ECOLOGICAL STUDY

HIDDEN LAKE, HADDAM, CT

1995

Prepared by

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For

Hidden Lake Association

Haddam, CT

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PREFACE

This report is intended to serve as a source of information for both technical and non-technical readers. It can be used for future comparisons should lake management efforts be undertaken or should changes in the lake warrant further investigation. It is necessarily detailed and descriptive. A glossary of terms has been provided and the table of contents will serve as an outline.

I would like to thank Mr. Lloyd Pearson for his support of the study and for valuable data and background information. I also thank Mr. William Carson for making his boat available for the field work.

INTRODUCTION

Hidden Lake is a shallow 39 acre lake located on Hidden Lake Road, west of Route 81 in Haddam, CT (Figure 1). The lake is privately owned and is managed by the Hidden Lake Association, a group of about 110 property owners. Residents use the lake for swimming, fishing, canoeing and boating. However, recreational activities are limited by the extensive growth of aquatic plants across the entire breadth of the lake.

There is very little information available concerning the ecology of Hidden Lake. The lake has no public access and therefore was not included in Connecticut Department of Environmental Protection (DEP) studies of 106 lakes (Frink and Norvell, 1984; DEP, 1991). A bathymetric map showing the contours of the bottom was included in an early fishery survey (State Board of Fisheries and Game, 1959), but there is no current information available concerning water quality or aquatic plant and algal communities. In particular, the level of nutrient enrichment has not been systematically quantified.

The purpose of this study is to provide baseline data describing the ecology of the lake during the summer of 1995. These data constitute a scientific documentation of conditions during the aquatic plant growing season. The report will give information needed to develop a lake management program and will

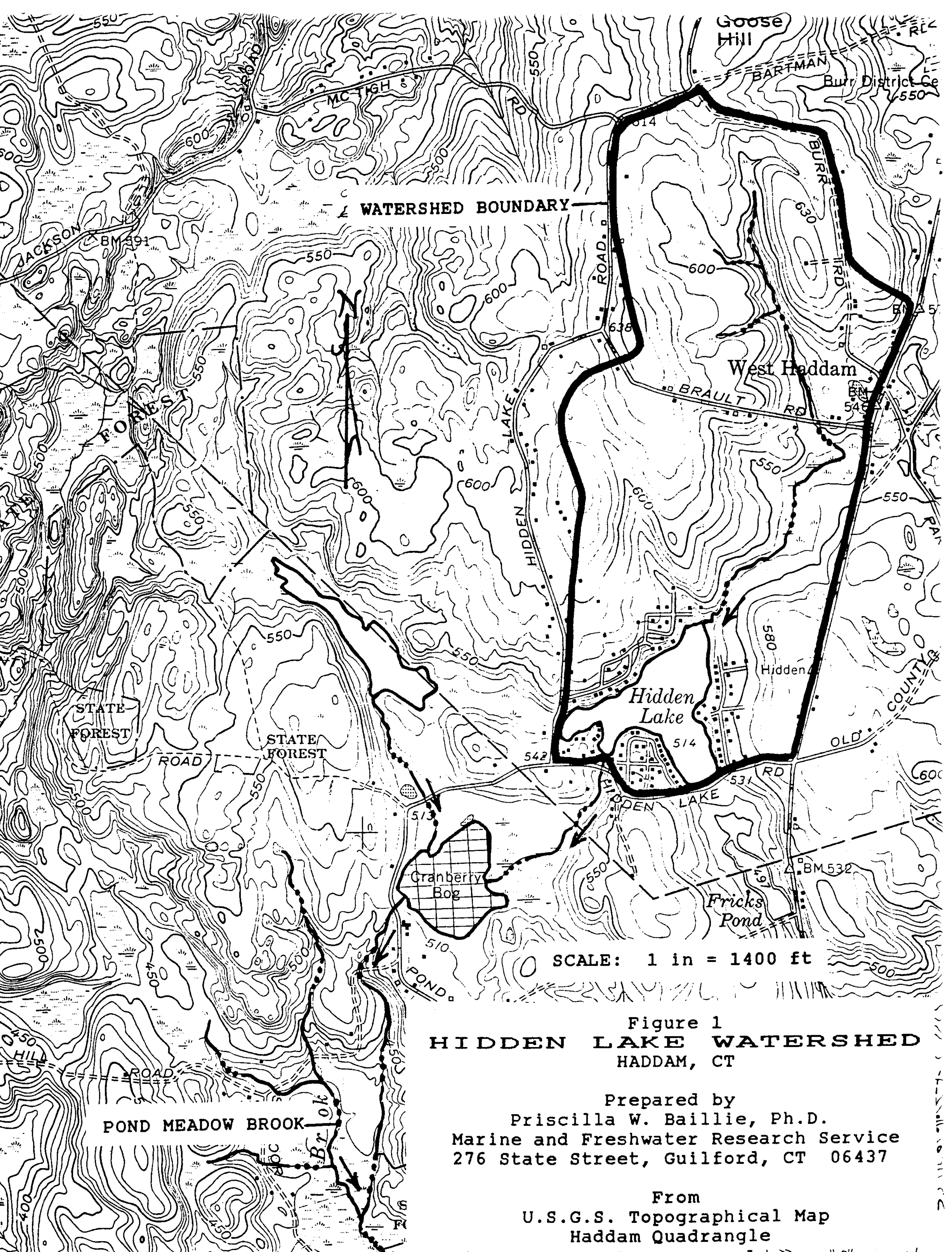

Figure 1
HIDDEN LAKE WATERSHED
HADDAM, CT

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From
U.S.G.S. Topographical Map
Haddam Quadrangle

include recommendations for various management techniques. The study will allow future comparisons to determine the response of the lake to management efforts.

FIELD METHODS

The lake was sampled by boat once a month from May through August, 1995. Three sampling stations were established (Figure 2). Station 1 (average depth 1.77 m, 5.8 ft) was located in the southwest arm of the lake off the peninsula between West Cove and Mill Bay. Station 2, the shallowest station (average depth 1.18 m, 3.9 ft), was located in South Cove, and Station 3 (average depth 1.56 m, 5.1 ft) was located in the center of North Cove.

At each station, measurements of water temperature, oxygen concentrations and conductivity (see Glossary for definition of unfamiliar terms) were taken at 0.5 m intervals from surface to the bottom. Water clarity was measured at Station 1 by lowering a white disk into the water (Secchi disk) and recording the depth at which it disappeared from view. Water samples were collected (0.35 m depth) and analyzed for pH, alkalinity, and the plant nutrients nitrate and total phosphorus. Phytoplankton (microscopic algae floating in the water) were counted and identified. Phytoplankton biomass was quantified as the concentration of chlorophyll a using a Turner fluorometer and the

HIDDEN LAKE SAMPLING STATIONS
HADDAM, CT

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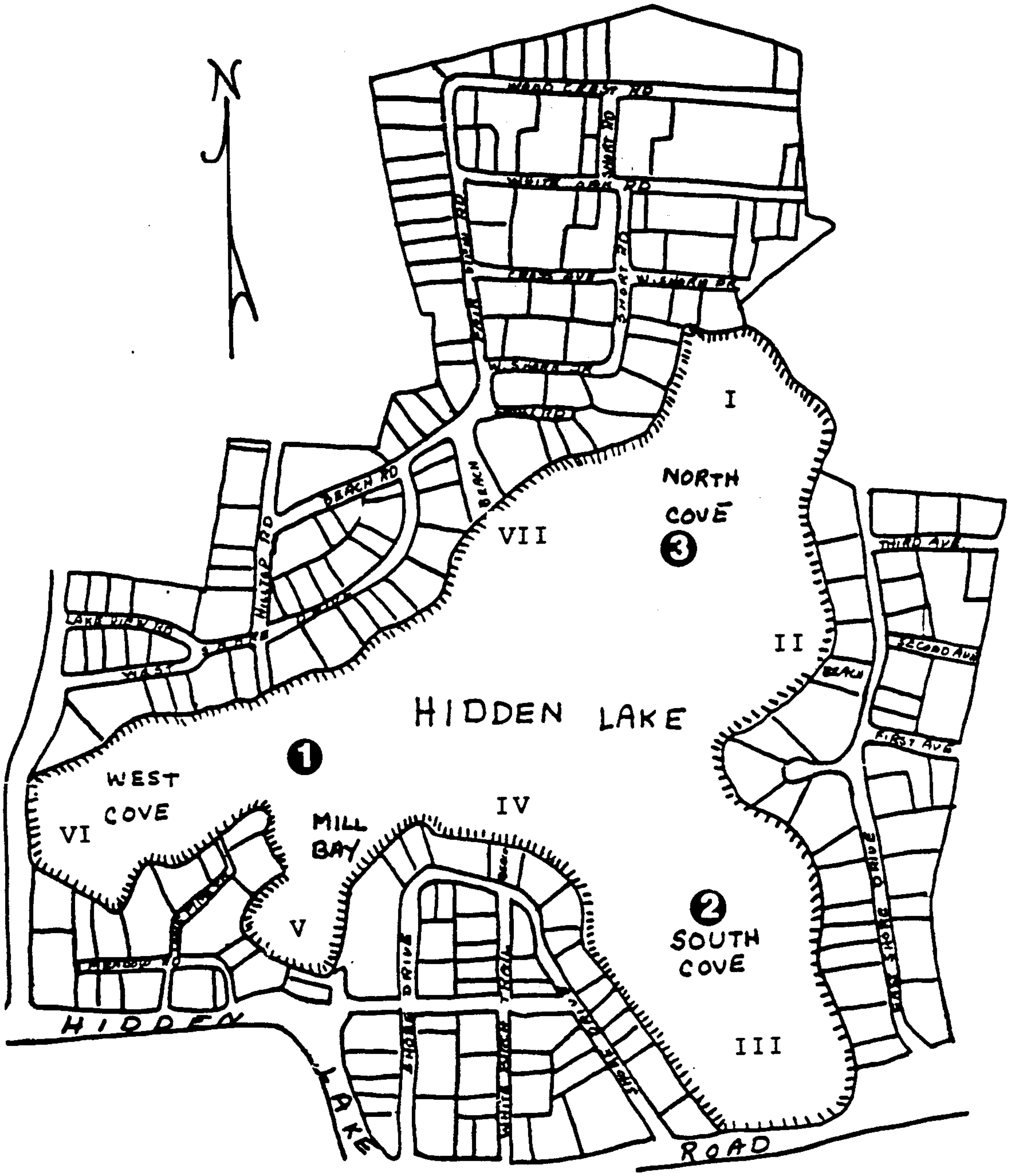
From
Hidden Lake Association Map



Circles = Study Stations
Roman Numerals = Lake Association Stations

SCALE: 1 in = 500 ft

methods of Axler and Owen (1994). Locations of aquatic plants were noted. Technical details of field and laboratory methods are presented in Appendix A.

It should be noted that the lake has also been sampled in the past by the Hidden Lake Association for total coliform and total phosphorus. Association sampling stations are shown as I through VII on Figure 2. Stations II, IV and VII represent the three beaches on the lake: East Shore Beach, Shore Drive Beach and West Shore Beach, respectively.

The major inflow stream, designated Inflow A (Figure 3), at the north end of the lake was sampled in May, June and July, but was not flowing in August. A second smaller stream, Inflow B, was sampled in May but was not running throughout the rest of the study; the summer of 1995 was remarkably dry. The stream samples were analyzed for all variables except phytoplankton and chlorophyll a.

