ASSESSMENT OF GALWAY LAKE

Report to the Galway Lake Homeowners Association

prepared by:

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* For appendices, see Renssel_r Fresh Water Institute Lake Management Manual: Lake Assessment Appendices for 1989. FWI Report 190-3.

EXECUTIVE SUMMARY

Findings

1. The transparency and phosphorus concentration of Galway Lake waters indicates that the lake should be classified as mesotrophic to eutrophic.

2. Water quality in Galway Lake is currently adequate for the primary use of its' residents, namely recreation.

3. The moderate alkalinity of Galway Lake makes it resistant, at the present time, to acidification by precipitation.

4. The deeper waters of the lake (hypolilllllion) show low dissolved oxygen concentrations and elevated nutriant levels during the latter part of summer stratification.

5. The two inlets tested were found to be contributing substantial amounts of sediments, nutrients, and dissolved materials to the lake.

6. A total of 19 submersed aquatic plant species, and a profusion of benthic algae, _re observed in Galway Lake. Eleven of these species were observed along five transects. The 5 most abundant species in order of importance in the lake were Myriophyllum spicatum, Ceratophyllum dernersum, Elodea canadensis, potamogeton proelongys, and Nitella sp.

7. Eurasian Watermilfoil was found throughout the lake, but formed particularly dense beds in the southern and western bays. Depth distribution of dense beds was from 2.5m (8') to 4.5m (15'). Scattered plants were found from 1m to 6m, but plants found beyond 5m were generally fragments that were not likely to establish and survive.

Recommendations

1. Establishment of an active lay monitoring program to continue data collection started by this assessment should be actively pursued. With some basic training, lake association members can collect information which can be used to signal sudden shifts in water quality or aquatic plant populations. This information is crucial for rapid response and remediation activities.

2. Encouragement of an active lake association with ties to regional and state lake federations is an important step. A water quality committee could organize education, prevention, control and evaluation activities. A thorough review of your town's zoning and planning laws with respect to mitigations of stormwater and wastewater controls should also be considered. A number of the things which threaten the lake are more regional or problems, such as runoff of sediments, nutrients, salt and corroeion products from area roads. SOlutions for these problems will probably require political action.

3. Sedimentation and the nutrients these sediments carry are the greatest threat to water quality. Agricultural and development activities within the lake basin make erosion of soils a serious problem. Contact with the Saratoga County Soil and Water Conservation Service (see Appendix G) to review appropriate eroeion control techniques (BMPs) is a necessary first step. Many techniques can be applied on an individual homeowner basis such as planting of erosion resistant species, maintenance of a green strip along the lakeshore, and altering the flow of runoff water to name a few.

4. The use of hypolimnetic withdrawal of nutrient-rich waters during the latter part of the summer stratification can aid in reducing nutrient concentrations in the lake. These in turn can reduce the abundance of algae and aquatic plante.

5. An active aquatic plant control committee should develop and implement an aquatic plant management plan, as part of an overall lake management plan. In addition to selecting and implementing control techniques, the committee should develop education, prevention, evaluation and monitoring activities.

6. Overwinter drawdown should prove to be an effective and inexpensive large-scale control technique. However, this technique should not be over-utilized, and other control techniques should be used in intervening years between drawdown episodes.

SECTION 1

BACKGROUND

Galway Lake is located on the western edge of Saratoga County in the Town of Galway. The lake's watershed is part of the Mohawk River drainage system. Included within the watershed is a smaller lake, Lake Butterfield, along with various streams and wetlands. Elevations within the watershed range from 259 meters at the surface of the lake to 390 meters above sea level (Table 1-1 and Figure 1-1).

The lake has a surface area of 209.8 hectares and a rolling watershed of 2236 hectares. The lake has maximum depth of 7.1 meters (23 ft.). Typical of lakes in the temperate region, it is dimictic, exhibiting both summer and winter thermal stratification. The shallow nature of this lake may lead to frequent breakdown and reformation of thermal stratification during the summer and fall of the year.

