groundwater flowing in the vicinity of the lake.

Erosion Control. Erosion in the Lake Boon watershed is not expected to be a significant problem for the most part because so little of the lake's inflow comes from surface flow. However, certain problem areas have been noticed by area residents, and could be corrected relatively easily by specific methods at each erosion site.

3.3 FINAL OPTIONS

The following options have been derived from the technologies discussed above using various combinations of alternatives. Each of the options attempts to deal with the most obvious problem, aquatic weeds, and to reduce nutrients in the lake's water column thus reducing potential algae problems.

3.3.1 OPTION 1 - SEWERING AND DREDGING

Description

This option includes two main components: a) the sewering of the Lake Boon shoreline, with transfer to the Hudson wastewater treatment plant about four miles away; and b) hydraulic dredging of Lake Boon with onsite dewatering and disposal.

Sewering of the Lake Boon shoreline would include the placement of lateral sewers along all streets within 300 meters of the shore of the lake. Transfer to a trunkline would be by gravity to collection points where lift stations would be required. The main trunk line would then transfer wastewater to the Hudson wastewater treatment plant slightly less than four miles away. Another pump station would probably also be required.

Full dredging of Lake Boon would involve hydraulic dredging since the lake can only be drawn down to a limited extent due to near-shoreline drinking water wells. To dredge the lake to a minimum ten foot depth throughout, Basin 3 would require almost complete dredging -- or about 35 acres and 209,000 cubic yards (160,000 cubic meters). A 1:4 foot slope would be left at the edges of the lake, and the liquid material would be pumped to a location along the shoreline where dewatering would take place.

Since the Town(s) do not own any areas that could be used, the land would have to be taken by eminent domain. About 25 acres should be sufficient to locate a dewatering facility, storage area, and staging area -- final disposal could also be on the site, with a minimum of about 14 acres (of the 25 acres) of land required for disposal of materials from Basin 3.

Basin 2 would require dredging of about 17 acres, or 74,000 cubic yards (57,000 cubic meters) to bring it to a minimum ten foot depth. Basin 1 would require only minimal dredging of the perimeter, about 5 acres maximum, or 15,000 cubic yards (11,000 cubic meters).

The dewatering of the spoil from these two areas will probably require a separate area from that used for Basin 3, due to the distance from dredging areas. Assuming that one central dewatering area could be used for Basin 1 and 2, about 15 acres would have to be taken for the dewatering operation and staging, although the final disposal could probably be accomplished at the 25 acre site used for dewatering/staging and disposal of materials from Basin 3. Dried materials would have to be trucked to the site from the dewatering area, and it is assumed that the dredging and dewatering of Basin 3 would occur first so that the site would be available for disposal of dry spoil from Basin 1 and 2 when those basins were dredged.

Cost Estimate

Capital Cost. The sewering portion of Option 1 has a capital cost estimated at $ 5,500,000, which represents construction of about 52,000 feet (10 miles) of laterals and a trunk line of about 16,000 feet (3 miles). Individual tie-ins of homes are not included, since these would be at the owner's expense (about $2,000 per house). Land takings for the sewer line are also not included since these are unknown. The cost does include construction of two pumping stations.

For the dredging portion of the option, the capital cost for dredging, dewatering, storage, and onsite disposal is estimated at about 4.5 million dollars. The required land takings would cost an additional $500,000. The total capital cost of Option 1 is almost $11 million. Unfortunately, little or no funding is readily available for sewering projects at present, and neither of the Towns involved has any plans for sewering the Lake Book area.

Operations and Maintenance Costs. While the dredging portion of the alternative does not have any significant operations and maintenance costs, the disposal site would require closure and probably reseeding/replanting. Some form of leachate control would have to be left in place, although it is unlikely that capping or leachate collection/treatment would be required. The sewering portion of the alternative would have an annual cost of approximately $600,000 for treatment of the wastewater at the Huson WWPT, and the operation and maintenance of the pump stations. This cost would not be eligible for funding.

Unit Costs. Option 1 as estimated above assumes full dredging and full sewering of the area, since this would reduce unit costs substantially over dredging only a small portion of the lake or sewering only part of the shoreline. Dredging unit costs are approximately $79,000 per average acre, including dewatering, disposal, etc. Downsizing of the sewering project to include fewer houses could not be recommended because the most expensive components of the project would still be required, namely the trunkline and pump stations. As a result, no unit costs can be given for sewering.

3.3.2 OPTION 2 - WEED SCREENS, PUBLIC EDUCATION, AND SEPTIC SYSTEM MEASURES

Description

This alternative includes two main components: a) the use of weed screens or other bottom coverings in areas of dense aquatic macrophytes; and b) the implementation of septic system measures to control and reduce septic system leachate entering Lake Boon.

The first portion of this option involves the use of weed screens to physically prevent weed growth or to block sunlight from the bottom of the lake in areas of normally dense macrophyte growth. One commercial type of material is Aquascreen, although several types of filter fabric material have been used for the same application previously.

The material, whether in rolls or blocks, is sunk to the bottom of the area for control, and then pinned or weighted down with blocks or weights. Divers may be used to secure the material in deeper areas, and it may be rolled out from shore and weighted at intervals along its length. The material is put in place in spring before macrophyte development is significant, and removed and cleaned in the fall after use.

In Option 1, it was estimated that a total of 57 acres of Lake Boon is less than 10 feet deep, and this same number could be used to estimate the acreage to be covered by weed screens. However, because this option is repeated each year rather than being a one-time event, fewer acres could be covered with similar effects. In other words, it does not appear necessary to treat areas with minimal macrophyte growth since these materials could be moved from year to year if desired. To cover the more dense areas, about 45 acres would be involved.

The second portion of this option involves the implementation of septic system measures to reduce/control leachate impacts on the lake. Basically, there are two major problems associated with septic systems in the Lake Boon area: a) many systems are old and undersized, with many cesspools; and b) even with new, approved systems, the soils have a high percolation rate and little filtering capacity, so many pollutants probably pass through to the lake. As a result, an inspection program to identify failures would produce little evidence. However, there are other ways to deal with the problem, including 1) frequent pumping of systems to improve their efficiency; 2) requiring the upgrade of cesspools upon resale of housing; 3) developing a method of identifying and controlling failing systems through private well sampling and subsequent Board of Health action; and 4) the implementation of a public education program. These steps are described below.

Step 1 - Institute a Septic System Pumping Program. From the questionnaire, it was estimated that fewer than 47% of the homeowners around the lake pump their septic systems regularly. It was also estimated that as many as 27% of homes may have cesspools. Based on this, it would appear that an annual pumping program would increase the frequency of maintenance of existing septic systems, thereby increasing their efficiency significantly. It would also identify the locations of cesspools. While many of the cesspools may be "grandfathered", some may be illegal and a pumping program would identify these for further action.

There are several methods to implement a pumping program, however, the most cost-effective appears to be the use of a user fee for homes within a given radius around the lake or within the entire watershed if desired. The pumping service would be similar to a garbage collection service, where the Towns bid out for the services of one or more pumping service vendors to go through the list of homes on an annual basis and pump each one.

At the end of the work, the vendor(s) would submit a ticket or other record for each home pumped recorded with the address, date, depth of sludge, quantity of septage pumped, condition of the system, and the location of the system access cover. Systems that could not be pumped for some reason would also be reported. Annual bills would then be sent out to each of the homes, while the addresses of those homes that could not be pumped or had other serious problems would be sent to the Board of Health or other designated agent for action.

Under Title 5, the Town of residence is responsible for providing a disposal site for septage. Assuming about 350 gallons per year per septic system and 500 homes, this would be approximately 175,000 gallons per year. A long-term agreement with a nearby wastewater treatment plant such as the Hudson plant would be advantageous to both Towns and would be the preferred method of disposal.

Because the entire area for pumping would be bid as a unit, or at the most, one unit per town, the cost savings to homeowners over hiring individual vendors should be significant. However, the political and legal ramifications of a mandatory program should be examined by the Town's counsel prior to implementation.

Step 2 - Require Cesspool/Septic System Upgrade Upon Resale. From the pumping program, a large part of the failing, inefficient systems will be dealt with -- resulting in a significant reduction in phosphorus loadings to the lake. One problem that will remain, however, are the "grandfathered" cesspools. Since the questionnaire survey resulted in an estimate of 27% or more of the homes (about 145) with cesspools, this could be a significant amount.

To deal with these, an amended by-law requiring the upgrade of cesspools upon resale could be adopted. In this way, cesspools would gradually be converted into more efficient systems. One problem that should be noted is that many of these old systems are associated with very small lots that cannot meet Title 5 requirements. In these cases, a variance from Title 5 should be requested, rather than leaving the system as is.

Step 3 - Institute a Private Well Sampling Program. In order to monitor the effectiveness of the above programs in accordance with the Clean Lakes Program, a multi-year monitoring program must be set up. To monitor the effectiveness of the above steps, and to implement a method by which residents can determine the status of their wells, a voluntary private well monitoring program should be developed as a part of the overall program.

Interested residents would be required to sign up for the program for the full term (3-5 years) at some designated location such as the Town Halls. Specific wells would then be selected from the homes volunteering, with special consideration going to homes with well records (depth, screening, etc.). The 25-50 wells would then be sampled on a quarterly basis for nitrogen parameters and phosphorus. Any wells with higher than background concentrations would then be reported immediately to the Boards of Health for further sampling from a public health perspective.

Step 4 - Implement a Public Education Program. As the final step in the implementation of this component, a public education program should be developed to attempt to reduce the phosphorus loadings to septic systems and to reduce the phosphorus loading from overland runoff.

This could include pamphlets or flyers discussing methods to reduce phosphorus use with detergents and fertilizers, as well as lists of available phosphorus-free products. As part of the educational program, the Towns could provide individual homeowners with information relative to cesspool and septic system operation.

Cost Estimate

Capital Costs. The purchase of weed screens for 45 acres of the lake represents the greatest capital cost of this option, at about $450,000. Other capital costs associated with this option include approximately $30,000 to: a) write amendments to the by-laws incorporating the pumping program and the requirements for upgrading systems upon resale; b) develop a well-monitoring program; and c) development, printing, and distribution of public educational materials. An additional $125,000 would be required for the 5 year well monitoring program. With 75% funding under the Clean Lakes Program, the capital cost would be $151,250 to the Towns of Hudson and Stow.

Operations and Maintenance. Annual costs associated with this option are also mostly associated with weed screen portion of the option, since these must be removed and cleaned each fall and replaced each spring. This operation and maintenance cost is estimated to be $25,000 per year. Some administrative costs will also be borne by the Towns for the billing/collections, etc. associated with the pumping program, and for the enforcement of the new by-laws. A $10,000 per year allowance should be sufficient to cover these costs as well as continuing public education activities.

Unit Costs. Although the cost of purchase and installation/removal of the weed screens will be smaller for larger acreages, in general, the capital cost is about $10,000 per acre, with an additional $600 per year per acre to maintain (install, remove, and clean) the screens. The other costs cannot be broken into units.