A bathymetric survey was carried out to map the approximate shape of the lake basin. Depths were measured during calm conditions at 23 locations using a weighted plumb line. Depths were plotted on a tracing of an enlarged aerial photograph (#CT DEP 8-51-1693, March 29, 1990) and bottom contours were estimated from the data (Figure 3). The surface area of the lake was found using the grid enumeration method (Lind, 1985) and the length of

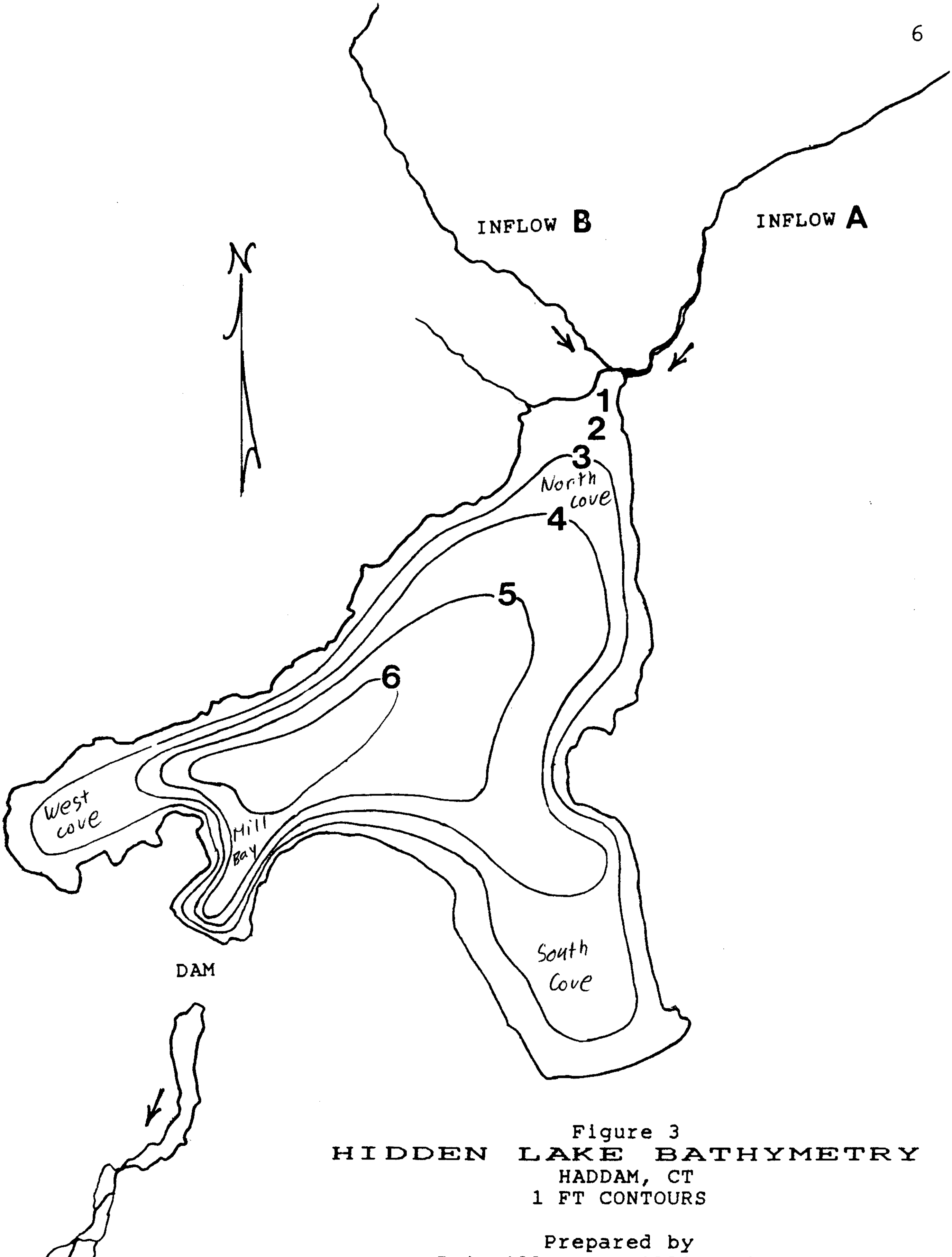


Figure 3
HIDDEN LAKE BATHYMETRY
HADDAM, CT
1 FT CONTOURS

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From
D.E.P. Aerial Photograph Enlargement

SCALE: 1 in = 400 ft

the shoreline was determined by means of a curvilinear map measurer. Maximum depth was measured in the field and mean depth was calculated as the average of the 23 depth readings.

DIMENSIONS

The dimensions of a lake (i.e. its area, mean depth, volume and length of shoreline) have important effects on many aspects of its ecology (Wetzel, 1983; Cole, 1979; Lind, 1985). Also, the nature of the land draining into a lake, termed the watershed, has a profound effect on the condition of the system. Important first steps in a lake study are determinations of the size, shape and depth of the basin, as well as the size and characteristics of its watershed.

THE WATERSHED

The watershed of Hidden Lake lies within the Chatfield Hollow Brook Drainage Basin No. 5105 (DEP, 1982). The lake, together with its inflow and outflow streams, is a tributary of Pond Meadow Brook (DEP, 1972). The lake watershed is 0.89 mi^2 in area and is largely undeveloped forest. The U.S. Geological Survey topographical map for the Haddam Quadrangle (1961, photo-revised 1971) shows the surface of the lake at elevation 514 ft above sea level (Figure 1). Slopes around the lake and within the watershed rise to a maximum elevation of about 640 ft. There are virtually no wetlands associated with the lake shore. Homes and lawns occupy most of the shoreline, although some areas support natural wooded vegetation (Figure 4). According to the topographical map, most of the houses around the lake were built prior to 1961. At present, there are 80 year-round homes and 30 seasonal homes comprising the lake-side community.

The main feeder stream (Inflow A) and a second intermittent stream (Inflow B) enter the lake from the north (Figure 3). The lake is also fed by groundwater, surface runoff and several small intermittent brooks and road drainage ditches. The lake outflow traverses a recently reconstructed masonry dam at the southwestern end. It is piped under Hidden Lake Road and then flows through a cranberry bog, eventually discharging into Pond Meadow Brook about 2.5 miles downstream. The fact that the inflow and outflow are at opposite ends of the lake ensures good water circulation during periods of high flow.

THE LAKE

Many physical, chemical and biological characteristics of a lake are affected by its dimensions (Wetzel, 1983). For example, the length of the shoreline and the type of bordering vegetation affect the quantity of leaves and debris entering a lake each season, thereby influencing nutrient input. The orientation of the lake with respect to the prevailing wind, and

Figure 4

Laser copy of DEP Aerial Photograph

3/29/90, CT-DEP-8-51-1693

The photograph shows the degree of development around the shoreline of Hidden Lake. The main inflow brook enters at the top right corner of the photograph. The outflow is at the bottom left. North is at the top of the photograph. The scale is 1 in = 400 ft.

the shelter provided by surrounding hills and vegetation, determine the degree of wind mixing. The overall depth of a lake affects the rate at which it ages. All lakes tend to fill gradually with accumulated organic matter and thus shallow lakes, such as Hidden Lake, tend to be shorter lived than deeper systems.

As earlier noted, the surface area of Hidden Lake is 39 acres. The maximum depth measured during this study (under severe drought conditions) was 6.10 ft and the mean depth was 4.48 ft. The lake level was approximately 9 inches below the spillway during the latter part of the study, meaning that the average depth is about 5.23 ft when the lake is filled to the height of the spillway. The lake volume therefore varies from about 7,620,000 to 8,895,000 ft^3 (175 to 204 ac ft). Using the above low water volume and a published "driest year" flow rate for Hidden Lake of 0.72 ft^3/sec (U.S. Geological Survey, 1982), the turnover time during drought conditions would be 123 days. Using the volume at the spillway and a "median" flow rate of 1.29 ft^3/sec, the turnover time would be 80 days. These turnover times mean that water is moving through the lake rather rapidly compared to other deeper systems. As long as good water quality is maintained in the inflow stream, this circumstance benefits the ecology of the lake.

The lake is generally triangular in shape. It is composed of three major bays and several peninsulas (Figure 4). The shoreline is about 4.28 mi in length. Shoreline irregularity is of interest because the amount of leaves, other terrestrial debris and overland runoff containing nutrients and sediments entering a lake increases with the length of its shore. A lake with numerous bays and indentations is more subject to impacts emanating from the watershed than a lake with a simple circular or oval shape.

The Shoreline Development Index (SDI) is a measure of shoreline irregularity. This index is the ratio of the length of shoreline to the circumference of a circle with an area equal to that of the lake (Wetzel, 1983). The index is calculated using the equation shown in Appendix B. A perfectly circular lake would have an SDI of 1.0. The relatively complex shoreline of Hidden Lake is reflected in a high SDI value of 4.89. This means that the ecology of the lake is highly impacted by disturbances in the land immediately adjacent to its shoreline.

A comparison of the bathymetric map (Figure 3) with an earlier map (Appendix C) developed in 1959 by the State Board of Fisheries and Game, indicates the extent to which the lake has filled in over a period of 36 years. The area enclosed within the 6 ft contour in Figure 3 is considerably reduced compared to the 6 ft contour developed in 1959. This represents a significant loss of depth in a shallow system.

PHYSICAL and CHEMICAL CHARACTERISTICS

LAKE WATER QUALITY

Temperature and Dissolved Oxygen

There was little difference in temperature between surface and bottom at any of the stations throughout the study (Table 1). Because the lake is shallow, wind action on the surface causes the lake to be well mixed, and measurements of lake characteristics from the surface down tended to be fairly uniform. For example, the lake was well oxygenated from surface to bottom throughout the summer. Dissolved oxygen levels ranged from 7.0 to 9.2 mg/l at the surface (Figure 5). Near the bottom, oxygen levels were more variable, ranging from 3.8 to 8.4 mg/l. Generally, however, even the sediments were quite well oxygenated. Dissolved oxygen concentrations in all areas of the lake were adequate to support fish and other aquatic organisms.

Alkalinity, pH and Conductivity

Alkalinity is a measure of the concentration of calcium carbonate in a lake and is related to water hardness. Since certain kinds of pollution (leakage from septic systems, for example) can increase alkalinity levels, this variable is routinely measured in water quality studies. In unpolluted lakes

HIDDEN LAKE
Haddam, CT

Table 1.
PHYSICAL CHEMICAL CHARACTERISTICS

MAY 22, 1995

Weather: Full sun, cool, light breeze
Secchi: 1.80 m

Location	Depth meters	Temp. oC	D.O. mg/l	Conduct. umhos/cm	pH	Alkal. mg/l	Chlo.a ug/l	Pheo.a ug/l	NO3-N mg/l	T.P. mg/l
Station 1										
Depth: 1.92 m										
Time: 0850										
	Surface	18.6	9.2	55	6.91	15	5.99	1.17	0.030	0.023
	0.5	18.5	9.0	54						
	1.0	18.1	9.0	54						
	1.5	17.5	9.9	54						
	Bottom	16.8	6.3	54						
Station 2										
Depth: 1.29 m										
Time: 0935										
	Surface	18.2	8.9	55	6.84	15	5.38	1.08	0.024	0.025
	0.5	18.1	8.7	55						
	1.0	18.0	8.8	56						
	Bottom	18.0	8.2	56						
Station 3										
Depth: 1.65 m										
Time: 1005										
	Surface	19.0	9.1	54	6.85	15	3.52	0.61	0.023	0.025
	0.5	18.8	9.0	55						
	1.0	18.2	8.8	55						
	1.5	18.1	9.3	55						
	Bottom	17.9	8.1	58						
Inflow A		14.5	9.3	47	6.68	15			0.055	0.015
Time: 1205										
Inflow B		14.9	9.7	29	6.75	15			0.062	0.053
Time 1215										

ABBREVIATIONS:

Temp. = Temperature
D.O. = Dissolved oxygen
Conduct. = Conductivity
Alkal. = Alkalinity
Chlo.a = Chlorophyll a
Pheo.a = Pheopigments a
NO3-N = Nitrate nitrogen
T.P. = Total phosphorus

m = Meters
oC = Degrees celsius
umhos/cm = Micromhos per centimeter
mg/l = Milligrams per liter
ug/l = Micrograms per liter
BDL = Below detectable level (0.010 mg/l)