Galway Lake is largely man-made, originally formed by a dam constructed in 1855 to provide a 450 acre reservoir. The lake was enlarged 1865 and again in 1875 to its current size. The waters of the lake were impounded to provide water power and a supply of clean water to the textile mills in Galway and Amsterdam. The dame were built by a group of mill owners headed by State Senator Steven Sanford. In 1980, the owner of the dam, Mohasco Industries, turned the dam and control of the water level of the lake over to the Galway Lake Campers Association. The dam is located on the western margin of the lake and is the only outlet. Winter drawdown of the lake, averaging 4 to 5 feet, is conducted on an annual basis to prevent spring flooding, protect docks from ice damage, facilitate inspection and maintenance of the dam and to control excessive weed growth. In the winter of 1989-90, the lake was drawn down to the base of the dam, approximately 18 feet below mean water level, in order to repair the dam.

The lake is classified by NYSDEC as class B, which indicates that its best use is for contact recreation and other recreational uses, but not as a water supply for drinking or food preparation.

Galway Lake is a residential/recreational lake with boating, fishing and swimming the primary uses. Public access is limited. The watershed is sparsely populated, however areas of undeveloped shoreline with potential for residential use are almost non-existent. There is no

Table 1-1. Physical Features of Galway Lake.

GALWAY LAKE - Galway. Saratoga County. New York	
Latitude	43 degrees 01 minutes
Longitude	74 degrees 05 minutes
Topographic Quad. Map	Galway
Watershed	Mohawk River
NYSDEC Pond Number	563
Maximum Depth	7.1 meters (23 feet)
Surface Area	209.8 he¢tares (518.2 acres)
Watershed Area	2236 hectares (5523 acres)
Shoreline Length	12.6 kilometers (7.8 miles)
Elevation Above Sea Level	259 meters (857 feet)
Annual Precipitation	40-50 inches
Water Quality Classification	B

commercial land use on the shore of the lake. Agricultural activities are present within the drainage basin and constitute a major land use in the region.

Dense growth of aquatic plants, "weeds", has been a concern of lake residents for an extended period of time. Long time residents indicate that heavy weed growth. particularly in the north end of the lake, has been observed for several decades (R. Otto, pers. comm.). The more recent introduction of Eurasian Watermilfoil however, has spurred camper association members to seek professional assistance in managing aquatic plant growth in the lake.

The fisheries resources of Galway Lake are characteristic of a warm-water temperate zone fishery (Table 1-2). Stocking of game species has been conducted with walleye pike the most recent, however both largemouth and smallmouth bass have been stocked in the past. The species present indicate average water quality.

A bathymetric (depth) map of the lake was found in the Amsterdam Water Department Office and updated in 19S9 by Mr. Lewis Denton and Mr. D. Swann of the Campers Association. A composite map of these is included as Figure 1-2.

Table 1-2. A Partial list of Fish Indigenous to Galway lake.'

Common Name	Classification
largemouth Bass·	Micropterus salmoides
Smallmouth Bass·	Micropterus dolomieu
Rock Bass	Ambloplites rupestris
Chain Pickerel	Esox niger
Brown Bullhead	Ictalurus nebulosus
pumpkinseed Sunfish	lepomis gibbosus
Yellow Perch	Perca flavescens
Walleye Pike·	Stizostedium vitreum

• These species have been stocked

Species listing provided by Mr. lewis Denton, Galway lake Resident.

Figure 1-1. Topographic Map showing the watershed of Galway Lake. Watershed area is estimated based on limited topographic data.