3.3.3 OPTION 3 - WEED HARVESTER, PUBLIC EDUCATION, AND SEPTIC SYSTEM MEASURES

Description

This option combines the septic system measures discussed under Option 2 and either contracted weed harvesting or the purchase of a harvester.

Although Lake Boon has a surface area of approximately 163 acres, total aquatic vegetation encompasses no more than 50-60 acres. The majority of this weed growth (approximately 30 acres) occurs throughout the third basin where shoreline development is generally sparse.

There are several manufacturers of mechanical weed harvesting equipment. These weed harvesters cut the vegetation to a maximum water depth of between 5 and 7 feet. Widths of cut vary from about 4 feet up to 10 feet for the larger machines. Storage capacity on a large 410-800 Harvester is 800 cubic feet or approximately 14,000 lbs. maximum. A small to medium size harvester such as a model HS-200 unit, would be capable of easily harvesting the 15-25 acres of nuisance vegetation at Lake Boon. This machine has a productivity of about a quarter acre an hour or two acres per day. In fact, two cuttings (30-50 acres total) per summer would be desireable and could be managed. A two-man operating crew would be required. A number of municipalities (Wellesley, Harvard, Westminster and others) have purchased and are now operating equipment. Another option would be to contract weed harvesting or hydroraking.

Cost Estimate

Capital. The purchase price a weed harvester as discussed above is about $35,000. A trailer conveyor system for disposal of the vegetation is an additional $10,000. Since this full amount should be fundable under the Clean Lakes Program, the Town's share would be $11,250. Contracted weed harvesting or hydroraking would not have any capital cost.

Adding in the approximate $155,000 cost associated with the implementation of septic system measures and the 5 year well monitoring program brings the total capital cost of this option with the purchase of a weed harvester to $200,000, of which $50,000 would be the Town's share with Clean Lakes funding. With no weed harvester purchase, the Town's capital cost would be $38,750 for the septic system measures and well monitoring.

Operations and Maintenance. As with Option 2, the annual cost of administration would be about $10,000. The $10,000 per year administrative costs would be expected to decline over time.

The annual costs associated with the purchase of a weed harvester are estimated at about $15,000 (not fundable) which would include operation, fuel, repairs, etc. The total O&M for this option would then be $31,250. A typical contracted rate for weed harvesting would be about $22,500, including disposal (assuming approximately 25 acres and two cuttings). Contracted hydroraking, which may have some carry over benefits from year to year, would be about $37,500 per year including disposal (assumes one cutting, 25 acres).

Unit Costs. Using a 25 acre area, the purchased weed harvester would have an approximate annual cost of about $625/acre, while contracted weed harvesting and hydroraking would have annual costs of $900/acre and $1,500-2,000/acre respectively, including disposal.

3.3.4 OPTION 4 - WEED HARVESTING, LIMITED WEED SCREENS, PUBLIC EDUCATION, AND SEPTIC SYSTEM MEASURES

Description

This option combines the weed harvesting and septic system measures from Option 3 with the use of weed screens by individuals or groups of individuals. Weed screens were described under Option 2, with the main differences here being that the Town would purchase (at a discount) enough of the screen to cover about three acres. The town would then resell the material to individual homeowners at cost. The purchase of the weed screens would not be fundable under the Clean Lakes Program. Purchasers would install, maintain and repair the screens at their own expense, using the material around private docks and swimming areas.

The septic system measures would be the same as in Options 2 and 3 but contracted hydroraking could be substituted for the purchase of a weed harvester. Because the weed screens would be used in individual areas, the acreage to be raked could probably be reduced to about 16 acres. In some years, hydroraking might not be necessary.

Cost Estimate

Capital Cost. The capital cost of this option would be $30,000 for the weed screen purchase and $155,000 for the septic system measures and well monitoring implementation. With funding, the capital cost would be $68,750, much of which could be recovered from individuals buying the weed screens.

Operations and Maintenance Annual costs would include $22,500 to $30,000 to hydrorake about 15 acres and $10,000/year administration costs for septic system measures.

Table 3-3 shows an overall cost comparison of the four final options. Using this table, and the descriptions of the four final options, the Lake Boon Commission selected Option 3 with minor modifications based on its cost-effectiveness and applicability to the local situation. This option, along with the modifications, is described in the next section.

3.4 PROPOSED PROJECT

3.4.1 DESCRIPTION

The recommended project consists of Option 3 - Weed Harvester and Watershed Management Plan plus contracted hydroraking for one year as a short-term, interim measure. However, Step 3 (the private well sampling program) would not be included since this is ongoing as part of a separate project.

The first part of the project would consist of purchasing a weed harvester by the Towns of Hudson and Stow. Of the total surface area of the lake of approximately 163 acres, dense aquatic vegetation encompasses only about 50-60 acres. The majority of this dense growth, around 30 acres, occurs throughout the third basin where shoreline development is generally sparse.

Mechanical weed harvesting equipment, made by several manufacturers, cuts the aquatic vegetation to a maximum water depth of between 5 and 7 feet. Cutting width varies from about 4 feet to about 10 feet for larger machines. A small to medium size harvester would be capable of easily harvesting the 15-25 acres of nuisance vegetation at Lake Boon.

This machine has a productivity of about a quarter acre an hour or two acres per day. Two cuttings (30-50 acres total) per summer would be desirable and could be managed. A two-man operating crew would be required. For operation of the harvester, the two towns could jointly hire staff for summers, or interested lake residents could share in the

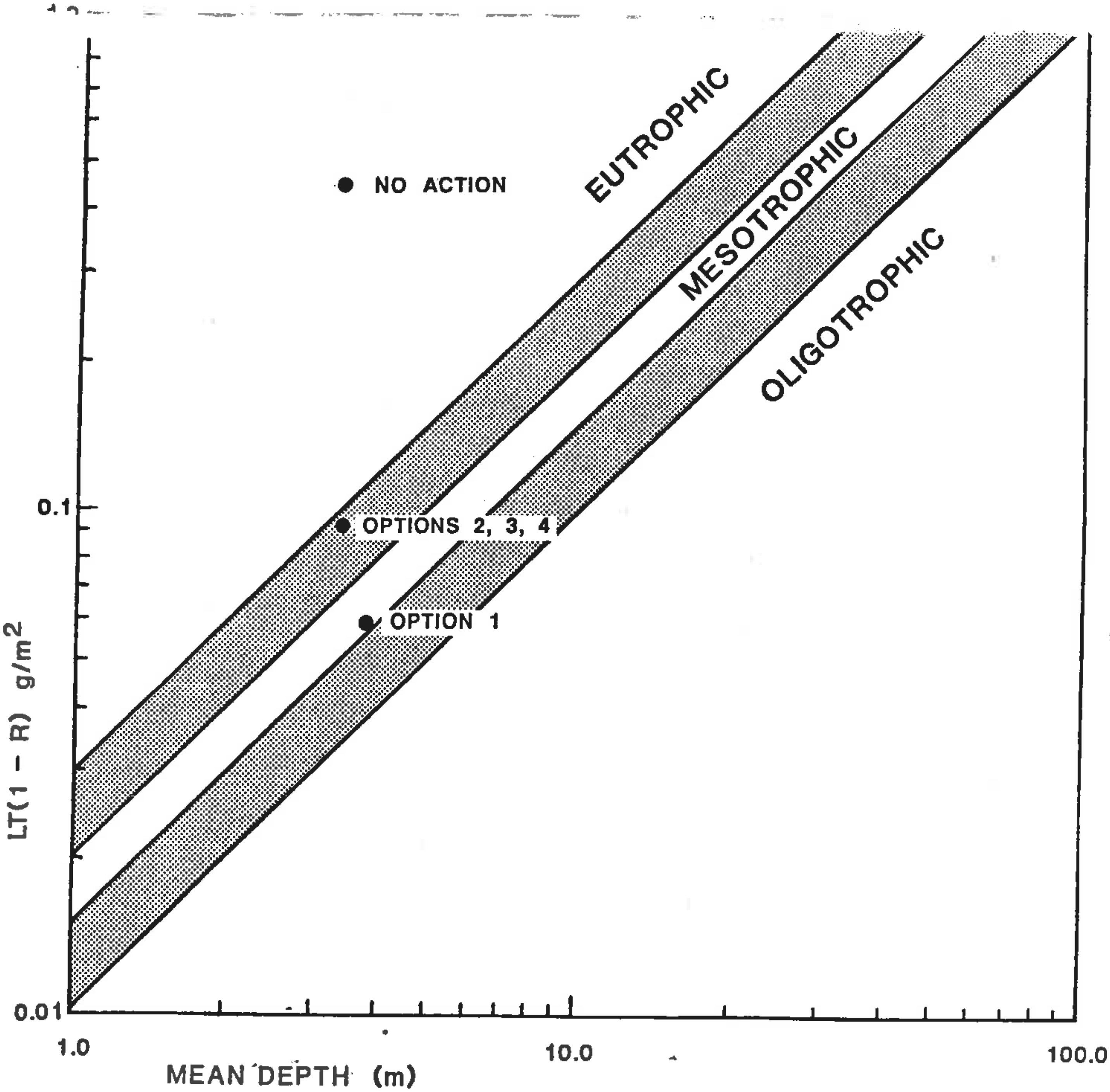
TABLE 3-3

COST ESTIMATES OF FINAL OPTIONS

Option No.	Component	Capital Cost	Annual Cost	Share Capital	Share Annual	Cost (if any)
1	• Sewering	$ 5,500,000	$600,000	$1,375,000	$600,000	
	• Dredging	5,000,000	-	1,250,000		$79,000/acre
	Total	$10,500,000	$600,000	$2,625,000	$600,000	
2	• Weed Screens	$ 450,000	$ 25,000	$ 112,500	$ 25,000	$10,000/acre
	• Septic System Measures (Steps 1, 2, 4)	30,000	10,000	7,500	10,000	
	(Step 3)	125,000		31,250		
	Total	$ 605,000	$ 35,000	$ 151,250	$ 35,000	
3A	• Weed Harvester Purchase	$ 45,000	$ 15,000	$ 11,250	$ 15,000	$625/acre/yr
	• Septic System Measures (Steps 1, 2, 4)	30,000	10,000	7,500	10,000	
	(Steps 3)	125,000		31,250		
	Total	$200,000	$ 25,000	$50,000	$ 25,000	
3B	• Contracted Harvesting (25 acres)		$ 22,500		$ 5,625 (22,500)[1]	$900/acre/yr
	• Septic System Measures	155,000	10,000	38,750	10,000	
	Total	$ 155,000	$ 32,500	$ 38,750	$ 15,625 (32,500)[1]	
3C	• Hydroraking (25 acres)		$ 37,500		$ 9,375 (37,500)[1]	$1500-2000/acre per year
	• Septic System Measures	155,000	10,000	38,750	10,000	
	Total	155,000	47,500	38,750	19,375 (47,500)[1]	
4	• Hydroraking (15 acres)		$22,500-30,000		$5,625-7,500 (22,500-30,000)[1]	$1500-2000 acre/per year
	• Weed Screen Purchase	30,000		30,000[2]		10,000/acre
	• Septic System Measures	155,000	10,000	38,750	10,000	
	Total	$ 185,000	$32,500-$40,000	$68,750	$15,625-$17,500 ($32,500-40,000)	

1 Contracted weed harvesting and hydroraking are eligible for funding, but are not preferred uses for Clean Lakes money--generally receiving very low priority.