HIDDEN LAKE
Haddam, CT

Table 1.
PHYSICAL CHEMICAL CHARACTERISTICS

JUNE 27, 1995

Weather: Bright sun, very windy
Secchi: 1.68 m

Location	Depth meters	Temp. oC	D.O. mg/l	Conduct. umhos/cm	pH	Alkal. mg/l	Chlo.a ug/l	Pheo.a ug/l	NO3-N mg/l	T.P. mg/l
Station 1 Depth: 1.80 m Time: 0855										
	Surface	22.8	7.0	63	6.93	15	14.89	3.74	BDL	0.013
	0.5	22.8	6.9	63						
	1.0	22.8	6.9	63						
	1.5	22.8	6.9	63						
	Bottom	22.8	4.5	75						
Station 2 Depth: 1.24 m Time: 0925										
	Surface	23.0	7.4	66	7.02	15	8.24	3.31	BDL	0.015
	0.5	23.0	7.3	65						
	1.0	22.9	7.3	66						
	Bottom	22.9	6.5	65						
Station 3 Depth: 1.61 m Time: 1000										
	Surface	23.2	8.0	64	7.00	15	9.04	2.75	BDL	0.015
	0.5	23.0	7.8	63						
	1.0	22.9	7.8	65						
	Bottom	22.9	7.8	66						
Inflow A		17.00	8.3	66	7.02	25			0.252	BDL
Inflow B		Not Running								

ABBREVIATIONS:

Temp. =	Temperature	m =	Meters
D.O. =	Dissolved oxygen	oC =	Degrees celsius
Conduct. =	Conductivity	umhos/cm =	Micromhos per centimeter
Alkal. =	Alkalinity	mg/l =	Milligrams per liter
Chlo.a =	Chlorophyll a	ug/l =	Micrograms per liter
Pheo.a =	Pheopigments a	BDL =	Below detectable level (0.010 mg/l)
NO3-N =	Nitrate nitrogen		
T.P. =	Total phosphorus		

HIDDEN LAKE
Haddam, CT

Table 1.
PHYSICAL CHEMICAL CHARACTERISTICS

JULY 20, 1995

Weather: Clear, scattered clouds, surface calm
Secchi: To bottom

Location	Depth meters	Temp. oC	D.O. mg/l	Conduct. umhos/cm	pH	Alkal. mg/l	Chlo.a ug/l	Pheo.a ug/l	NO3-N mg/l	T.P. mg/l
Station 1 Depth: 1.66 m Time: 0820										
	Surface	25.8	8.2	68	7.20	15	5.05	2.78	BDL	0.016
	0.5	25.8	8.2	69						
	1.0	25.8	8.2	69						
	1.5	25.1	6.4	69						
	Bottom	25.1	3.8	72						
Station 2 Time: 0915										
	Surface	26.2	7.3	69	7.00	15	7.60	2.25	BDL	0.020
	0.5	26.1	7.3	69						
	1.0	26.0	7.3	69						
	Bottom	26.0	4.6	71						
Station 3 Depth: 1.49 m Time:0955										
	Surface	26.5	8.8	69	7.34	15	5.37	0.29	BDL	0.019
	0.5	26.3	8.7	69						
	1.0	26.0	8.6	69						
	Bottom	26.0	8.4	70						
Inflow A Time: 1200		18.9	7.9	122	6.68	15			0.263	0.012
Inflow B		Not Running								

ABBREVIATIONS:

Temp. =	Temperature	m =	Meters
D.O. =	Dissolved oxygen	oC =	Degrees celsius
Conduct. =	Conductivity	umhos/cm =	Micromhos per centimeter
Alkal. =	Alkalinity	mg/l =	Milligrams per liter
Chlo.a =	Chlorophyll a	ug/l =	Micrograms per liter
Pheo.a =	Pheopigments a	BDL =	Below detectable level (0.010 mg/l)
NO3-N =	Nitrate nitrogen		
T.P. =	Total phosphorus		

HIDDEN LAKE
Haddam, CT

Table 1.
PHYSICAL CHEMICAL CHARACTERISTICS

AUGUST 26, 1995

Weather: Full sun, mild, calm
Secchi: To bottom

Location	Depth meters	Temp. oC	D.O. mg/l	Conduct. umhos/cm	pH	Alkal. mg/l	Chlo.a ug/l	Pheo.a ug/l	NO3-N mg/l	T.P. mg/l
Station 1										
Depth: 1.70 m										
Time: 0840										
	Surface	22.0	7.4	69	7.19	15	2.18	1.62	BDL	BDL
	0.5	22.0	7.4	69						
	1.0	22.0	7.6	69						
	1.5	22.0	7.5	69						
	Bottom	22.0	6.9	70						
Station 2										
Depth: 1.00 m										
Time: 0908										
	Surface	21.2	8.0	68	7.09	15	2.50	1.27	BDL	0.012
	0.5	21.0	7.7	68						
	Bottom	21.0	7.7	68						
Station 3										
Depth: 1.49 m										
Time: 0935										
	Surface	22.0	7.7	69	7.04	15	2.55	0.23	BDL	0.012
	0.5	21.9	7.7	69						
	1.0	21.9	7.9	68						
	Bottom	21.9	6.6	70						

Inflow A Not running

Inflow B Not Running

ABBREVIATIONS:

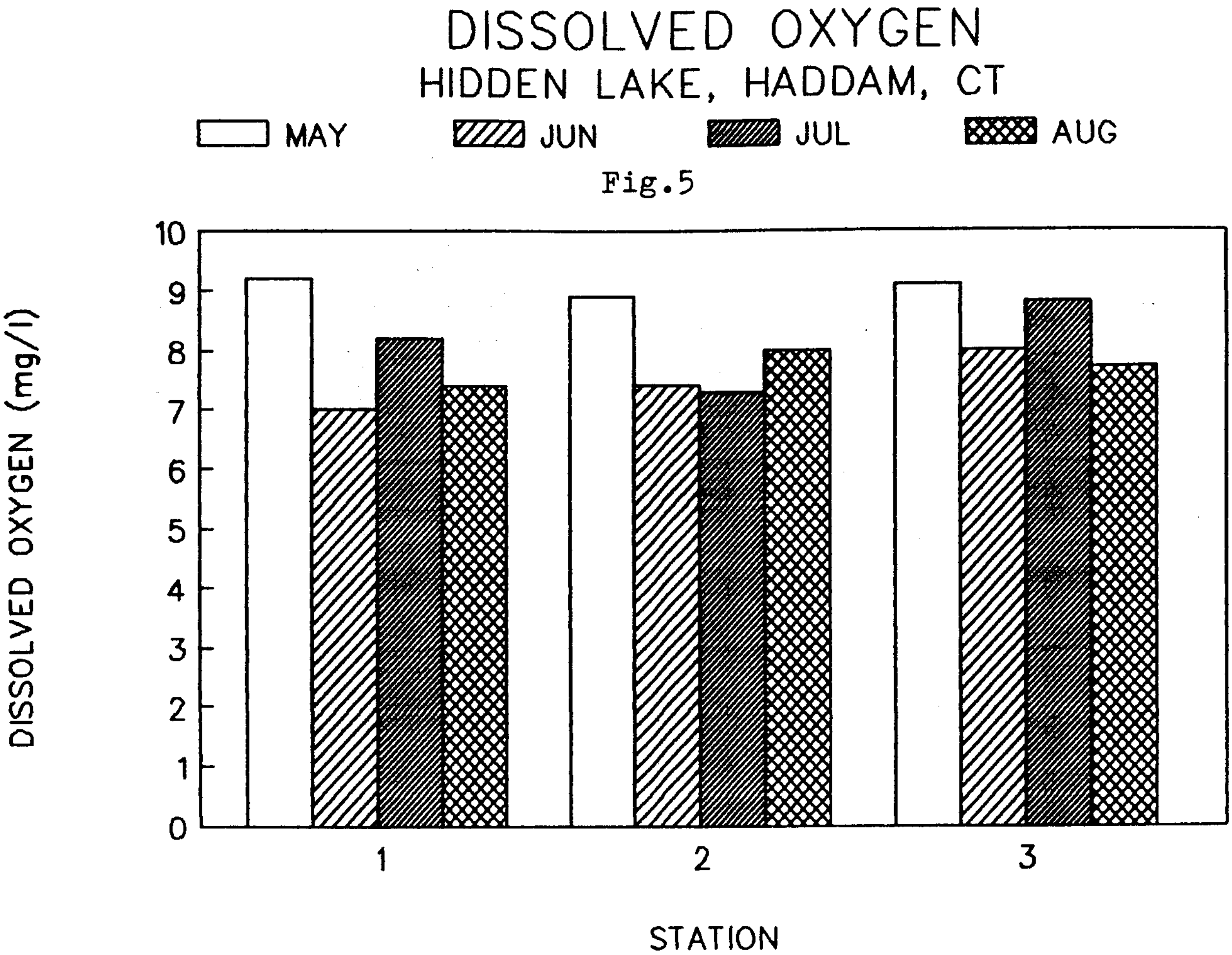
Temp. = Temperature
D.O. = Dissolved oxygen
Conduct. = Conductivity
Alkal. = Alkalinity
Chlo.a = Chlorophyll a
Pheo.a = Pheopigments a
NO3-N = Nitrate nitrogen
T.P. = Total phosphorus

m = Meters
oC = Degrees celsius
umhos/cm = Micromhos per centimeter
mg/l = Milligrams per liter
ug/l = Micrograms per liter
BDL = Below detectable level (0.010 mg/l)

and ponds, alkalinity is primarily regulated by the geology of the watershed; levels are higher in areas of sedimentary rock and lower in areas of igneous rock. The eastern regions of Connecticut are dominated by schist, gneiss and granite (Bell, 1985). Therefore, eastern lakes tend to be softwater systems with low alkalinity. Alkalinity in Hidden Lake was consistently very low (15 mg/l) at all stations and on all sampling occasions, and the lake is thus classified as a softwater system.

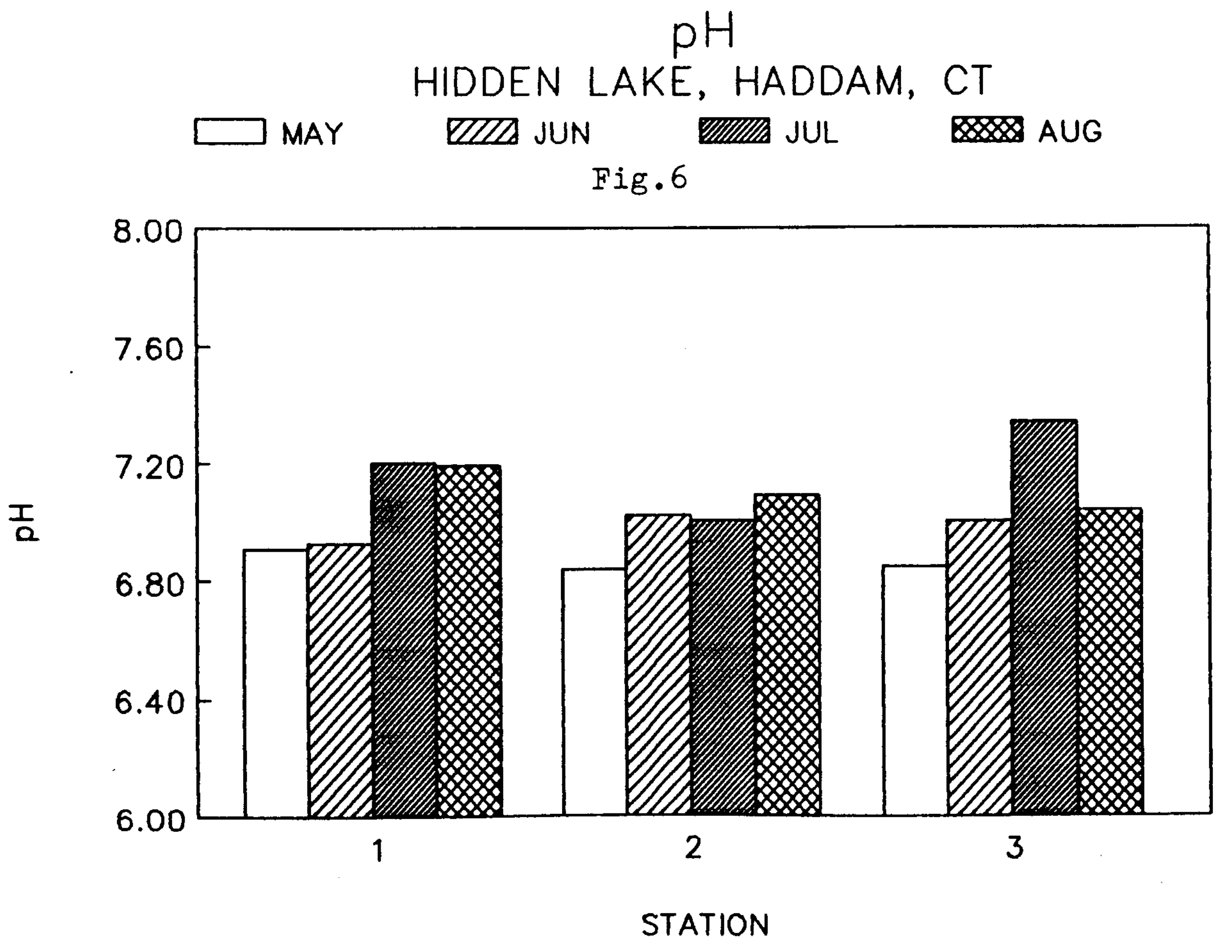
PH is a measure of the acidity of lake water. On a scale of 1 to 14, a pH of 7 is neutral, below 7 is acidic and above 7 is basic. In natural waters, pH usually ranges between 6 and 9. In Hidden Lake, pH was close to neutrality, ranging from 6.84 to 7.34. There was no significant difference in pH between stations or between sampling dates (Figure 6).