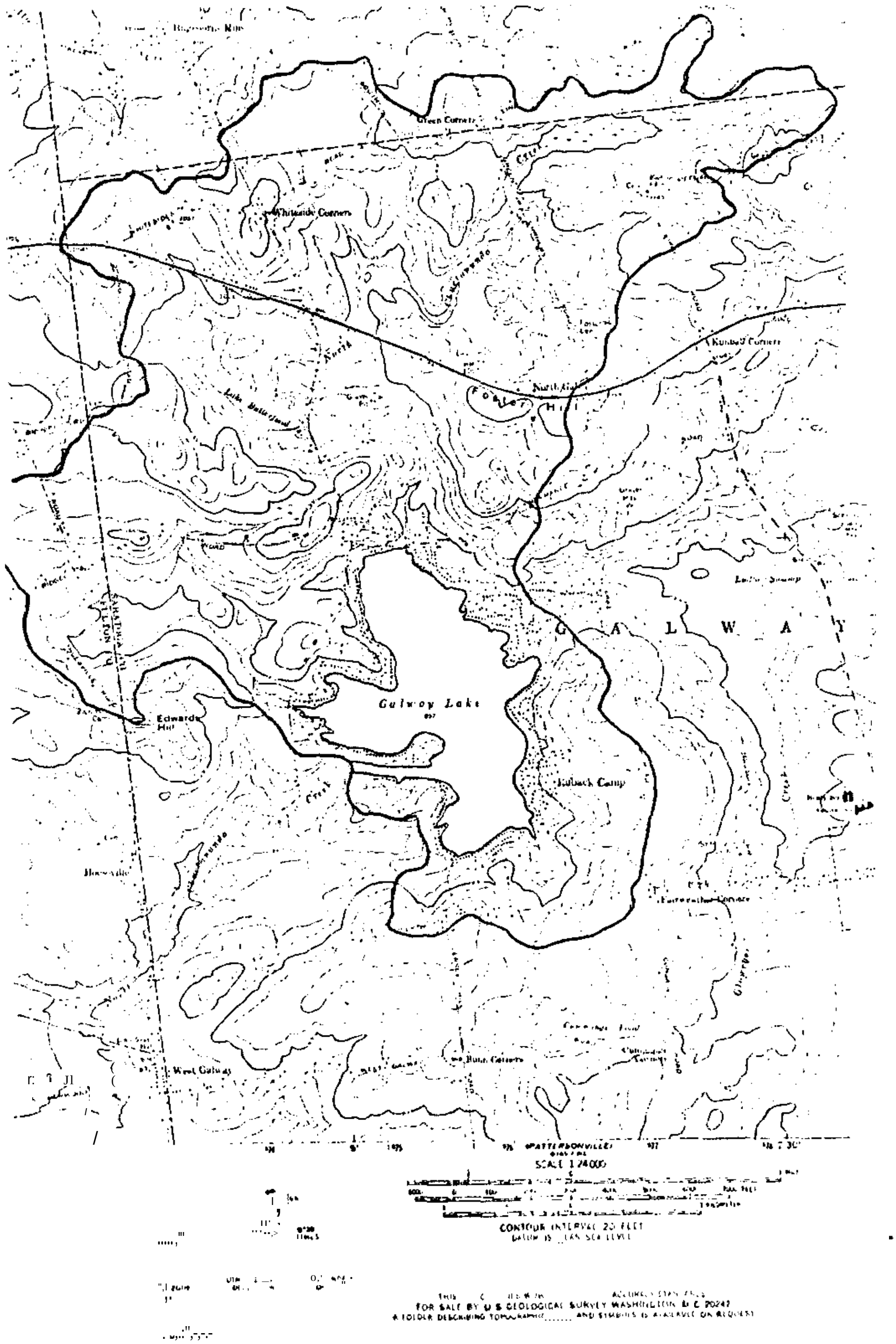