2 In the cost of weed screen purchase would be offset by individual purchase from Towns



L: AREAL PHOSPHORUS LOADING $(g/m^2/yr)$

R: PHOSPHORUS RETENTION COEFFICIENT

T: HYDRAULIC RETENTION TIME (yr)

LAKE BOON DIAGNOSTIC FEASIBILITY STUDY TOWNS OF HUDSON AND STOW MASSACHUSETTS	CAMP DRESSER & McKEE INC. in association with IEP, INC.	**FIGURE 3-1** EFFECTS OF FINAL OPTIONS ON TROPHIC STATUS

operation with a designated Town staff person in charge of maintenance and operations. For the interim, a contractor should be hired to hydrorake for the first summer before the remainder of the project is in place.

The second portion of this option involves the implementation of a Watershed Management Plan to reduce/control leachate impacts on the lake by 1) frequent pumping of septic systems to improve their efficiency; 2) requiring the upgrade of cesspools upon resale of housing; and 3) the implementation of a public education program. These steps are described below.

Institute a Septic System Pumping Program

It is estimated that fewer than 47% of the homeowners around the lake pump their septic systems regularly, and as many as 27% of homes may have cesspools. Based on this, an annual pumping program would increase the frequency of maintenance of existing septic systems, thereby increasing their efficiency significantly.

There are several methods to implement a pumping program, however, a voluntary pumping program has been the most commonly used. This could be set up similar to a garbage collection service, where the Towns bid out for the services of one or more pumping service vendors to go through a list of homes on an annual basis and pump each one. Since the program would be voluntary, interested citizens would be required to sign up for the program.

At the end of the work, the vendor(s) would submit a ticket or other record for each home pumped recorded with the address, date, depth of sludge, quantity of septage pumped, condition of the system, and the location of the system access cover. Systems that could not be pumped for some reason would also be reported. Annual bills would then be sent out to each of the homes.

Under Title 5, the Town of residence is responsible for providing a disposal site for septage. Assuming about 350 gallons per year per septic system and 500 homes, this would be approximately 175,000 gallons per year. A long-term agreement with a nearby wastewater treatment plant such as the Hudson plant would be advantageous to both Towns and would be the preferred method of disposal.

Because the entire area for pumping would be bid as a unit, or at the most, one unit per town, the cost savings to homeowners over hiring individual vendors should be significant.

Require Cesspool/Septic System Upgrade Upon Resale

From the pumping program, a large part of the failing, inefficient systems will be dealt with, resulting in a significant reduction in phosphorus loadings to the lake. One problem that will remain, however, are the grandfathered cesspools. Since the questionnaire survey resulted in an estimate of 27% or more of the homes (about 145) may have cesspools, this could be a significant amount.

To deal with these, an amended by-law requiring the upgrade of cesspools upon resale could be adopted. In this way, cesspools would gradually be converted into more efficient systems. One problem that should be noted is that many of these old systems are associated with very small lots that cannot accept full size septic systems that meet Title 5 requirements. In these cases, a variance from Title 5 should be requested, rather than leaving the system as is.

Implement a Public Education Program

As the final step in the implementation of this component, a public education program should be developed to attempt to reduce the phosphorus loadings to septic systems and to reduce the phosphorus loading from overland runoff.

This could include pamphlets or flyers discussing methods to reduce phosphorus use in detergents and fertilizers, as well as lists of available phosphorus-free products. As part of the educational program, the Towns could provide individual homeowners with information relative to cesspool and septic system operation.

3.4.2 COST ESTIMATE

A cost summary for the proposed project is given on Table 3-4, along with a breakdown of capital and annual costs.

The annual costs associated with the purchase of a weed harvester are estimated at about $18,000 (not fundable) which would include operation, fuel, repairs, etc. Some administrative costs will also be borne by the Towns for the billing/collections, etc. associated with the pumping program, and for the enforcement of the new by-laws. A $10,000 per year allowance should be sufficient to cover these costs as well as continuing public education activities, so the total annual cost would be $28,000 per year.

3.4.3 SCHEDULE

The overall schedule for the project is shown in Table 3-5.

3.4.4 PUBLIC PARTICIPATION

The first public meeting for the project was held April 2, 1986. Copies of the meeting agenda, public participation handout, the sign-in list, and newspaper articles are attached in the Appendix. The final public meeting was held on July 15, 1987 to discuss the results of the study. Press releases, meeting agendas, and newspaper articles from the second meeting are also in the Appendix.

TABLE 3-4

COST SUMMARY OF PROPOSED PROJECT

Lake Boon Diagnostic/Feasibility Study

Component	Capital Cost	Annual Cost	Share Capital	Share Annual
A. Hydroraking (1 year only)	$38,000		$9,500(1)	
B. Watershed Management Plan(2)	$30,000	$10,000	$7,500	$10,000
C. Weed Harvester Purchase and Operation	$50,000	$18,000	$12,500	$18,000
TOTALS	$118,000	$28,000	$29,500	$28,000
DWPC 3 year Monitoring Program	$50,000		$12,500	
	$168,000		$42,000	

(1) Hydroraking is eligible for funding but is not a prefered use for DWPC Clean Lakes money and generally receives very low priority.

(2) Components include development of bylaws for cesspool conversion and a public education program (capital cost) and the administration of a septic system pumping program and a continuing public education program.

TABLE 3-5

IMPLEMENTATION SCHEDULE
LAKE BOON PHASE II

Milestone Date	Task	Responsibility
October 1, 1987	Deadline for approved Phase I Final Report	Camp Dresser & McKee Inc. and IEP, Inc.
January 30, 1988	Deadline for Priortization for Funding	Division of Water Pollution Control (DWPC)
May 15, 1988	Deadline for Local Match Committment	Towns of Hudson and Stow
May 31, 1988	Deadline for Full Program Requirements Compliance	Towns of Hudson and Stow
September 1, 1988	Substate Agreement/ Phase II	DWPC
October 3, 1988	Issue Phase II Request for Proposals	Towns of Hudson and Stow
October 28, 1988	Deadline for Proposals	Towns of Hudson and Stow
November 30, 1988	Selection of Consultant for Phase II	Towns of Hudson and Stow
January 2, 1989	• Begin Pumping Program Voluntary Sign-up • Begin Development of By-Law Revisions • Begin Development of Public Education Program	Consultant
February 2, 1989	Begin Public Education Program, including advertisement of voluntary sign-up for pumping program	Consultant

April 3, 1989	• Hire hydroraking contractor • Compile list of homes for pumping program and advertise for bids for pumping contractor	Towns of Hudson and Stow
May 1, 1989	• Hire pumping contractor to begin work • Implement by-law revisions • Continue public education program	Towns of Hudson and Stow
January 1, 1990	Purchase Weed Harvester	Towns of Hudson and Stow
March 1, 1990	Advertise for weed harvester operating staff	Towns of Hudson and Stow
June 1, 1990	Begin operation of Town-owned harvester	Towns of Hudson and Stow

3.4.5 MONITORING PROGRAM

The implementation monitoring program should begin when the work begins on the Watershed Management Plan implementation, currently scheduled for January 1989. Sampling should occur on a quarterly, or seasonal, basis for the three year post-implementation period running until January of 1992. Parameters for sampling should include the following:

1) temperature profiles within one meter intervals
2) dissolved oxygen profiles within one meter intervals
3) pH
4) total alkalinity
5) suspended solids
6) dissolved solids
7) conductivity
8) Kjeldahl nitrogen
9) ammonia nitrogen
10) nitrate nitrogen
11) total phosphorous
12) total and fecal coliform bacteria
13) turbidity
14) flow rate (either instantaneous or time-integrated)
15) chlorophyll _a_

3.4.6 ENVIRONMENTAL EVALUATION

Since the project does not involve any construction, the only environmental effects are positive and relate to water quality improvements relative to the no-action alternative.

a. Historical Commission. No approval is required since no potential historic or archaelogic resources could be impacted by the project.

b. Evaluation of Chemical Treatment. Use of chemicals is not involved in the proposed project.

c. Dredging Evaluation. Dredging is not proposed.

d. Effects on fish and wildlife, wetlands or wildlife habitat. The prevention of water quality deterioration over time will have generally beneficial effects on aquatic resources. Although weed harvesting removes some aquatic vegetation that may be used as cover for fish, only the densest areas of growth are to be harvested, leaving adequate amounts of vegetation for cover.

None of the components of the proposed project, including weed harvesting, require Conservation Commission review under the Wetlands Act or MEPA and U.S. Fish and Wildlife Service review.

e. Downstream Effects. None

f. Mitigation Measures. None required.

3.4.7 RECREATIONAL PLAN

Although the possible development of a recreational plan for Lake Boon was discussed in the proposal for this project, expansion of current recreational uses of the lake was not considered desirable by interested residents who attended the first public meeting or by the Lake Boon Commission. Because of this, no formal recreational plan to expand recreational use at Lake Boon is included at present.

PUBLIC MEETING AGENDA

lay

the Johnson Auditorium, in the Walker Build-
s. The performance was part of the Greater

Staff photo by Steve Jusseaume

Hearing is tomorrow on Lake Boon study

HUDSON — The Lake Boon Commission will hold a public hearing in the selectmen's office of Town Hall at 7:30 p.m., tomorrow.

The hearing will provide the commission, its advisory committee, and residents of Hudson and Stow with up-to-date findings of the Lake Boon study, which has been underway since last fall.

Camp Dresser and McKee of Boston is performing the study. When complete, it will identify various sources of declining water quality in the lake and suggest corrective measures.

At the hearing, firm engineers will present interim findings and recommendations and will solicit input from those in attendance.

Solutions to the problem, which includes excessive weed growth, will be neither short-term nor inexpensive, according to Commission Chairman Alan Kattelle.

The state is funding the current study along with local aid from Hudson and Stow.

For further information, contact Alan Kattelle, Hudson commissioner at 562-9184 or Donald Hawkes, Stow commissioner, 562-6630.

Editorial

Page 14 Wednesday, March 26, 1986

'Boon or bust' drive must not die in April

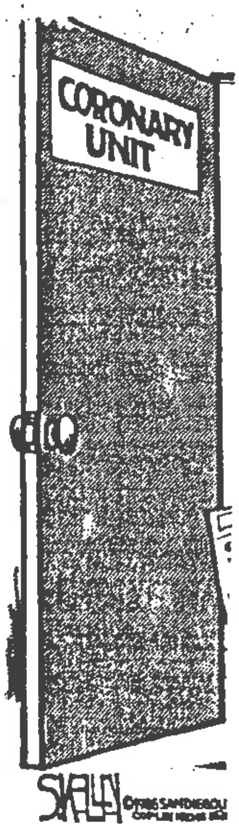
The concern that runs deeply, if quietly, in Hudson, Stow and neighboring communities for correcting the weed and pollution problems in Lake Boon could end next month.