Conductivity reflects the overall concentration of ions in the water and is a non-specific pollution indicator. It is directly related to the concentration of total dissolved solids but does not indicate the type of ions in solution. Again, the geology of the watershed affects conductivity. Levels less than 100 umhos/cm are typical of unpolluted softwater systems. In Hidden Lake, conductivity fell within the expected range, varying from 54 to 75 umhos/cm. There was no significant difference in conductivity between the three stations (Figure 7).



DISSOLVED OXYGEN
HIDDEN LAKE, HADDAM, CT
MAY
JUN
JUL
AUG
DISSOLVED OXYGEN (mg/l)
10
9
8
7
6
5
4
3
2
1
0
1
2
3
STATION

Fig.5



pH
HIDDEN LAKE, HADDAM, CT
MAY
JUN
JUL
AUG
pH
8.00
7.60
7.20
6.80
6.40
6.00
1
2
3
STATION

Fig.6

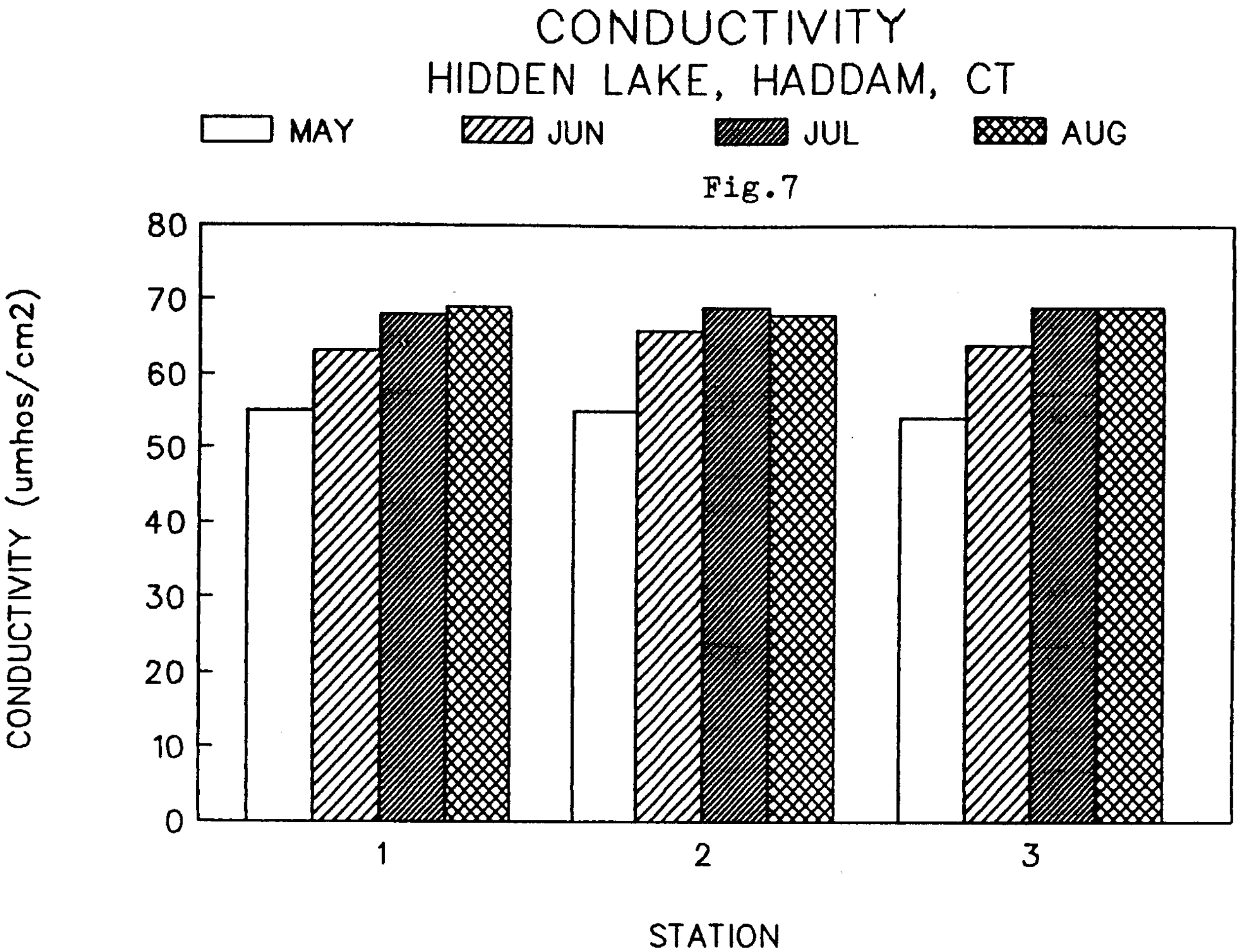

CONDUCTIVITY
HIDDEN LAKE, HADDAM, CT
MAY
JUN
JUL
AUG
CONDUCTIVITY (umhos/cm2)
80
70
60
50
40
30
20
10
0
1
2
3
STATION

Fig.7

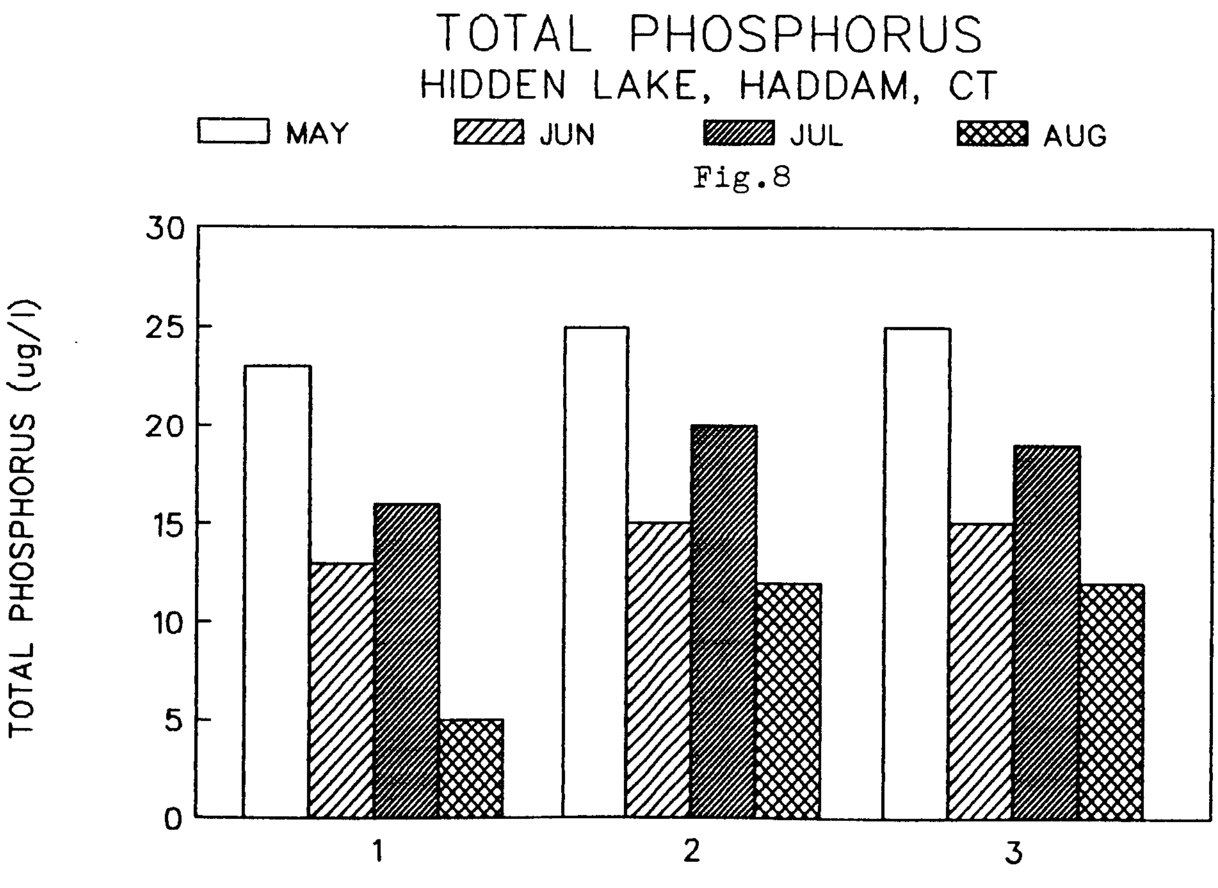

TOTAL PHOSPHORUS
HIDDEN LAKE, HADDAM, CT
MAY
JUN
JUL
AUG
TOTAL PHOSPHORUS (ug/l)
30
25
20
15
10
5
0
1
2
3

Fig.8

During the May and June sampling trips, the conductivity probe was trolled around the entire shoreline of the lake in an effort to detect pulses of elevated conductivity which might indicate septic input. No peaks were detected. On those two occasions, conductivity ranged within expected limits, between 55 and 68 umhos/cm.

Nitrate and Total Phosphorus

The two most important plant nutrients in ecosystems are nitrogen and phosphorus. Nutrients entering Connecticut lakes have increased in recent years as the result of man's activities. Nutrients are plentiful in septic waste, fertilizers and road runoff. Soil erosion, originating in areas of construction, is also a major source of nutrients, especially phosphorus.

Nitrogen occurs naturally in the environment in greater quantities than phosphorus. It is present in several dissolved and particulate forms (nitrate, nitrite, ammonia and organic nitrogen). The form of nitrogen measured in this study was nitrate-N, which is the form most readily used by plants and algae. In Connecticut lakes and ponds, nitrate-N levels generally range between 0.50 and 1.00 mg/l. In Hidden Lake, nitrate-N levels were very low in May, ranging from 0.023 to 0.030 mg/l, and were undetectable throughout the rest of the study.

Phosphorus is normally less plentiful in the natural environment than nitrogen. It is derived from rock and is associated with soil particles. Therefore, when eroded sediments reach a lake they not only increase turbidity and decrease depth, but they also carry large amounts of phosphorus into the system. Levels below 0.030 mg/l are considered acceptable for lakes and ponds (Frink and Norvell, 1983). Total phosphorus levels in Hidden Lake were generally low, ranging from 0.025 mg/l to undetectable (Figure 8). Phosphorus enters a lake primarily in streams or overland runoff. Severe drought conditions during the summer of 1995 (with the resulting lack of stream flow and runoff) prevented phosphorus from reaching the lake.

Lake Association Data

Total phosphorus levels and total coliform counts have been monitored by the Hidden Lake Association for several years (Table 2). The data indicated that there may have been a sporadic problem with septic input at the western end of the lake. The State of Connecticut standard is 500 total coliform bacteria per 100 ml of water (DEP, 1992). This standard was greatly exceeded at the West Cove and West Shore stations in 1993, and again at West Cove in 1995 (Figure 9).

Total phosphorus levels ranged from 0.05 to 0.14 mg/l at the Mill Bay and West Cove stations in 1993 and 1994 (Figure 10).