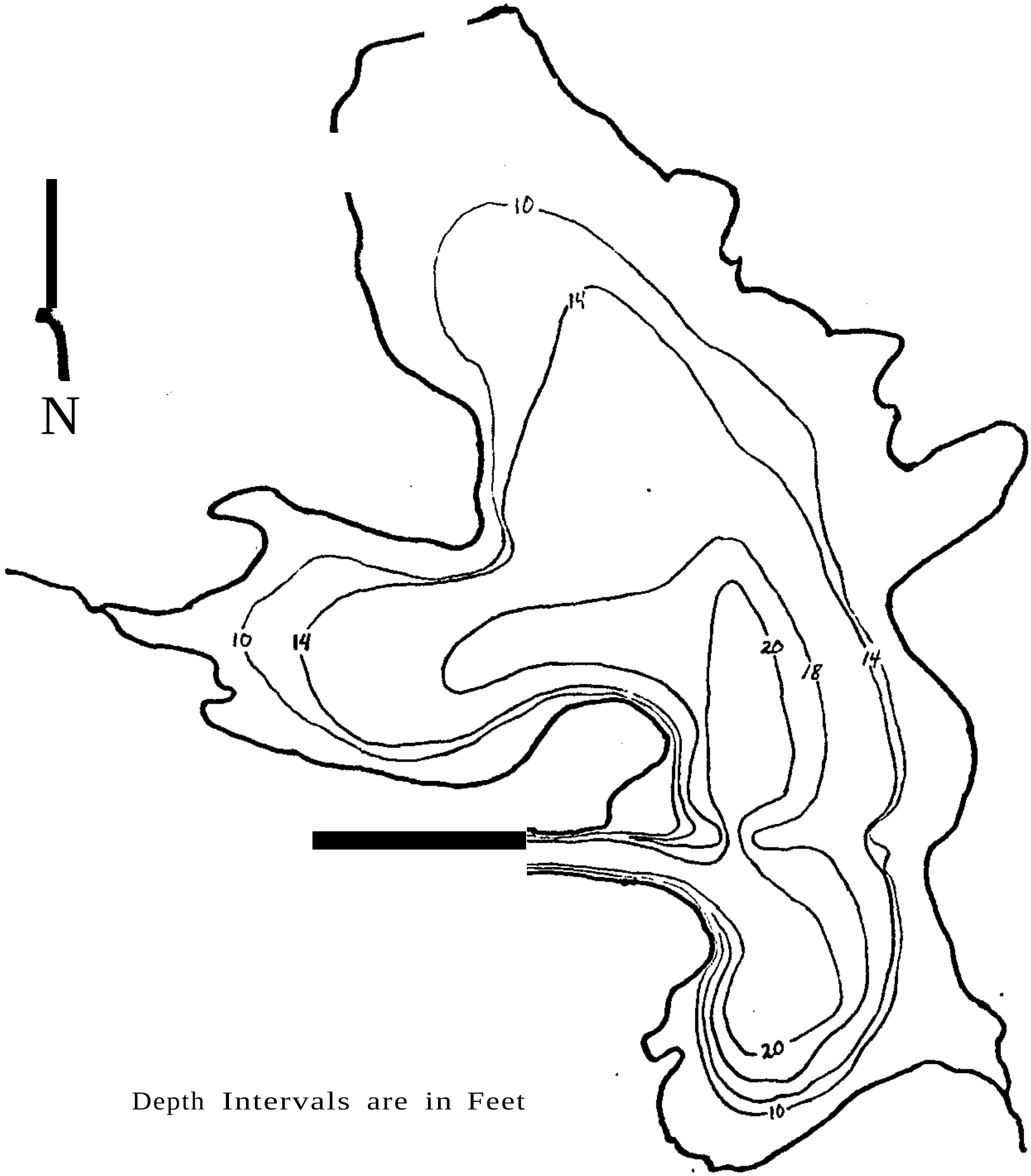