But it shouldn't. Chances are that when technical experts from Camp, Dresser and McKee of Boston present their interim report on the health of the lake at a public meeting April 2, the recommended "cure" will involve a lot more time, money and disruption that anyone really wants to face up to.

The report, commissioned with Hudson, Stow and state funds by the Lake Boon Commission, is likely to point out that the troublesome excessive weed growth in the favored recreational lake in the area is a symptom. The real problem, most likely, will turn out to be a combination of chemical run-off from above-ground fertilizers and lawn treatments, and underground nitrate sources like leaky septic systems or sewer pipes.

Fixing all that, as Commission Chairman Alan Kattelle has already indicated, will be neither quick nor cheap. That fact that could tend to take some of the vigor out of the public zeal for cleaning up Lake Boon. It must not, though.

It's time to toughen public determination to go for the long haul and to see through the campaign to clean Lake Boon. Even if the word April 2 (Hudson Town Hall, 7:30 p.m.) is that it will take more time and money than anyone wanted.



it poli

Correction

HUDSON — Yesterday's editions incorrectly stated that the Lake Boon Commission will meet tonight in the Hudson Town Hall. The meeting is scheduled for Wednesday, April 2.

BURIED ON PG 4!

Lake cleanup progress aired

By DONALD ST. JOHN
News Staff Writer

Engineering consultants will outline their progress in a "weed study" and in trying to come up with a plan to clean plant-choked Lake Boon at a hearing Wednesday night.

The lake's problem is well-known, meaning that potential solutions will be a primary topic of discussion at the 7:30 p.m. meeting in Hudson Town Hall, said Lake Boon Commission member Donald Hawkes of Stow.

"It's a natural process of nitrogens leaching into the water through the sandy soils of septic systems from nearby houses," Hawkes said. "Basically, it creates fertilizer."

The process, known as eutrophication, creates a healthy breeding ground for both green weeds and algae, which have made parts of the lake almost "useless" for recreational boating and swimming, Hawkes said.

"The perceived problem of weeds is most noticeable in the shallower ends," he said. The lake was man-made about 150 years ago, and some basins are shallower than others, he said.

Consultants from the Boston engineering firm Camp Dresser and McKee and IEP of Northboro, which have been studying the lake and its water quality, will be present at the Wednesday hearing and another one in the fall, Hawkes said.

There, they will discuss findings to date and hear ideas for a feasibility study of ways to clean Lake Boon.

"There will be state funding available," Hawkes said. "The current study is partly state-funded; they picked up 60 percent of the cost, and Stow and Hudson split the other 40 percent.

"In the implementation phase, it's a 90 percent-10 percent split, so the state bears most of the burden," he said. "Of course, it depends on the bidding process, and the magnitude of the final recommendations."

A recent report by the Metropolitan District Commission aimed at identifying potential water sources to avoid future shortages included Lake Boon.

But although Hawkes said the lake has never had a coliform bacteria or any other serious health problem, the weed and algae problem is first on its agenda.

"We'll probably have about three possible solutions on the table at the fall hearing, down from maybe 10 at this Wednesday's," he said. "One might be a gold-plated solution, which would restore the lake to pristine condition.

"You might also have a Band-Aid approach, to do the minimum you can. The third would be something in the middle — maybe something over a phased period, to minimize the cost impact," Hawkes said.

The lake lies mostly within Stow, with about one-third of its area in Hudson. The membership of the commission parallels this; two members come from Stow, one from Hudson.

However, the membership of a technical advisory commission reversed the weight toward Stow, slanting two-to-one toward Hudson residents, Hawkes said.

PUBLIC MEETING AGENDA

DIAGNOSTIC/FEASIBILITY STUDY
LAKE BOON

INTRODUCTION

STUDY COMPONENTS

- Diagnostic Study
  - Sampling and Analysis
  - Septic System Survey
- Feasibility Study
  - Alternative Identification
  - Preliminary Screening
  - Selection of Best Alternative
  - Proposed Project

FINDINGS TO DATE

LIST OF TECHNOLOGIES

ALTERNATIVES DEVELOPMENT

SUMMARY

OPEN DISCUSSION

OVERVIEW

LAKE BOON

DIAGNOSTIC/FEASIBILITY STUDY

The purpose of this meeting is to present the results of work to date on the Lake Boon Diagnostic/Feasibility Study, and to describe some of the methods that are available for correcting problems in the lake.

Lake Boon has been studied extensively in the past. Because of this, only a limited amount of new data is being collected to make sure that no significant changes have occurred since the last study and to provide more detail in particular areas. The following results have been obtained:

- Water quality results from this study have been generally consistent with those of the Division of Water Pollution Control study of 1979-80. However, the results from samples to be collected during the growing season will be necessary to fully confirm this.

- Aquatic weed problems appear to be the result of shallow depths, rich organic sediments and high nutrient levels.

- Two of the primary sources of nutrients to the lake that may be controllable are 1) runoff from roads and residences and 2) septic system leachate that enters the lake.

The main purpose of this study is to develop a plan for the restoration of Lake Boon. This plan must take into account the unique aspects of the lake, and it must be practical and affordable.

A number of technologies for lake restoration are presented on the next page, representing a wide range of cost and effectiveness.

Several feasible alternatives will be selected out of this list of alternative technologies. These that are selected will then be evaluated further and combined into three or four alternative "projects". These "projects" which will represent a range of cost and degrees of effectiveness, will be presented at the second public meeting to be held next fall. Following public input, the proposed project can then be selected.

LIST OF TECHNOLOGIES

PHYSICAL

- Dredging
- Weed Harvesting
- Aeration
- Mixing
- Diversion of Stormdrains
- Treatment of Inflows
- Benthic Barriers
- Sewer Inspection
- Sewer Installation
- Dilution
- Drawdown
- Watershed Management
- Power Boat Regulation

BIOLOGICAL

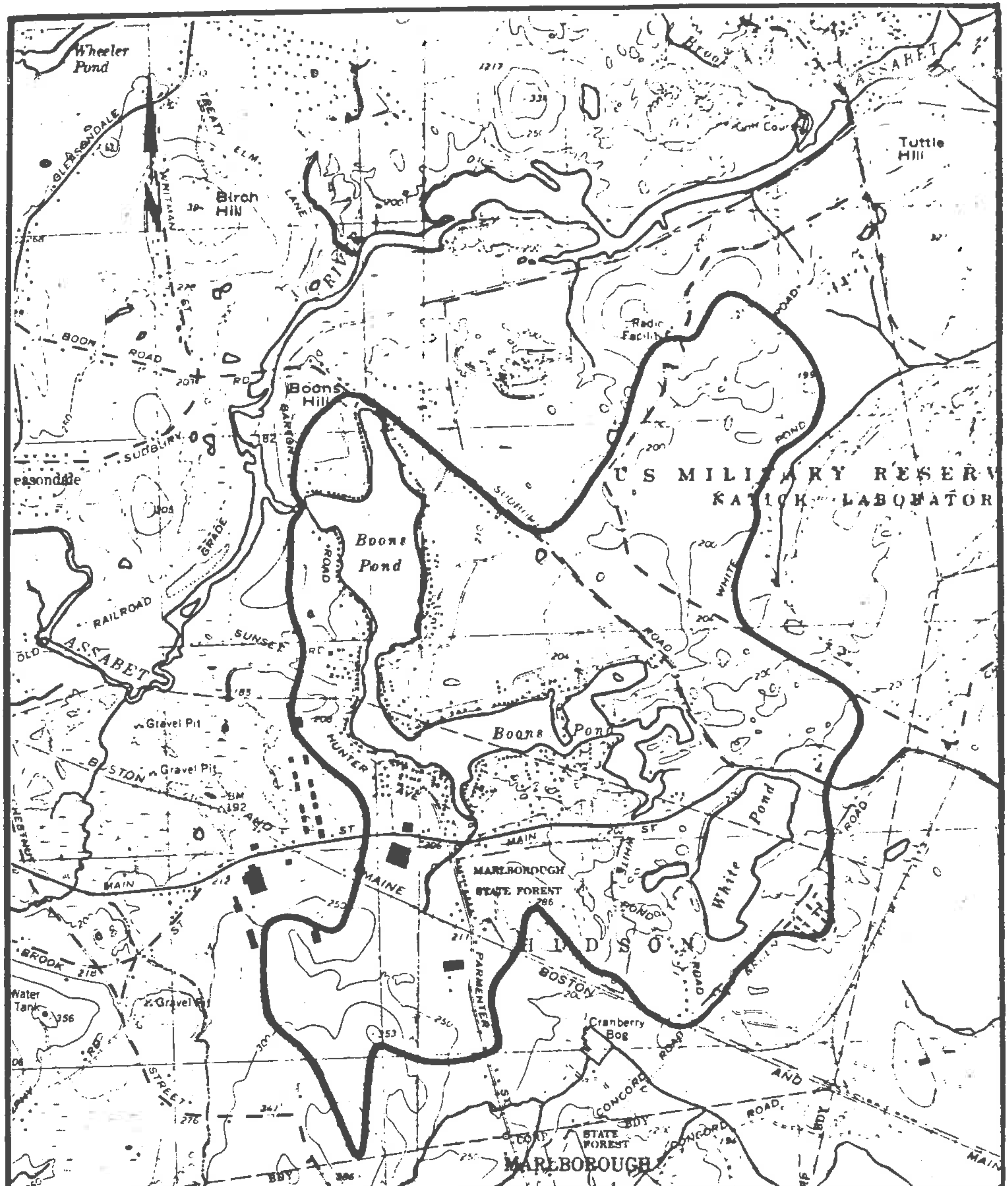
- Fish Removal and Restocking
- Zooplankton Manipulation
- Wetlands Treatment

CHEMICAL

- pH Adjustment
- Algicides
- Herbicides
- Chemical Precipitation
- Light Blockage
- Trace Chemical Addition
- Flyash