Table 2

HIDDEN LAKE
Haddam, CT

HIDDEN LAKE
ASSOCIATION DATA

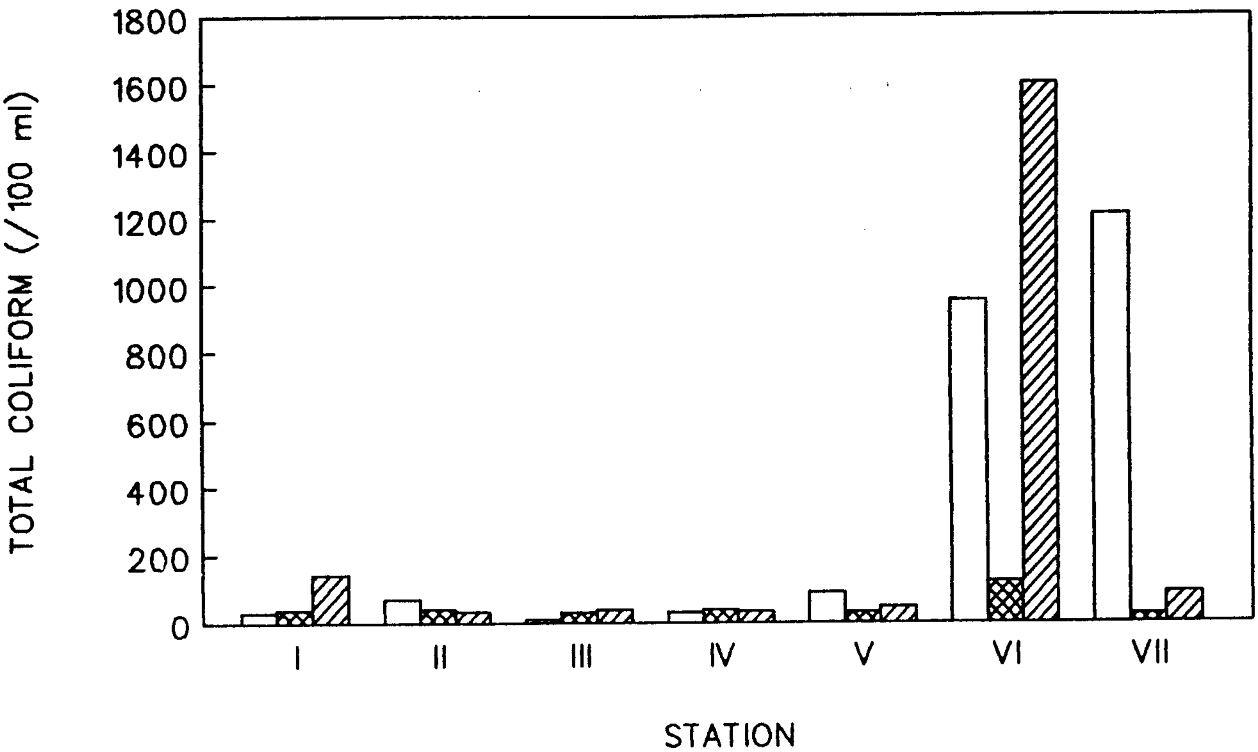
Date	Station Number	Station Name	Total Coliform /100 ml	Total Phosphorus mg/l
JUNE 9, 1993	I	NORTH COVE	30	0.03
	II	EAST SHORE	70	0.03
	III	SOUTH COVE	10	0.04
	IV	SHORE DRIVE	30	0.03
	V	MILL BAY	90	0.05
	VI	WEST COVE	955	0.06
	VII	WEST SHORE	1210	0.03
AUGUST 8, 1994	I	NORTH COVE	38	0.03
	II	EAST SHORE	42	0.03
	III	SOUTH COVE	30	0.03
	IV	SHORE DRIVE	40	0.04
	V	MILL BAY	30	0.14
	VI	WEST COVE	120	0.05
	VII	WEST SHORE	22	0.03
JULY 17, 1995	I	NORTH COVE	138	0.01
	II	EAST SHORE	34	0.01
	III	SOUTH COVE	40	0.01
	IV	SHORE DRIVE	34	0.01
	V	MILL BAY	48	0.04
	VI	WEST COVE	* 1600	0.01
	VII	WEST SHORE	90	0.01

* Bacteria re-tested August 4, 1995
Range: 42 - 270 /100ml; Mean 138 /100ml

TOTAL COLIFORM
HIDDEN LAKE ASSOCIATION DATA

1993 1994 1995

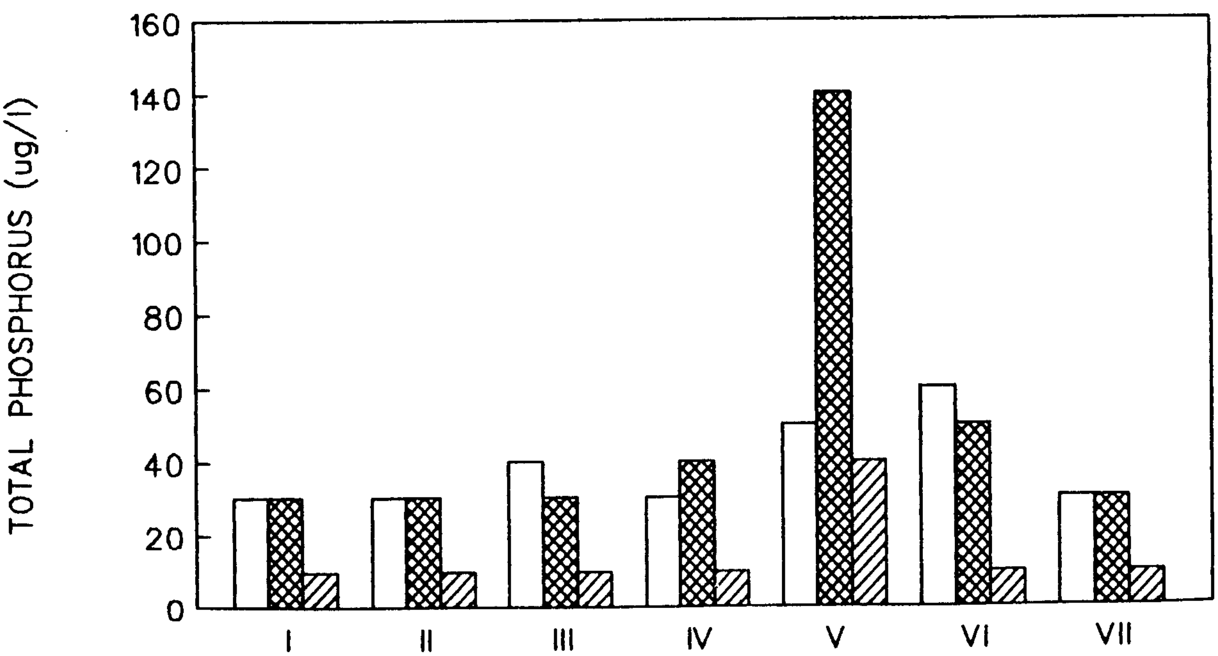
Fig.9



TOTAL PHOSPHORUS
HIDDEN LAKE ASSOCATION DATA

1993 1994 1995

Fig.10



However, Lake Association data and the data developed by this study indicated that phosphorus levels were generally low in 1995 compared to 1993 and 1994.

INFLOW STREAMS WATER QUALITY

Stream A, the main inflow to the lake, drains the major part of the watershed (Figure 1). There is very little development within the drainage area of this stream, and the stream passes through a large wetland south of Brault Road. Accordingly, water quality in the stream was very good. The stream was well oxygenated, pH ranged from 6.7 to 7.0, and both nitrate and total phosphorus levels were low. Conductivity rose to 122 umhos/cm in July. This was somewhat higher than conductivity in the lake, which ranged from 68 to 72 umhos/cm. However, the high reading may have been related to the lack of adequate flow in the stream at that time.

Stream B was a small intermittent brook draining a hilly area north of the lake. The brook was flowing in May but was dry during the rest of the study. Water quality in the one sample was excellent with low conductivity, pH and nutrients.

PLANT AND ALGAE COMMUNITIES

PHYTOPLANKTON

The phytoplankton community is made up of microscopic algae which float or swim in the open water. Although most of these organisms cannot be seen without the aid of a microscope, they are important to the ecology of a lake. During photosynthesis, phytoplankton transform the energy of sunlight into food energy. These free floating microalgae are grazed on by zooplankton (microscopic animals,) which, in turn, serve as a food source for larger carnivorous animals including insects, crustaceans and fish. Thus, phytoplankton form the base of many complex feeding interactions in a lake.

The Phytoplankton Community

Phytoplankton from seven algal classes were observed in Hidden Lake: Blue-Green Algae, Green Algae, Euglenas, Chrysophytes, Diatoms, Dinoflagellates and Cryptomonads (Table 3). Chrysophytes and Diatoms prefer cooler waters and are generally most prevalent in the spring and fall. Dinoflagellates and Cryptomonads are very common small unicellular algae that swim actively through the water. Green algae are a large group comprised of many different species. They are often important in lakes and ponds having high nitrogen concentrations and are

HIDDEN LAKE
Haddam, CT

Table 3
PHYTOPLANKTON

MAY 22, 1995

CLASS	GENUS	STA.1	STA.2	STA.3	AVERAGE	CLASS %TOTAL
		(Organisms per milliliter)				
BLUEGREEN ALGAE					8	0.1%
	Anabaena	0	0	14		
	Polycystis	0	9	0		
GREEN ALGAE					17	0.2%
	Chlamydomonas	9	9	14		
	Eudorina	9	0	0		
	Pediastrum	9	0	0		
EUGLENAS					9	0.1%
	Trachelomonas	9	19	0		
CHRYSOPHYTES					36	0.5%
	Dinobryon	0	0	14		
	Mallomonas	19	47	28		
DIATOMS					9	0.1%
	Melosira	9	0	0		
	Navicula	9	9	0		
DINOFLAGELLATES					179	2.3%
	Gymnodinium	85	85	56		
	Peridinium	94	47	169		
CRYPTOMONADS					181	2.4%
	Cryptomonas	56	169	127		
	Rhodomonas	56	9	127		
NANNOPLANKTON (Too small to identify)		2855	9493	9493	7280	94.4%
TOTAL PER STATION		3219	9896	10042	7711	100.0%

HIDDEN LAKE
Haddam, CT

Table 3
PHYTOPLANKTON

JUNE 27, 1995

CLASS	GENUS	STA.1	STA.2	STA.3	AVERAGE	CLASS %TOTAL
		(Organisms per milliliter)				
BLUEGREEN ALGAE					0	0.0%
GREEN ALGAE					12	0.2%
	Ankistrodesmus	9	9	0		
	Chlamydomonas	0	9	0		
	Oocystis	0	0	9		
EUGLENAS					25	0.4%
	Trachelomonas	19	38	19		
CHRYSOPHYTES					147	2.5%
	Dinobryon	141	75	85		
	Mallomonas	56	19	66		
DIATOMS					3	0.1%
	Cyclotella	0	9	0		
DINOFLAGELLATES					476	8.0%
	Gymnodinium	28	47	197		
	Peridinium	460	376	319		
CRYPTOMONADS					404	6.8%
	Cryptomonas	423	150	103		
	Rhodomonas	178	254	103		
NANNOPLANKTON (Too small to identify)		10536	2207	1944	4896	82.1%
TOTAL PER STATION		11850	3193	2845	5963	100.0%

HIDDEN LAKE
Haddam, CT

Table 3
PHYTOPLANKTON

JULY 20, 1995

CLASS	GENUS	STA.1	STA.2	STA.3	AVERAGE	CLASS %TOTAL
		(Organisms per milliliter)				
BLUEGREEN ALGAE					9	0.4%
	Aphanizomenon	0	9	0		
	Chroococcus	9	0	0		
	Gloeocapsa	0	9	0		
GREEN ALGAE					34	1.5%
	Eudorina	0	9	19		
	Pediastrum	9	0	0		
	Scenedesmus	0	19	0		
	Tetraedron	28	19	0		
EUGLENAS					9	0.4%
	Euglena	0	19	0		
	Trachelomonas	0	9	19		
CHRYSOPHYTES					175	7.7%
	Dinobryon	28	122	19		
	Mallomonas	19	0	19		
	Synura	169	103	47		
DIATOMS					40	1.8%
	Cyclotella	0	9	19		
	Navicula	9	9	9		
	Synedra	0	56	9		
DINOFLAGELLATES					254	11.2%
	Ceratium	9	0	0		
	Gymnodinium	38	38	0		
	Peridinium	254	310	113		
CRYPTOMONADS					157	6.9%
	Cryptomonas	150	85	66		
	Rhodomonas	56	38	75		
NANNOPLANKTON (Too small to identify)		1427	1418	1930	1592	70.1%
TOTAL PER STATION		2205	2281	2344	2270	100.00%