Figure 1-2. Bathymetric (depth) map of Galway Lake, derived from Amsterdam Water Department records and soundings taken in 1989 by Mr. L. Denton and Mr. D. Swann. Lake level at 21 ft.



SECTION 2

METHODS

Water Quality

In order to characterize the chemistry of Galway Lake water, four sampling sites were selected (Figure 2-1 and Table 2-1). Sites were selected to provide samples representative of the lake as a whole. Selection criteria include: water depth, degree of shoreline development, density of aquatic weed growth, and proximity to inlets or outlets.

Table 2-1. Chemical Water Quality Sampling Sites.

Site	Name	Location
1	Inlet 1	Samples were collected in the central channel of this inlet approximately 20 meters upstream from the lake. Very little flow was observed. A sample was taken at 0.5 meters below the lake surface. Maximum water depth at this site was 1.0 meter.
2	Inlet 2	Samples were collected in the central channel of this inlet approximately 80 meters upstream from the lake. Moderate flow of clear water was observed. A sample was taken at the water surface. Maximum water depth at this site was 0.5 meter.
3	Outlet	Samples were collected adjacent to the dam pylon. The stage height at the pylon was 20.5 feet at the time of sampling. A sample was taken at 0.5 meters below the lake surface. Maximum water depth site was 3.5 meters.
4	Midlake	Samples were collected in the south central portion of the lake. This site was over the spillway of the old dam. A sample of the epilimnion was taken at 0.5 meters below the lake surface. Maximum water depth at this site was 7.1 meters.
4	Midlake Deep	The sampling site was at the same point as site 3. A deep, point sample was taken at a depth of 6.5 meters.

At each lake site, measurements were made of maximum water depth and water transparency by Secchi depth, conditions permitting (i.e., not greater than maximum depth). Temperature and dissolved oxygen (D.O.) were measured using a YSI Model 54 D.O./Temperature Meter. Determinations were made at 1 meter intervals for the entire water column. Also at each site, a surface water (epilimnion) sample at a predetermined depth (0.5 meter) was taken. At the midlake site, a deep point sample from near the bottom of the lake and below the thermocline was collected to be representative of the hypolimnion of the lake.

Surface grab samples were cOllected by submerging an appropriate container below the surface of the water and then inverting it to fill in such a manner that the mouth of the bottle was as far as possible from the samplers arm and hand. Care was taken to avoid collecting portions of the surface film in these samples. Surface grab samples were collected at all sites. At the midlake site, a deep-water sample was also taken using a Van Dorn collection bottle which was lowered to the desired depth (6.5 meters) and remotely triggered to shut, thus collecting a sample of water at that depth.

All water samples were stored on ice until return to the laboratory. Immediately upon returning to the laboratory a portion of each sample was analysed for pH, specific conductance, orthophosphorus, total suspended solids and alkalinity. A separate portion, to be used for total filterable phosphorus determination, was frozen until analysed. The remainder of each sample was filtered (0.4 um Nuclepore filter) and stored at 4° C until analysed for nitrate and ammonia concentrations. The analytical methods used for all determinations are listed in Appendix L.