CULTURAL

- Public Education Programs



LOCUS MAP

LAKE BOON

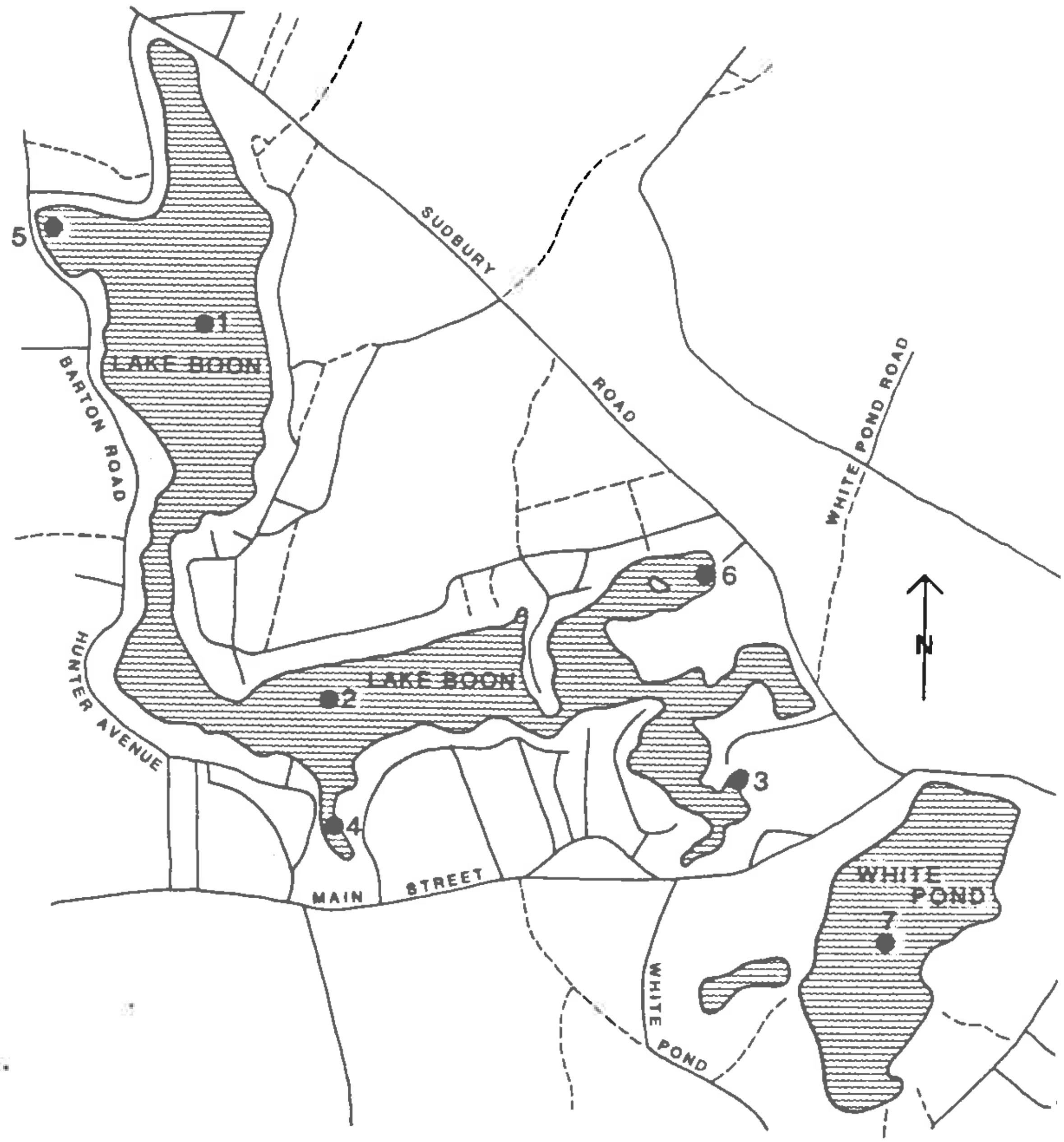
HUDSON MASSACHUSETTS

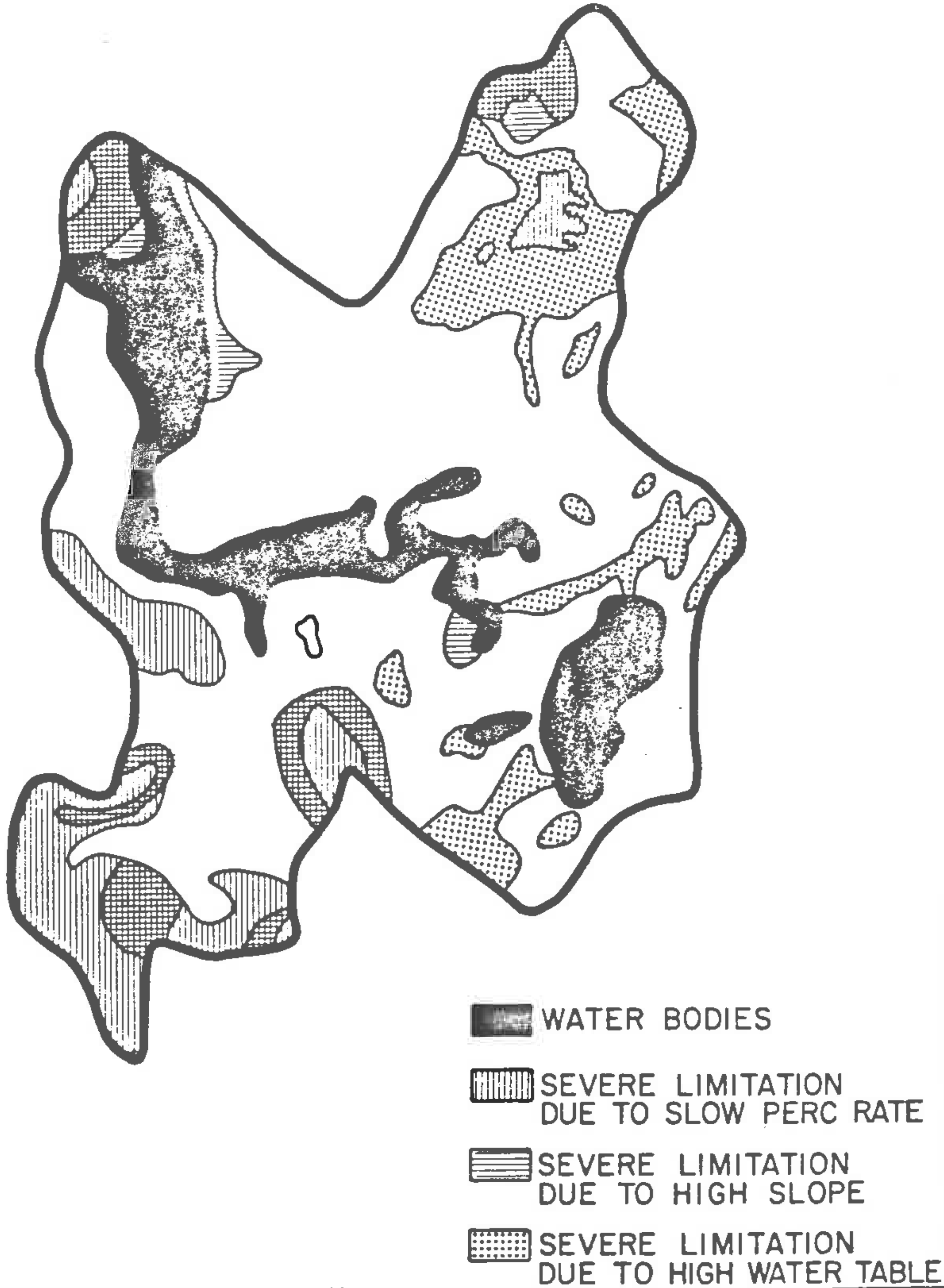
0 1/2 1 MILE

BASELINE DATA

Location of Sampling Stations

Lake Boon





FIGURE

LAKE BOON

SOILS LIMITATIONS TO SEPTIC SYSTEMS

0 1000 2500 5000 FT.

IEP inc.

MEETING MEMO

PUBLIC MEETING, LAKE BOON, HUDSON TOWN HALL

April 2, 1986 7:30 p.m.

The meeting was opened and introductions were made by Mr. Alan Katelle of the Lake Boon Commission. About 35 persons were in attendance. The meeting was well advertised through newspaper ads and flyers distributed to shoreline residents. Eileen Pannetier from Camp Dresser & McKee Inc. and Scott Bailey from IEP, Inc. presented the basic components of the Diagnostic/Feasibility study of Lake Boon as well as the results of the study to date. Various types of technologies used on lakes were presented and the preliminary screening of alternatives was discussed. Alternative technologies not suitable for Lake Boon were eliminated, and the remaining alternatives were described. The presentation consisted of a slide show, handouts, and a discussion period moderated by Mr. Katelle. A copy of the handout, the advertisements for the meeting, and the sign up sheet are attached.

Comments and questions raised during the discussion period are summarized below.

- We should look at scraping (dry dredging) of individual basins, possibly by draining one basin at a time.
- Treatment of polluted inflows (from overland runoff) should be examined using some type of basin.
- Dredging will be too expensive, and harvesting only treats the symptoms.
- Some questions were raised about the groundwater flows and reasons for low flushing rate of the lake. Also questions on differences between soils considered suitable from the standpoint of lakes as opposed to soils that have rapid percolation rates and pass the percolation tests.
- There is some new information that should be obtained from SCS on soils potential. Also new groundwater data from MAPC.
- Methods and techniques that can be used by individual residents to improve their shoreline conditions should be addressed, such as weed screens and other methods.
- Interest in the use of dye was expressed but with many concerns over the appearance of the dye and transparency problems.
- White Pond should be compared for types and extent of vegetation since it does not have the shoreline residences that Lake Boon has and does not appear to have the same weed problems also.

- Several residents felt that sewering of the shoreline homes was necessary as a long-time measure, others felt it would be too expensive.

- Dick Gelpke from the Lake Boon Commission mentioned that the progress reports were available for public review, and also had several comments on the most recent progress report, including: the land use map needs some revisions to reflect new developments; the town line shown on several maps was relocated slightly and should be revised; it should be noted that Hudson enacted conversion by-laws recently.

- Don Hawkes of the Lake Boon Commission asked what would happen to the Lake if nothing is done, and the gradual filling in and further eutrophication of the Lake was discussed.

LAKE [illegible] STUDY
MTG - [illegible]/2/86;

NAME	ADDRESS
Patricia & Stephen Pollard	19 Hale Rd. Stow
KEN RAINA	106 No. Shore Dr. STOW
JEFF LOVELL	88 PINE POINT Rd.
Isaac E. King	25 Worcester Ave Hudson
DAVID KAPLAN	25 HALLOCK POINT RD STOW
DICK GELPKE	53 LAKESIDE AVE - HUDSON
Phyllis Frechette	113 Hunter Ave., Hudson
STEVEN KATZ	4 DAVIS RD. STOW
Wm. C Brandon	100 North Shore Dr. Stow
EDNA A JOHNSON - PAUL D JOHNSON	114 BARTON RD STOW
[illegible]	Hudson Sun
Linda Rogers	92 PINE Point RD Stow
[illegible] Gail Downey	81 Barton Rd Stow
Freddy Duissault	43 Hale Rd Stow
Reinhard Schumann	12 Davis Rd Stow
John McGrath	51 Hunter Ave, Hudson
John O'Buck	8 DAWES Rd, STOW
PATTE RICE	8 DAWES Rd, STOW
Thomas MORGAN	63 LAKESIDE Ave Hudson
Tom Gately	39 Worcester Ave Hudson
[illegible]	Middlesex News
Todd Alving	82 North Shore Drive
LEE ESTRIN	145 BARTON RD STOW
	Natalie Kattelle, Hudson
Mary Anne [illegible]	21 Lakeside Ave Hudson

PRESS RELEASE

FOR IMMEDIATE RELEASE

July 7, 1987

For further information call:
Donald Hawkes - 562-6630
Alan Kattelle - 562-9184
Keith Myles - 562-6109

LAKE BOON COMMISSION TO HOLD PUBLIC HEARING

Water quality and aquatic weed growth in Lake Boon, which has been studied for nearly a year and a half, will be the focus of a public hearing to be held at the Stow Town Hall, 7:30 P.M., Wednesday, July 15, 1987. The Lake Boon Commission oversees the local body of water, which lies partly in Stow and partly in Hudson.