HIDDEN LAKE
Haddam, CT

Table 3
PHYTOPLANKTON
AUGUST 26, 1995

CLASS	GENUS	STA.1	STA.2	STA.3	AVERAGE	CLASS %TOTAL
		(Organisms per milliliter)				
BLUEGREEN ALGAE					56	5.5%
	Anabaena	0	9	0		
	Oscillatoria	75	28	19		
	Polycystis	9	28	0		
GREEN ALGAE					12	1.2%
	Cosmarium	0	0	9		
	Scenedesmus	9	9	0		
	Tetraedron	9	0	0		
EUGLENAS					34	3.4%
	Euglena	0	9	0		
	Trachelomonas	19	47	28		
CHRYSOPHYTES					37	3.7%
	Mallomonas	0	19	9		
	Synura	56	0	28		
DIATOMS					12	1.2%
	Asterionella	0	0	9		
	Navicula	0	28	0		
DINOFLAGELLATES					78	7.7%
	Gymnodinium	66	9	56		
	Peridinium	19	47	38		
CRYPTOMONADS					154	15.0%
	Cryptomonas	38	85	56		
	Rhodomonas	113	131	38		
NANNOPLANKTON (Too small to identify)		667	732	516	638	62.4%
TOTAL PER STATION		1080	1181	806	1022	100.00%

usually dominant in the early summer. Euglenas are rather large unicellular swimming forms which are common in enriched ponds. Blue-green algae are an ancient group of extremely primitive organisms more closely related to bacteria than to other algae. They tend to dominate lakes during hot weather. Nannoplankton are a composite group of very small cells which cannot be easily identified or classified.

The average number of phytoplankton in Hidden Lake was moderate, ranging from about 7,700 organisms/ml in May to about 1,000 organisms/ml in August. Levels of 2,000 to 5,000 organisms/ml are not unusual in local lakes and ponds during the summer. In general, species diversity was high with at least 29 genera represented during the study (Table 3). About 15 to 20 genera are commonly found in lakes and ponds.

The dominant phytoplankton in the lake on all occasions were the Nannoplankton. A bloom of Nannoplankton occurred at Station 1 in July with about 12,000 organisms/ml counted (Figure 12). The Nannoplankton comprised over 94% of the total algae present in May. Their importance declined to about 62% of the total in August. In my experience, Nannoplankton are frequently dominant when nutrients are in short supply.

Chlorophyll a

Chlorophyll a is a pigment, specific to plants and algae,

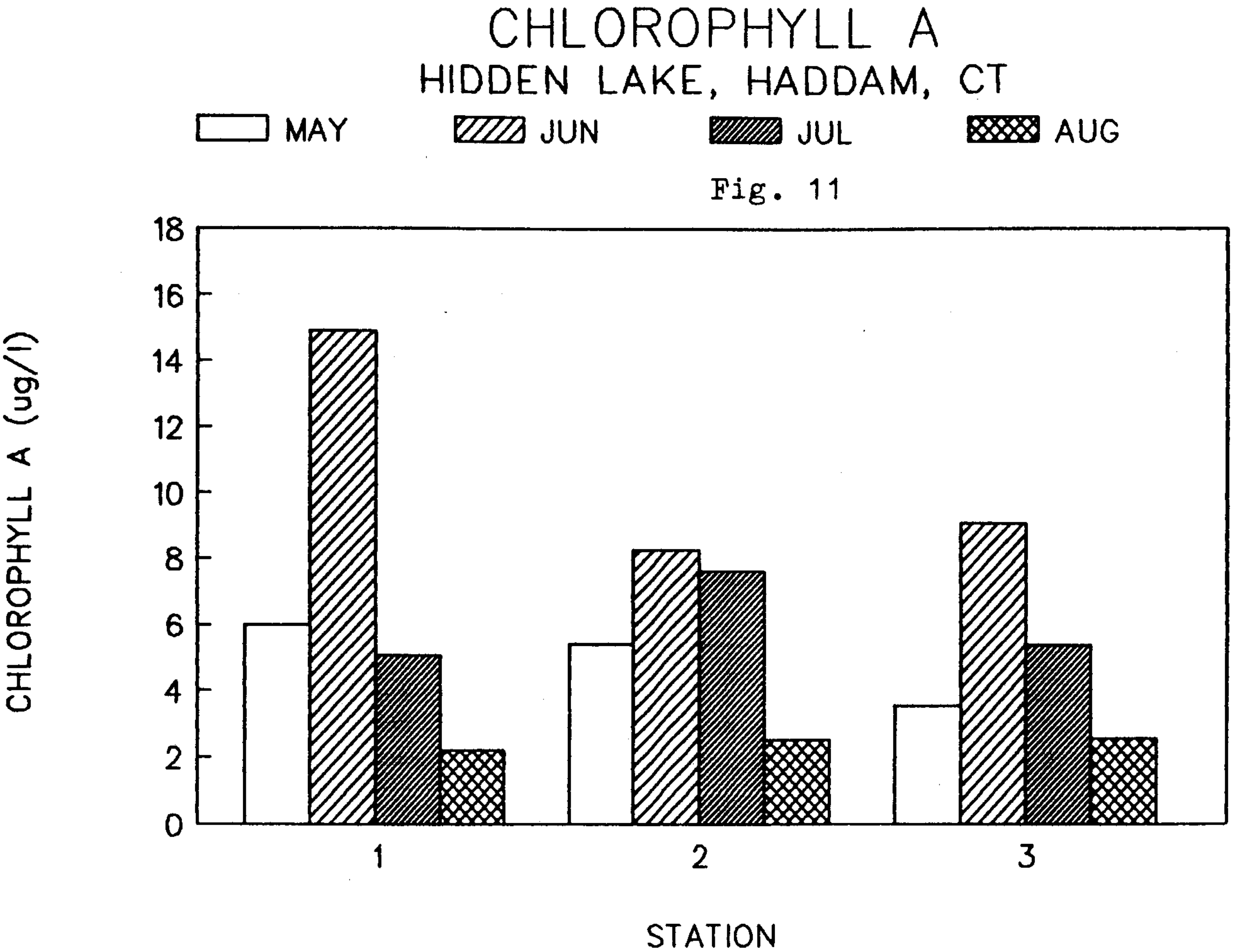

CHLOROPHYLL A
HIDDEN LAKE, HADDAM, CT
MAY
JUN
JUL
AUG
18
16
14
12
10
8
6
4
2
0
CHLOROPHYLL A (ug/l)
1
2
3
STATION

Fig. 11

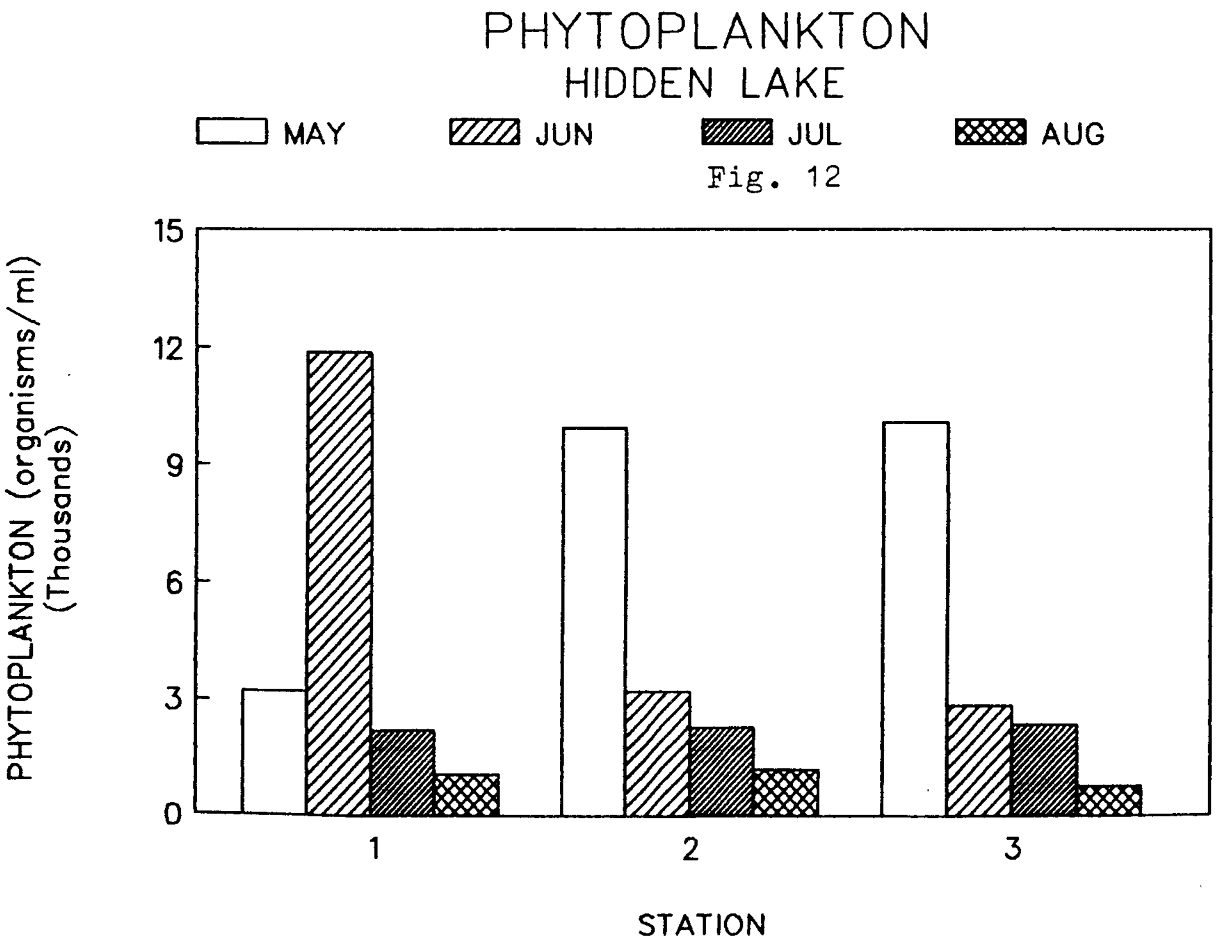

PHYTOPLANKTON
HIDDEN LAKE
MAY
JUN
JUL
AUG
15
12
9
6
3
0
PHYTOPLANKTON (organisms/ml)
(Thousands)
1
2
3
STATION

Fig. 12

which is used in photosynthesis. Photosynthesis is the metabolic process whereby plants and algae use carbon dioxide from the atmosphere and the energy of sunlight to manufacture carbohydrates and other energy rich molecules. Concentrations of chlorophyll a are a measure of the total amount of living phytoplankton biomass present in the water. Chlorophyll a is a delicate substance which tends to deteriorate rapidly when the algal cells die. The resulting breakdown product is termed pheopigment. Low levels of pheopigment indicate that the algal population is growing and reproducing, whereas high amounts indicate senescence.

Chlorophyll a levels were moderate in May, ranging from 3.5 to 6.0 ug/l. The concentration of chlorophyll in the lake peaked in June, with a maximum of 14.9 ug/l at Station 1 (Figure 11). This peak corresponded with high numbers of nannoplankton at this location (Figure 12). Levels declined in July and were lowest in August, ranging from 2.2 to 2.6 ug/l. Pheopigment concentrations remained relatively low throughout the study indicating a healthy algal population.

PLANTS

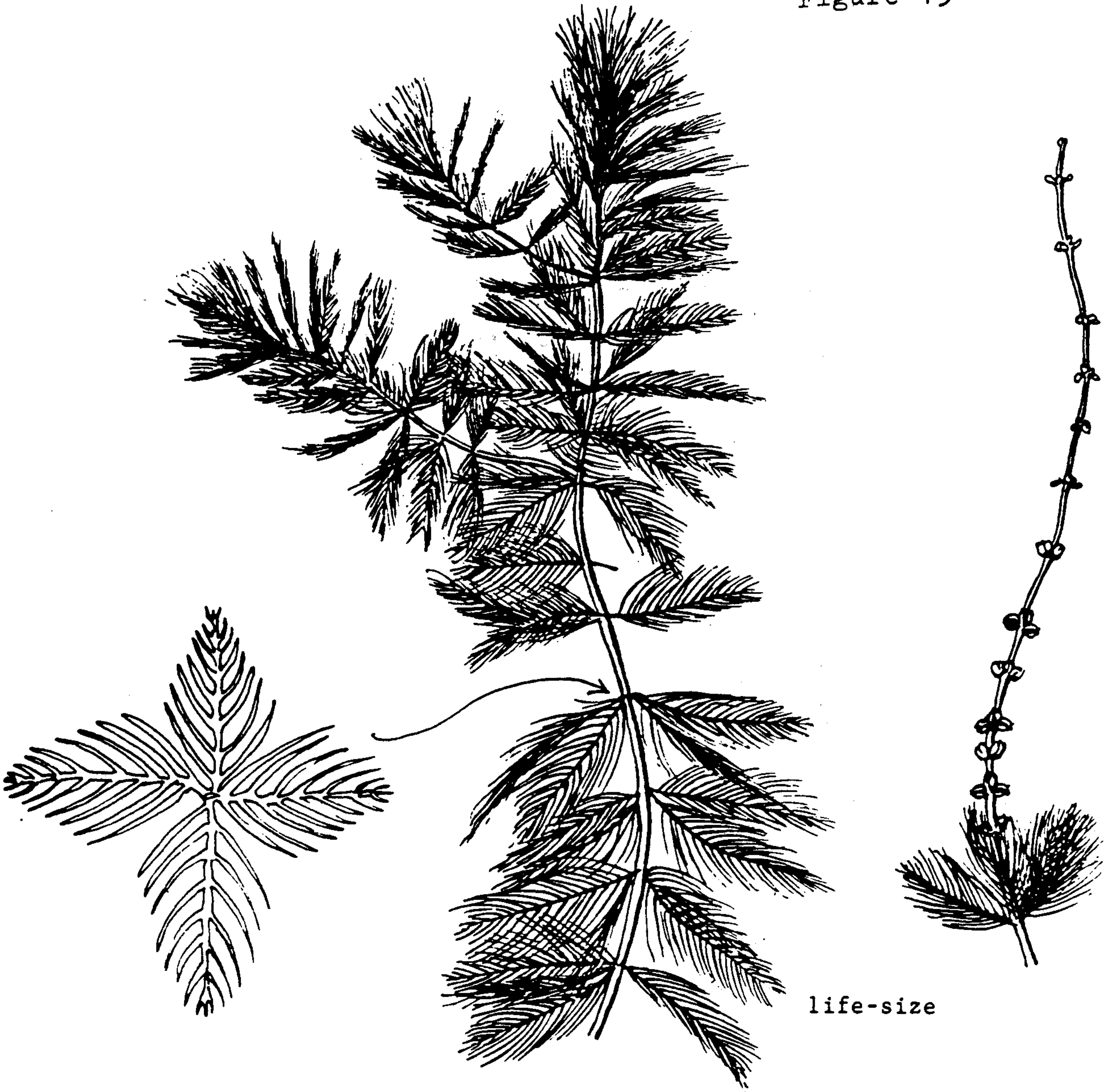
Aquatic Plant Species

Aquatic plants serve such important functions as nutrient uptake and habitat for fish and other aquatic organisms. Plants grow in shallow areas where light reaches the bottom, and where soft sediments are available for attachment.

Aquatic plants grew across the entire bottom of Hidden Lake. The dominant floating leaved plants were white water lily (Nymphaea odorata), yellow water lily (Nuphur luteum) and watershield (Brasenia schreberi). Two pondweeds with both floating and submersed leaves included ribbon leaf pondweed (Potamogeton epihydrus) and floating pondweed (Potamogeton natans). Fully submersed plants were dominated by bladderwort (Utricularia spp.), elodea (Elodea canadensis), water celery (Valisneria americana), slender pondweed (Potamogeton pusillus) and the plant-like alga, stonewort (Nitella flexilis). Other plants observed occasionally were leafy pondweed (Potamogeton foliosus) and low watermilfoil (Myriophyllum humile).

Dense stands of white water lily were noted in the shallow interior sections of West Cove and South Cove (Figure 2) and along the shore in other areas. The deeper sections of the lake (4 to 6 ft) supported scattered patches of yellow water lily. Water celery grew mostly in South Cove, but the other submersed species appeared to be distributed in all sections of the lake.

One aquatic plant not found in the lake during this study was Eurasian Watermilfoil (Myriophyllum spicatum). This introduced species is among the most aggressive nuisance aquatic weeds in North America. The plant grows prolifically, displacing



EURASIAN WATERMILFOIL, Myriophyllum spicatum

Fresh inland water and fresh to brackish coastal water; California; and Wisconsin to Vermont, Texas, and Florida.

This plant has been in the United States for at least seventy years. Since 1955 it has become very abundant in Upper Chesapeake Bay, the tidal Potomac River, and several Tennessee Valley reservoirs.

Leaves look like weatherbeaten feathers because of their 12-16 pairs of close-together leaflets.

Resembles Northern (page 32) and Whorled (page 34) Watermilfoils, with which it sometimes grows; but can be told from them by its more featherlike leaves.

Hotchkiss, N., 1972.
<u>Common Marsh, Underwater and Floating Leaved Plants of the United States and Canada</u>
Dover Publications, Inc., New York

native vegetation (Sorsa, et al. 1988). Eurasian Watermilfoil grows in depths up to about 15 ft. When it reaches the water surface it continues to grow, forming a tangled floating mat. Its main method of propagation is by fragmentation. Fragments separated from their root systems are able to survive in water of low nutrient concentrations (Madsen, et al., 1988). Therefore, the living fragments float from one area of the lake to another, eventually sink and become rooted to form new plants. Also, plant fragments can be carried into a lake on boats, motors or harvesting equipment. If this plant is ever observed by Hidden Lake residents, immediate steps should be taken to eradicate it. An illustration of the species is included in this report for reference (Figure 13).

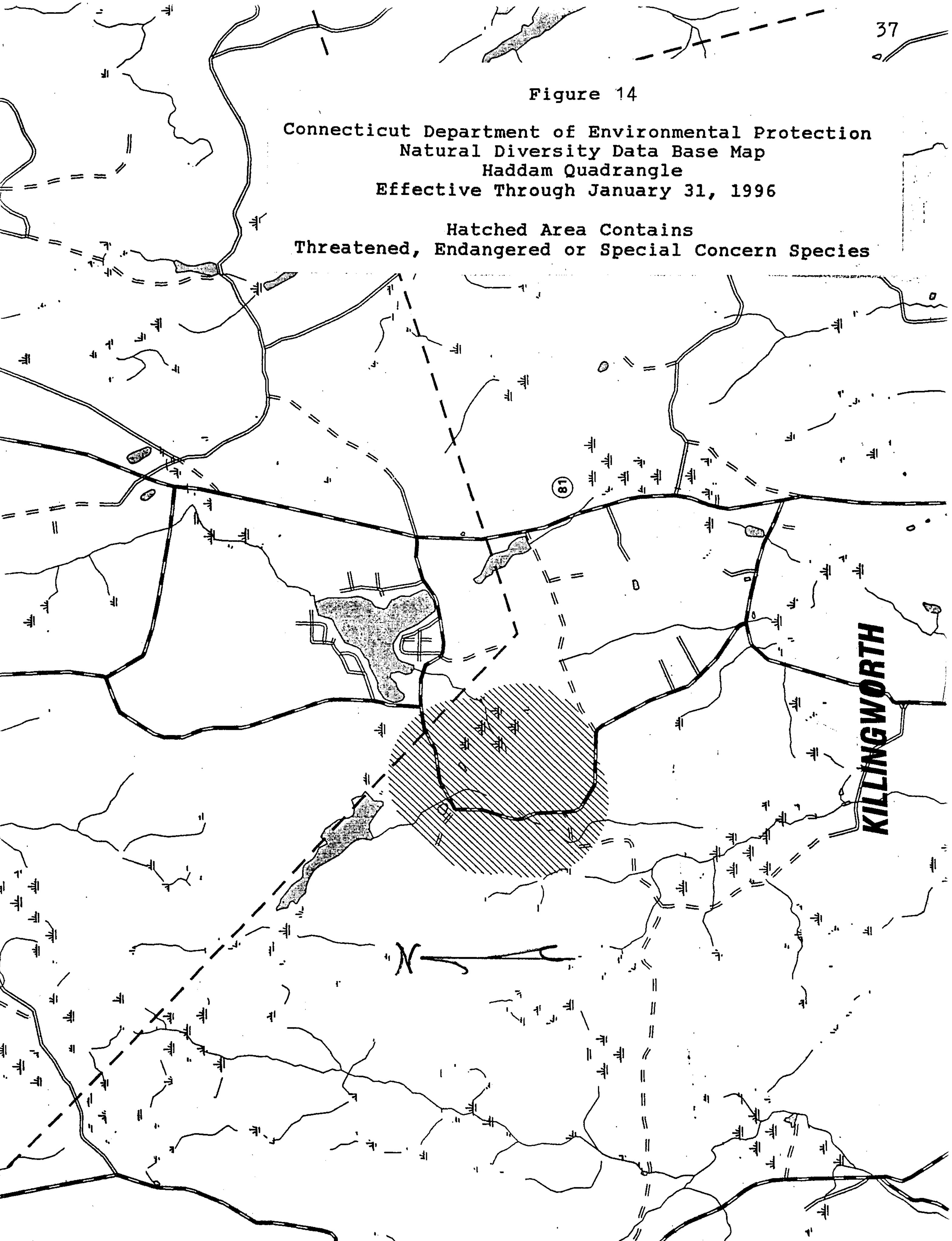
Rare Species

The Connecticut DEP Natural Diversity Data Base publishes maps showing the general locations of all species designated "threatened, endangered or of special concern". According to the map for the Haddam Quadrangle, in effect through January 1996, there are no such species in the immediate area of the lake or its inflow stream. However, a large wetland immediately downstream, identified on the topographical map as a bog, contains such species (Figure 14). Because this location falls within half a mile of the lake, it must be taken into consideration when planning any lake management efforts which might affect downstream habitats.

Figure 14

Connecticut Department of Environmental Protection
Natural Diversity Data Base Map
Haddam Quadrangle
Effective Through January 31, 1996

Hatched Area Contains
Threatened, Endangered or Special Concern Species



TROPHIC STATUS

Lakes can be classified and compared according to their level of fertility (trophic status). They range from oligotrophic (low nutrients) to eutrophic (high nutrients). The classic characteristics of oligotrophic lakes are low phytoplankton numbers, excellent water clarity, few aquatic plants and high to moderate levels of oxygen from surface to bottom. At the other end of the scale, eutrophic lakes are often high in nutrients, low in deep water oxygen, choked with weeds and subject to phytoplankton blooms. Most lakes are mesotrophic (moderate nutrients) with intermediate characteristics (Frink and Norvell, 1985).

One of the goals of this study was to establish the current trophic status of Hidden Lake. A number of different criteria can be used to determine trophic status. Two important indicators are chlorophyll a as a measure of algal abundance, and total phosphorus as a measure of fertility (Jones and Lee, 1982; Wetzel, 1983; Frink and Norvell, 1984; Canavan and Siver, 1995). In Hidden Lake, average concentrations for three stations over the four month period were 0.017 mg/l total phosphorus and 5.44 ug/l chlorophyll a. The maximum chlorophyll reading during the study was 14.89 ug/l. These data indicate that the lake can be classified as mesotrophic or, in other words, as moderately enriched (Table 4).