The study, jointly funded by the state's Clean Lakes Program and both towns, seeks to identify causes of deteriorating water quality and to recommend action which may be taken to improve the Lake's condition. Representatives of the consulting firm of Camp, Dresser and McKee will present their findings to concerned area residents/property owners. The Commission has also invited state officials and members of Boards and Commissions of both towns to hear the findings and recommendations of the study.

"The future of this recreational resource, as well as area property values, depends upon the action taken as a result of this report," stated Commission Chairman Donald Hawkes of Stow. "We hope to gain wide support for action which can improve, and then maintain, the water quality of Lake Boon."

THE LAKE BOON COMMISSION

HUDSON AND STOW, MASSACHUSETTS
LAKE BOON

COMMISSIONERS:

Donald Hawkes - Stow
Alan Kattelle - Hudson
Keith Myles - Stow

June, 1987

Dear Lake Boon Area Resident:

"Our lake is dying - parts of it will be a swamp in our lifetime."

"There's no problem with Lake Boon - just a few weeds."

Do either of these paraphrased statements reflect an accurate picture of the condition of our valuable resource? As in the case of most general statements, the truth probably lies somewhere in the middle.

The Lake Boon Commission has spent a year and a half and a considerable sum of money in studying the lake's condition, and is now calling a public hearing to hear the consultant's report and recommendations. Ample time will be available to discuss these issues.

The next step in the process of moving toward a cleaner lake - one which will be available to us as a recreational resource as well as increasing our property values - is to apply to the state for funding to begin to implement the study's findings. This will require appropriation by the Town Meetings of both Hudson and Stow of 25% of the total funding sought. If we are to end up with any result from this long process except a consultant's final report left to gather dust on a shelf, we must have significant public support. Thus we urge all lake area residents and/or property owners to attend the public hearing listed below.

Thank you for your support.

PUBLIC HEARING

Wednesday, July 15, 1987 - 7:30 P.M.
Stow Town Hall

PUBLIC MEETING

July 15, 1987

Lake Boon Study

Towns of Hudson & Stow, Massachusetts
and the Lake Boon Commission

AGENDA

LAKE BOON DIAGNOSTIC/FEASIBILITY STUDY

Second Public Meeting

I. INTRODUCTION	Lake Boon Commission
II. STUDY COMPONENTS Diagnostic Study Feasibility Study	Camp Dresser & McKee Inc. and IEP, Inc.
III. PROPOSED PROJECT	Camp Dresser & McKee Inc. and IEP, Inc.
IV. OPEN DISCUSSION	Lake Boon Commission

LAKE BOON DIAGNOSTIC STUDY

<u>GENERAL INFORMATION</u>

o Data Collection

o Watershed Description

o Recreational Description

o Geological Description

o Historical Account

<u>INVESTIGATIONS</u>

o Physical Measurements

o Water Quality Sampling

o Storm Surveys

o Sediment Analyses

o Source Investigations

FIGURE 1

LAKE BOON WATERSHED

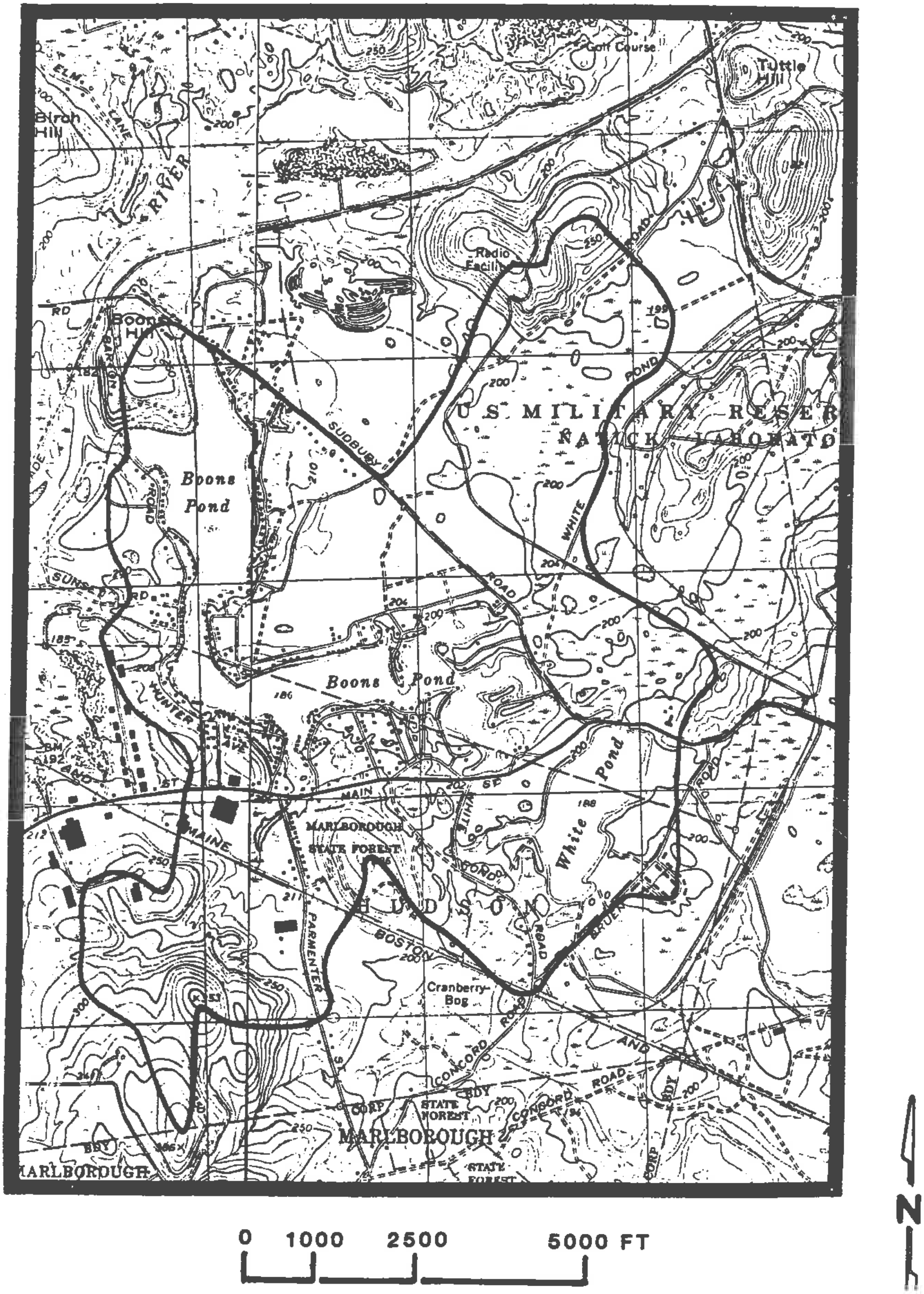
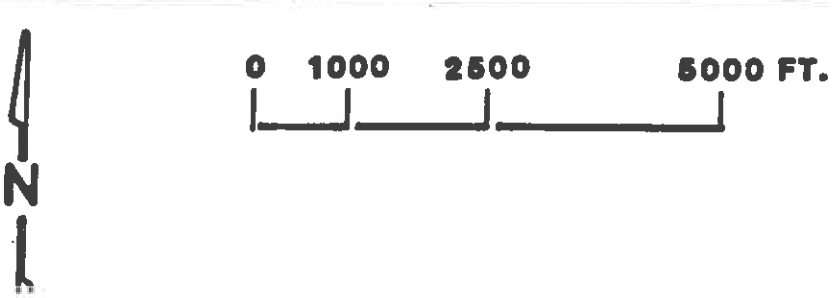


FIGURE 6
SAMPLING STATIONS 1985-1986
LAKE BOON
HUDSON/STOW, MA



LAKE BOON FEASIBILITY STUDY

ALTERNATIVE IDENTIFICATION AND EVALUATION

- o Identification of All Possible Alternatives
- o Preliminary Screening
- o Selection and Evaluation of Best Alternatives
  - Effects on Water Quality
  - Overall Effectiveness
  - Cost/Benefit Ratio
  - Probability of Implementation

DEVELOPMENT AND DETAILED EVALUATION OF PROPOSED PROJECT

- o Cost Effectiveness
- o Projected Water Quality/Recreational Improvements
- o Impacts on Annual Nutrient Budget
- o Permitting and Monitoring Program

SUMMARY OF PROPOSED PROJECT

Lake Boon Diagnostic/Feasibility Study

Component	Description
A. Hydroraking	Contracted for 1 year only. Consists of aquatic vegetation by uprooting. May have carryover benefits to next year. Purpose is to provide interim relief for aquatic weed problems.
B. Watershed Management Plan	Purpose is to reduce/control pollution in Lake Boon over the long term. Steps include a voluntary pumping program for septic systems; new Town bylaws requiring the upgrading of cesspools upon resale of housing; and the implementation of a public education program.
C. Weed Harvester Plan	Weed harvester for annual summer use to be purchased and operated for long-term control of nuisance aquatic vegetation.

COST SUMMARY OF PROPOSED PROJECT

Lake Boon Diagnostic/Feasibility Study

Component	Capital Cost	Annual Cost	Share Capital	Share Annual
A. Hydroraking (1 year only)	$38,000		$9,500-38,000[1]	
B. Watershed Management Plan[2]	$30,000	$10,000	$7,500	$10,000
C. Weed Harvester Purchase and Operation	$50,000	$18,000	$12,500	$18,000
TOTALS	$118,000	$28,000	$29,500-58,000	$28,000

(1) Hydroraking is eligible for funding but is not a prefered use for DWPC Clean Lakes money and generally receives very low priority.

(2) Components include development of bylaws for cesspool conversion and a public education program (capital cost) and the administration of a septic system pumping program and a continuing public education program.

1625 Trapelo Road
Waltham, MA 02154
July 20, 1987

Mr. Donald Hawks, Chairman
Lake Boon Commission
Stow, MA 01775

Dear Mr. Hawks:

We attended the public hearing held on July 15, 1987 and found the hearing to be both encouraging and informative. Long time residents of the lake, such as ourselves, fully realize that the life of Lake Boon is limited if the weed problem/pollution is not reversed.

We applaud the Commissions' efforts in seeking a solution to the weed infestation. Likewise we endorse the program proposed by Camp, Dresser & Mc Kee as a result ot their diagnostic/feasilility study. Implementation of such a program will serve as a major step toward the preservation of Lake Boon.

Please plan on our support, financial and other, in your effort to preserve this unique and beautiful body of water.