Table 4

TROPHIC INDICES

Variable	Author/Date	Oligotr. (mg/m3)	Oligo-Mesotr. (mg/m3)	Mesotr. (mg/m3)	Meso-Eutr. (mg/m3)	Eutr. (mg/m3)	Hidden Lake (mg/m3)
		CRITERIA					
Summer Chl.a	Frink & Norvell, 1984	<2	2-5	5-10	10-15	>15	5.44
Mean Chl.a	Jones & Lee, 1982	<2	2.1-2.9	3.0-6.9	7.0-9.9	>10	5.44
Chl.a Maxima	Wetzel, 1983	1.3-10.6		10.6-49.5		49.5-275	14.89
Mean T.P.	Frink & Norvell, 1984	<10	10-15	15-25	25-30	>30	17
Mean T.P.	Jones & Lee, 1982	<7.9	8-11	12-27	28-39	>39	17

RECOMMENDATIONS

WATERSHED MANAGEMENT

The most effective and least damaging long term method of controlling aquatic plant and algae growth is to limit the supply of the essential nutrients nitrogen and phosphorus entering a lake from the watershed. Plants and algae use nitrogen to build protein and use phosphorus for energy conversions within the cell. Thus both nutrients are required, and growth is limited by the nutrient in lowest supply. High nitrogen stimulates the growth of aquatic plants, since they can obtain virtually unlimited phosphorus from the sediments through their roots. High phosphorus, on the other hand, favors the growth of phytoplankton, especially certain blue-green algae which are able to utilize the unlimited supply of nitrogen in the atmosphere. Some common sources of nutrients in residential areas are failed or improperly maintained septic systems, lawn or garden fertilizers, waterfowl, soil erosion, road runoff and beach sand.

Septic Systems

Because of the sloping shoreline around the lake (Figure 1), septic systems are a major concern with respect to nutrient input. Both nitrate and phosphorus concentrations are very high in wastewater. Maintenance is critical, and lake-side residents should have their septic systems pumped out every two years. It is recommended that the Lake Association take on the role of public education concerning the importance of locating every septic system around the lake and scheduling neighborhood pump-outs. It may be possible to obtain reduced rates if enough homeowners participate in the program. It is also possible to conduct dye tests to determine whether septic systems are leaking into the lake.

Nitrate is soluble and inevitably travels with the groundwater from a septic system toward a lake, whereas phosphorus tends to be retained in the soil near the leaching field. Many household detergents contain extremely heavy concentrations of phosphorus. Continual use of such detergents can saturate the soil, allowing phosphorus to move freely with the groundwater into the lake. All of the residents should be encouraged to use only non-phosphate detergents.

As earlier noted, high total coliform counts have been recorded in the past for some areas of the lake (Table 2). It is often difficult to detect pollution indicator bacteria due to dilution once septic material reaches a lake. Because of the health implications for swimming, it would be advisable to continue testing for enteric bacteria on a regular and frequent basis during the summer. Currently, the bacterial test of choice for swimming areas is Enterococcus (DEP, 1992). This organism is specific to human waste (as opposed to the more general total coliform test specific to warm blooded animals). The Association should contact the Town of Haddam Health Officer for advice on how and when to collect Enterococcus samples.

Fertilizers

Lawn fertilizers should be used very sparingly or not at all in the vicinity of the lake. Liquid fertilizers applied by lawn care companies can be a major problem. If fertilizers must be used, only slow-release types should be considered. The use of lawn or garden herbicides and pesticides should also be kept to a minimum. Grass clippings, raked leaves or other organic material should never be deposited in the lake.

Geese

Canada geese can add significant quantities of nutrients to aquatic systems. Geese can also contribute to elevated coliform levels in the lake. Residents should not feed the waterfowl. Low wire mesh fences along the shoreline may help to keep geese away from individual lawns. However, it is very difficult to discourage these birds as long as the combination of open lawns for grazing and water is present.

Soil Erosion

Phosphorus is carried on soil particles and moves into lakes with eroded soils during periods of high runoff. Whenever an area of open soil or active erosion occurs on a property in the vicinity of the lake or along near-shore roads it should be stabilized as soon as possible by seeding and mulching. Such erosion controls as silt fence or hay bales should be used to contain any anticipated erosion due to construction, especially during high run-off periods in the spring. Advice can be obtained from the Soil Conservation Service regarding the deployment of erosions controls.

Sand

Phosphorus is associated with sand particles as well as with other types of soils. Additions of sand to the beaches should be minimized. Because of the slope of some of the roads and their proximity to the lake (Figure 2), considerable road sand and salt may reach the lake in the spring. High spring flow rates should ensure that the salt is diluted and is quickly washed out of the system. However, the lake will act as a settling basin for any road sand reaching it.

AQUATIC PLANT MANAGEMENT

Grass Carp

The use of sterile grass carp (*Ctenopharyngodon idella* Val.) to control aquatic vegetation is a fairly recent management technique in Connecticut. Grass carp (also known as White Amur) can be stocked only with strict supervision and permitting by the DEP. Permission must be obtained in writing from all individuals having ownership rights on the lake. The outlet and all inlets must be screened to prevent emigration of the fish. It is especially important that the fish not escape over the dam during periods of high water because of the presence of protected plant species in the bog immediately downstream from the lake. All screening must be inspected and approved by the DEP.

Grass carp are non-selective grazers, eating desirable plants as well as weed species. Good to excellent control by the carp has been reported for some of the submersed species present in Hidden Lake: elodea, stonewort, and several pondweeds. Poor control has been found for more visible floating leaved species: white water lily, yellow water lily and watershield (DEP, 1989). The fish do not remove organic material from the lake but deposit it as waste. The resulting dissolved nutrients stimulate the growth of phytoplankton, and thus turbidity often increases dramatically following the introduction of the fish. In my opinion, grass carp would not be a good choice for aquatic plant management in Hidden Lake.

Herbicides

I generally recommend the use of chemicals for plant management only as a last resort. Problems can arise with the use of chemicals. A sudden drastic reduction in the aquatic plant population can encourage the growth of algae which are able to take advantage of the available nutrients and reproduce quickly, producing algal blooms. Decomposition of the dead plant material also depletes oxygen concentrations in the water, thereby stressing fish and other aquatic organisms. Herbicides provide only temporary control. Long term effects on pond ecology of repeated chemical applications are not well understood. A pesticides permit from the DEP is required. Herbicides must be applied by a licensed professional, who will recommend the type of chemical and calculate the dosage.

Benthic Barriers

Individual homeowners may elect to install "benthic barriers" around their docks or in swimming areas to eliminate weeds. The barriers are either PVC coated fiberglass mesh or a solid PVC pond liner. These materials are rolled out and pinned to the bottom in the spring, blocking the light and physically preventing the growth of the plants. They must be taken up and cleaned every one to two years to prevent the accumulation of sediment on top of the fabric, and the subsequent regrowth of the plants. The application and maintenance of these barriers can be fairly difficult. Benthic barriers are costly and would be appropriate only in small areas.

Harvesting

A commercial aquatic plant harvester is a large cutting machine which cuts and collects lake vegetation to a depth of about 5 to 7 ft. A hydrorake is a rake shaped backhoe mounted on pontoons which is used to uproot water lilies. Both machines transport the masses of plants to a shoreline dumping area, where they are trucked away. It is usually necessary to obtain an Inland Wetlands permit for stockpiling the plants on shore. The cost of harvesting the entire lake would be about $15,000 not including the cost of trucking away the plants. Depending on the rate of plant regrowth, harvesting might have to be repeated once a year, and hydroraking every 4 to 5 years. Therefore, commercial harvesting is an expensive operation with relatively short term benefits. There is also the chance that the machines might bring in invasive species, such as Eurasian water milfoil, from other lakes.

Another option the Association might wish to consider is to purchase a small harvester and conduct their own harvesting operation in various areas of the lake. This harvester is known as a Hockney Underwater Weed Cutter (Appendix D). The machine could be used to maintain the areas around the beaches and in front of individual houses, as needed. The machine would be used only in Hidden Lake, thereby avoiding the importation of invasive plants. The cost of the equipment including delivery is about $12,000. It is reportedly very reliable equipment. Individual homeowners or neighborhood groups might also consider purchasing a Water Weeder, which is a hand held battery operated cutter for use in small areas (Appendix D). A variety of rakes can also be used. One of the most effective is a long-handled landscape rake with wooden teeth, which can be ordered from a hardware store. Another is the Beachcomber (rake head 36 inches wide, plastic teeth 7.25 inches long) which is specifically designed for aquatic weed removal (Appendix D).

Winter Drawdown

Winter drawdown has been conducted at Hidden Lake over many years to reduce aquatic plants and permit shoreline and dock maintenance. It is the only plant control technique which has been systematically used at the lake. It is required in the by-laws of the Association, and the recently reconstructed dam has been designed with drawdown capability. The reported average drawdown for the lake is 1.5 to 2 ft. The literature indicates that drawdown will produce a reduction in both white and yellow water lily (Cooke, et al. 1986). For maximum plant control, not only freezing but also desiccation of exposed sediments is required (North American Lake Management Society, 1988). The established practice of drawdown notwithstanding, aquatic plants were abundant during the course of the study period. Nevertheless, I believe that winter drawdown used together with some form of harvesting would be an effective combination.

LAKE MANAGEMENT

Aeration

Devices which oxygenate the water can improve water quality in lakes where large amounts of organic matter are decomposing and reducing the oxygen content. However, Hidden Lake was well oxygenated and wind-mixed during this study. In my opinion, an aerator is not indicated.

Dredging

Because of the uniformly shallow depth of Hidden Lake, dredging is an alternative which should be carefully considered. The lake could be dredged to a depth beyond which aquatic plants cannot grow (about 12 to 15 ft). The nutrient rich surface sediments would also be removed. Dredging would be a long term solution to the weed growth problem, and would also improve the recreational quality of the lake.

Dredging requires a complicated permitting process which can extend over a period of 1 to 2 years. Permits would be needed from the Town of Haddam Inland Wetlands Commission, the DEP and, probably, the U.S. Army Corps of Engineers. Engineering plans would have to be drawn up and the services of other consultants, such as a geohydrologist, soil scientist, biologist, etc., might be required. The lake would be drawn down during the dredging process, probably over a span of several years. There is also a potential for downstream sedimentation. This is a particularly sensitive matter because of the close proximity of the downstream bog. Strict erosion controls would be required.

The cost of dredging is prohibitive for most lake associations. However, if deposits of good quality sand or gravel underlie the lake, these materials might have considerable value. Some associations have been able to exchange dredge spoils for excavation costs. The ongoing deposition of aquatic plant material, terrestrial debris and sediment from the watershed is gradually filling the system. Dredging would reverse this eutrophication process and would fundamentally extend the life of the lake.

CONCLUSIONS

Hidden Lake is a shallow, moderately enriched mesotrophic system with an extensive plant population. Unlike many mesotrophic lakes in Connecticut, the watershed is undeveloped except for the area immediately surrounding the lake. The lake has a long shoreline, and is especially sensitive to impacts originating in the residential neighborhoods. By disseminating information to concerned residents and developing management programs, the Hidden Lake Association has an excellent opportunity to control the major sources of nutrients to the lake. An effort to restrict nutrients must be undertaken, regardless of any other accompanying management approaches.

The first priority should be to investigate the condition of septic systems around the lake by means of a sanitary survey and dye tests. This is especially important since Association testing of coliform and total phosphorus over the past few years indicates the likelihood of septic problems. Homeowners should be informed about the impact of erosion, fertilizers and high phosphate detergents. A road management plan should be developed to control road runoff. Catch basins should be cleaned regularly and accumulations of road sand should be swept up in the spring. Consideration should be given to the construction of sedimentation basins or biofilters between runoff gullies and the lake.

In an effort to deal directly with the aquatic weeds, the Association should investigate the possibility of plant harvesting. Either a commercial harvesting company could be engaged at considerable cost, or a small harvester purchased by the Association could be used throughout the growing seasons in selected weedy areas. Equipment ownership by the Association could be an ongoing cost effective approach to harvesting. The limiting factor for the depth of harvesting is the reported presence of tree stumps on the lake bottom. Individual homeowners can be encouraged to manage the weeds in front of their property by the use of a hand held weed cutter and raking, or benthic barriers. Winter drawdown, together with harvesting, should stress the plants and may eventually reduce populations.

The premier solution to the basic problem of Hidden Lake - its shallowness and dense aquatic vegetation - is dredging. A comparison of the current bathymetric map with the 1959 version indicates that there has been a significant loss of depth. The possibility of dredging should be carefully weighed with regard to costs, permit requirements and the design of the present dam.

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