Very truly yours,

Louise Butler
William C. Butler
Hallock Point Road
568-8497
890-2828

cc: ✓ Eileen Pannener
Camp, Dresser & Mc Kee

FORM DWPC-628-01

APPENDIX C

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
DIVISION OF WATER POLLUTION CONTROL

CLEAN LAKES PROGRAM

REQUEST FOR ASSISTANCE

1. State the legal name of the lake or pond and its specific location.

   Lake Boon. Located in the northeastern portion of Hudson and the southeastern portion of Stow, Massachusetts.

2. State the ownership of the lake or pond. If water rights are privately owned then this must also be stated.

   Town of Hudson and Town of Stow.

3. Describe in detail the public access area(s) including its location relative to the lake and public roadway. This description must include a locus map clearly indicating the public access area(s).

   Public access off Sudbury Road in Stow. Public beach off Sudbury Road for Stow residents.

4. Describe the recreational uses of the lake. Be sure to include historical uses, if different.

   Swimming, boating, fishing, skating.

5. Describe the particular problems and nuisance conditions affecting the lake.

   Excessive aquatic weed and algal growth.

FORM DWPC-628-01

6. What type of project do you seek to implement?

Phase II Implementation

7. Submitted by:

Camp Dresser & McKee Inc. for

Lake Boon Commission
Applicant's Name (print or type)

53 Lakeside Avenue
Address

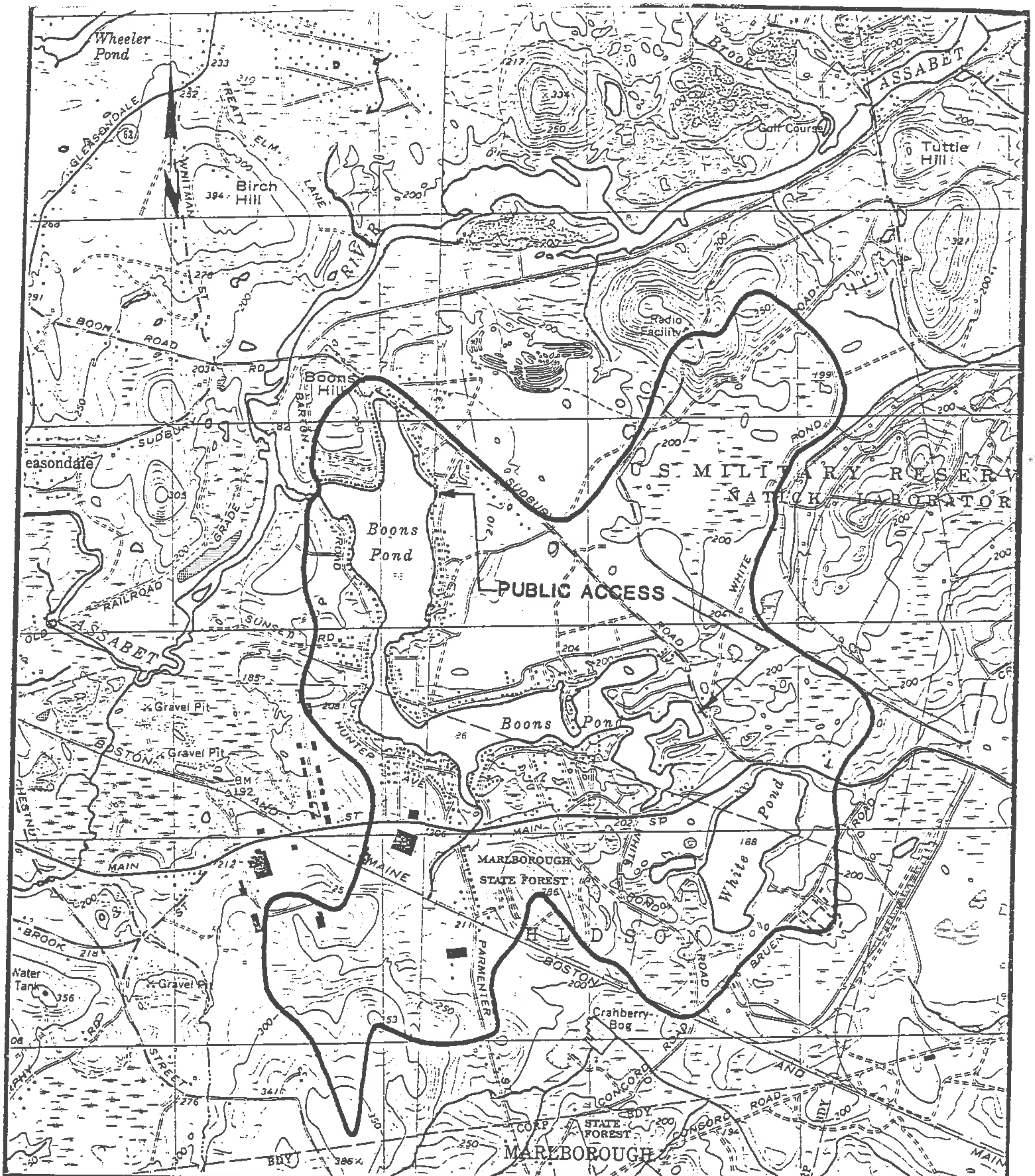
Title

Hudson, MA 01749
City/Town

Eileen Pannetier
Signature Camp Dresser & McKee Inc.

(617) 562-3535
Tel. No.

Return to: Lakes Section, Division of Water Pollution Control, Lyman School, Westview Building, Westborough, Massachusetts 01581



HUDSON AND STOW
MASSACHUSETTS

0 1/2 1 MILE

PUBLIC ACCESS
LAKE BOON

LIMNOLOGIC DATA

Table A1. Lake Boon, pH Analyses (standard units)

Date	Station Number 1 surface	1 bottom	2 surface	2 bottom	3	4	5	6	7
10/29/85	6.8	6.8	6.9	7.0	NA	6.1	7.0	6.9	6.9
01/28/86	6.4	6.4	5.7	6.5	4.5	5.6	6.6	6.0	6.4
04/08/86	6.6	6.4	6.6	6.5	4.8	5.9	6.6	NA	6.6
07/29/86	7.4	6.3	7.1	6.6	4.7	5.9	7.2	NA	7.0

NA = No sample taken, dry inlet

Table A2. Lake Boon, Total Alkalinity Analyses (mg/l)

Date	Station Number 1 surface	1 bottom	2 surface	2 bottom	3	4	5	6	7
10/29/85	11	11	11	11	NA	8.8	11	9.4	10
01/28/86	7.0	8.9	3.5	9.3	<1	2.7	8.3	9.3	4.8
04/08/86	11	8.8	10	8.36	1.81	5.85	11	NA	9.04
07/29/86	9.9	16	9.9	12	2.2	6.4	9.9	NA	7.0

NA = No sample taken, dry inlet

Table A3. Lake Boon, Total Suspended Solids Analyses (mg/l)

Date	Station Number 1 surface	1 bottom	2 surface	2 bottom	3	4	5	6	7
10/29/85	6.0	0.8	<0.4	0.4	NA	2.0	1.6	1.6	0.8
01/28/86	1.6	1.2	2.4	6	5.3	4	2.4	18	0.4
04/08/86	<0.4	5.2	0.8	2	6.8	0.8	1.2	NA	3.6
07/29/86	4.0	8.0	5.2	7.0	16	5.0	4.5	NA	5.6

NA = No sample taken, dry inlet

Table A4. Lake Boon, Total Dissolved Solids Analyses (mg/l)

Date	Station Number 1 surface	1 bottom	2 surface	2 bottom	3	4	5	6	7
10/29/85	49	25	49	49	NA	76	53	65	68
01/28/86	35	59	32	64	45	45	35	80	32
04/08/86	55	53	55	56	116	60	57	NA	62
07/29/86	108	63	67	71	187	124	61	NA	76

NA = No sample taken, dry inlet

Table A5. Lake Boon, Turbidity Analyses (NTU)

Date	Station Number 1 surface	1 bottom	2 surface	2 bottom	3	4	5	6	7
10/29/85	2.5	2.5	<2	3.5	NA	<2	<2	4	<2
01/28/86	<2	2	8	4	11	<2	<2	32	<2
04/08/86	<2	3	3	3	4	4	2	NA	<2
07/29/86	4	2	2	4	2	2	<2	NA	<2

NA = No sample taken, dry inlet

Table A6. Lake Boon, Conductivity Analyses (umhos/cm)

Date	Station Number 1 surface	1 bottom	2 surface	2 bottom	3	4	5	6	7
10/29/85	93	93	93	91	NA	117	95	87	91
01/28/86	64	81	47	100	55	51	76	129	51
04/08/86	86	84	87	84	69	82	86	NA	79
07/29/86	91	96	94	96	80	137	96	NA	86

NA = No sample taken, dry inlet

Table A7. Lake Boon, Chloride Analyses (mg/l)

Date	Station Number 1 surface	1 bottom	2 surface	2 bottom	3	4	5	6	7
10/29/85	16	16	17	18	NA	21	16	16	16
01/28/86	17	21	11	24	13	13	22	39	14
04/08/86	18	18	19	18	15	15	19	NA	18
07/29/86	23	20	21	22	21	32	21	NA	17

NA = No sample taken, dry inlet

Table A8. Lake Boon, Kjeldahl-Nitrogen Analyses (mg/l)

Date	Station Number 1 surface	1 bottom	2 surface	2 bottom	3	4	5	6	7
10/29/85	0.60	0.61	0.66	0.84	NA	0.48	0.64	0.75	0.65
01/28/86	0.28	0.35	0.91	0.52	0.84	0.70	0.86	0.91	0.67
04/08/86	0.25	0.21	0.24	0.32	3.4	0.25	0.26	NA	0.25
07/29/86	0.34	0.45	0.48	0.39	2.2	0.20	0.37	NA	0.16

NA = No sample taken, dry inlet

Table A9. Lake Boon, Ammonia-Nitrogen Analyses (mg/l)

Date	Station Number 1		2		3	4	5	6	7
	surface	bottom	surface	bottom					
10/29/85	0.13	0.21	<0.10	<0.10	NA	<0.10	<0.10	<0.10	<0.1
01/28/86	<0.10	<0.10	0.14	<0.10	0.25	<0.10	<0.10	0.19	<0.10
04/08/86	0.014	0.015	<0.01	<0.01	0.011	0.042	<0.01	NA	<0.01
07/29/86	<0.010	<0.010	<0.010	0.017	0.034	0.019	<0.010	NA	<0.010

NA = No sample taken, dry inlet

Table A10. Lake Boon, Nitrate-Nitrogen Analyses (mg/l)

Date	Station Number 1		2		3	4	5	6	7
	surface	bottom	surface	bottom					
10/29/85	0.05	0.09	0.08	0.08	NA	0.88	0.09	<0.012	<0.012
01/28/86	0.10	0.16	0.14	0.21	0.07	0.22	0.10	0.01	0.04
04/08/86	0.16	0.12	0.069	0.11	0.052	0.28	0.071	NA	0.026
07/29/86	0.08	0.14	0.13	0.03	0.10	1.4	0.03	NA	0.03

NA = No sample taken, dry inlet

Table A11. Lake Boon, Total Phosphorus Analyses (mg/l)

Date	Station Number 1 surface	1 bottom	2 surface	2 bottom	3	4	5	6	7
10/29/85	0.04	<0.01	<0.01	<0.01	NA	*	*	0.03	<0.01
01/28/86	<0.01	<0.01	0.01	<0.01	0.06	<0.01	<0.01	0.04	<0.01
04/08/86	<0.01	0.015	<0.01	0.011	0.30	0.014	0.013	NA	<0.01
07/29/86	<0.01	0.03	0.01	<0.01	0.28	<0.01	<0.01	NA	<0.01

NA = No sample taken, dry inlet

* No analysis available due to lab error

Table A12. Lake Boon, Total Coliform Analyses (colonies/100 ml)

Date	Station Number 1	2	3	4	5	6	7
10/29/85	0	0	NA	0	0	0	0
01/28/86	0	27	11	22	4	106	1
04/08/86	0	6	5	6	5	NA	1
07/29/86	<10	40	*	2,500	50	NA	1,000

NA = No sample taken, dry inlet
* = confluent growth

Table A13. Lake Boon, Fecal Coliform Analyses (colonies/100 ml)

	Station Number						
Date	1	2	3	4	5	6	7
10/29/85	3	0	NA	0	1	1	0
01/28/86	0	24	1	4	0	0	4
04/08/86	0	2	0	4	2	NA	0
07/29/86	*	*	*	*	*	NA	*

NA = No sample dry inlet
* = confluent growth

Table A14 . Lake Boon, Iron Analyses (mg/l)

	Station Number								
Date	1		2		3	4	5	6	7
	surface	bottom	surface	bottom					
10/29/86	0.26	0.26	0.17	0.12	NA	0.30	0.15	0.43	*
01/28/86	0.05	0.05	0.11	0.21	0.45	0.14	0.28	7.2	0.27
04/08/86	0.08	0.18	0.17	0.21	1.8	0.31	0.10	NA	0.14
07/29/86	<0.02	0.15	0.08	0.34	3.0	0.21	<0.02	NA	<0.02

* = No analysis due to lab error
NA = No sample taken, dry inlet

Table A15. Lake Boon, Chlorophyll-a (mg/m^3) and Secchi Disc Transparency (m)

Date	Station 1		Station 2		Station 7
	chlorophyll-a	Secchi Disk	chlorophyll-a	Secchi Disk	Secchi Disk
10/29/85	9.6	3.0	8.7	2.5	3.2
01/28/86	3.59	NA	5.45	NA	NA
04/08/86	11.0	2.7	8.6	2.7	2.6
07/29/86	16	1.7	14	1.7	6.0

NA = Secchi disk not measured at ice cover

Table A16. Lake Boon, Phytoplankton Analyses (cells/ml); Station 1

	10/29/85	01/28/86	04/08/86	07/29/86
Bacillariophyceae "diatoms"				
Amphora	13			
Asterionella		27	40	
Cocconeis		80		
Cyclotella	93		40	20
Fragilaria	27			
Navicula	13		40	80
Synedra	53			20
Tabellaria				60
Subtotal	199	107	120	180
Chlorophyceae "green algae"				
Ankistrodesmus		27		40
Arthrodesmus				80
Chlamydomonas		13	160	40
Chlorella	40			40
Chlorococcum	13			
Closteriopsis	53	40	40	20
Elakatothrix	67		40	40
Gloeocystis		93		140
Pediastrum			20	20
Oocystis			20	60
Radiococcus				20
Scenedesmus	13	13	120	
Schroederia			60	20
Sphaerocystis	40	133	180	220
Staurastrum	13			20
Subtotal	239	319	640	760
Chrysophyceae "other pigmented algae"				
Chrysococcus			200	
Dinobryon	27	173	40	20
Mallomonas	13			
Subtotal	40	173	240	20

Table A16. (continued)

Cryptophyceae				
Cryptomonas				80
Subtotal	0	0	0	80
Cyanophyceae "blue green algae"				
Anabaena	27		20	840
Aphanocaspsa (colonies/ml)	27			20
Gloeotrichia				20
Oscillatoria (filaments/ml)	13			
Subtotal	67	20	0	880
Euglenophyceae/Dinophyceae				
unidentified		13		
Subtotal	0	13	0	0
Total (cells/ml)	545	625	1020	1920
Total genera	17	11	14	22

Note: Colonial and filamentous algae are counted as natural units/ml. Algae that occur as single cells are counted as cells/ml.

Table A17. Lake Boon, Phytoplankton Analyses (cells/ml); Station 2

	10/29/85	01/28/86	04/08/86	07/29/86
Bacillariophyceae "diatoms"				
Asterionella			20	
Cocconeis		13		
Cyclotella			40	
Diatoma	13			
Eunotia	27			
Fragilaria	53		20	
Navicula	40	27		
Synedra	40			20
Tabellaria	13	13		20
Subtotal	186	53	80	40
Chlorophyceae "green algae"				
Ankistrodesmus				60
Arthrodesmus				20
Carteria		40		
Chlamydomonas		200	80	
Chlorella	27			60
Closteriopsis	40			
Closterium	27			
Elakatothrix				60
Gloeocystis				120
Golenkinia				20
Oocystis	13			40
Sphaerocyctis			40	180
Subtotal	107	267	120	620
Chrysophyceae "other pigmented algae"				
Chrysococcus		173	20	
Dinobryon			60	80
Mallomonas	27		40	
Unidentified			40	
Subtotal	27	173	160	80
Cryptophyceae				
Cryptomonas		27		60
Subtotal	0	27	0	60

Table A17. (continued)

Cyanophyceae "bluegreen algae"				
Anabaena	13			660
Aphanocaspsa (colonies/ml)	13			
Subtotal	26	0	0	660
Euglenophyceae/Dinophyceae				
Euglena	13	13		
unidentified		13		
Subtotal	13	26	0	0
Total (cells/ml)	359	519	360	1400
Total genera	14	9	9	13

Note: Colonial and filamentous algae are counted as natural units/ml. Algae that occurs as single cells are counted as cells/ml.

Table A18. White Pond, Phytoplankton Analyses (cells/ml); Station 7

	10/29/85	01/28/86	04/08/86	07/29/86
Bacillariophyceae "diatoms"				
Cyclotella	13		40	
Diatoma	27			
Fragilaria		13		
Frustulia	13			
Melosira	27			
Navicula	40	93	80	120
Synedra	53	133	300	
Tabellaria	27		60	
Subtotal	200	239	480	120
Chlorophyceae "green algae"				
Ankistrodesmus			20	
Anthrodesmus			20	13
Carteria				13
Chlamydomonas			120	13
Chlorella		13	140	146
Closteriopsis	80	40		13
Euastrum			13	
Oedogonium	40			
Oocystis				53
Scenedesmus	13			
Sphaerocystis				53
Ulothrix			20	
Unidentified			20	
Subtotal	133	53	300	317
Chrysophyceae "other pigmented algae"				
Centritractus	146	27	100	
Chrysococcus	67	13	80	
Dinobryon		226	1000	
Mallomonas	13			
Ochromonas			80	
Subtotal	226	266	1260	0
Cryptophyceae				
Cryptomonas				13
Subtotal	0	0	0	13

Table A18. (continued

Cyanophyceae "blue green algae"				
Aphanocaspsa (colonies/ml)	13			
Subtotal	13	0	0	0
Unknown				
Unidentified	13			
Subtotal	13	0	0	0
Total (cells/ml)	585	558	2080	450
Total genera	15	8	14	10

Note: Colonial and filamentous algae are counted as natural units/ml. Algae that occur as single cells are counted as cells/ml.

Table A19. Lake Boon, Temperature (^{o}C) - Dissolved Oxygen (mg/l) - Saturation (%)

Date	Surface	1m	2m	3m	4m	5m	6m
	- - - - - - - - - - -	- - - - In-Lake	Station #1 - - - -				
10/29/85	12.8 8.9 84	12.8 8.8 83	12.8 8.8 83	12.8 8.7 82	12.8 8.7 82	12.8 8.7 82	12.5 8.8 82
01/28/86	0.2 11.6 80	2.1 8.9 65	4.3 7.5 58	4.5 6.8 53	4.7 6.6 51	4.7 6.3 49	4.7 6.1 47
04/08/86	10.0 10.2 90	10.0 10.2 90	10.0 10.2 90	10.0 10.2 90	10.0 10.2 90	10.0 10.2 90	9.0 7.8 87
07/29/86	26.0 8.9 109	26.0 8.9 109	26.0 8.8 107	26.0 8.8 107	24.2 9.9 116	21.6 5.0 57	18.9 0.7 7

Table A20. Lake Boon, Temperature (°C) - Dissolved Oxygen (mg/l) Saturation (%)

- - - - - - - - - In-Lake Station #2 - - - - - - - - - -

Date	Surface	1m	2m	3m
10/29/85	11.5	11.5	11.3	11.3
	9.7	9.7	9.7	9.8
	88	88	88	89
01/28/86	0.5	3.2	4.0	3.6
	10.0	9.6	9.6	9.0
	69	72	73	68
04/08/86	10.2	10.2	10.2	10.2
	9.8	9.8	9.9	9.8
	87	87	88	87
07/29/86	26.0	26.0	26.0	25.0
	8.7	8.6	8.6	4.4
	106	105	105	52

Table A21. Lake Boon, Temperature (^{o}C) - Dissolved Oxygen (mg/l) - Saturation (%), Inlet and Outlet Stations

Date	Station Number 3	4	5	6
10/29/85	NA	10.7	11.1	8.9
	NA	3.3	7.9	9.9
	NA	29	71	85
01/28/86	0.1	0.6	4.2	NA
	11.0	12.6	8.8	NA
	75	90	68	NA
04/08/86	7.8	7.5	10.0	NA
	6.8	8.9	10.3	NA
	57	73	91	NA
07/29/86	20.8	15.9	26.0	NA
	3.0	8.2	8.4	NA
	33	82	102	NA

NA = No sample taken, dry inlet

Table A22. White Pond, Station 7 - Temperature (^{o}C) - Dissolved Oxygen (mg/l) Saturation (%)

	Station Number 7		
Date	Surface	Mid depth	Bottom
10/29/85	13.5 9.0 86	13.6 9.0 86	13.4 8.8 84
01/28/86	0.8 10.3 73	4.2 7.3 56	4.4 3.8 29
04/08/86	10.0 10.6 94	10.0 10.5 93	7.6 10.0 84
07/29/86	25.5 8.3 100	25.8 8.1 98	21.2 7.9 87

Table A23. Lake Boon, Flow Measurements (cfs)

Date	3 (inlet)	4 (inlet)	5 (outlet)	6 (inlet)
10/29/85	NF	LF	0.024	NF
01/28/86	0.43	0.80	LF	NF
04/08/86	0.01	0.70	2.20	NF
07/29/86	LF	0.06	1.10	NF

LF = No measurement because of low flow velocity.
NF = No flow, inlet dry