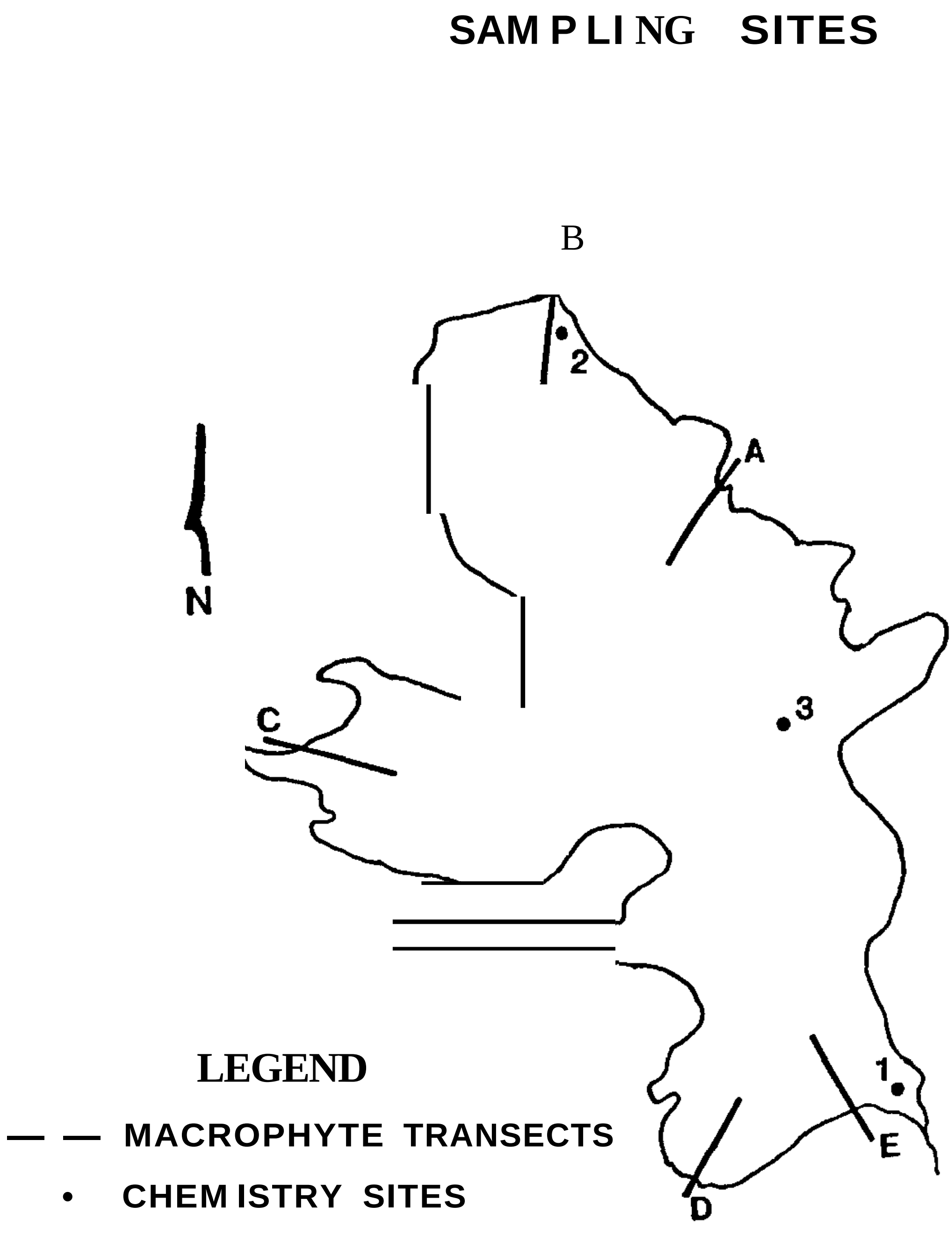
VEGETATION METHODS

The location of scattered and dense Eurasian Watermilfoil (Myriophyllum spicatum L.) populations for the entire lake were noted on a map. To further quantify the aquatic plant populations around the lake, five locations were located evenly around the lake for diver swim-over transects (Figure 2-1). Along each transect, the diver estimated the abundance of all aquatic plant species in each depth interval using the following abundance classes:

Class	Code	% Cover Range	Centroid
Abundant	A	greater than 50% cover	75%
Common	C	25% to 50% cover	37.5%
Present	P	15% to 25% cover	20%
Occassional	o	5% to 15% cover	10%
Rare	R	less than 5% cover	2.5%

In addition to using these abundance class data to evaluate plants at each transect, the abundance class data was summed for all transects using the centroid of the abundance class percent cover range. This data both provides average depth distributions of plants, and an estimate of the relative abundance of all species in the lake.

Figure 2-1. Map of sampling locations indicating chemistry sites and vegetation transects on Galway Lake.



SECTION 3

WATER QUALITY IN GALWAY LAKE

Samples were collected from Galway Lake on September 12, 1989. At the time of sampling, the temperature of the upper waters of the lake (epilimnion) was between 18.5 and 21°C (65 - 70°F). The lake displayed only weak thermal stratification (Figure 3-1), however chemical stratification in the form of declining dissolved oxygen concentrations with depth, was apparent.

Oxygen levels in the surface waters of the lake were at or near saturation, with a peak in dissolved oxygen concentration at a depth of 2 meters (see Figure 3-1). This peak is commonly seen during the period of summer stratification, and is due to the settling of phytoplankton at the thermocline. These phytoplankton release oxygen as a byproduct of photosynthesis, thus increasing the concentration of dissolved oxygen in the waters. Reduced levels of oxygen in the hypolimnion (waters deeper than 3 meters) of Galway Lake during the summer (see Figure 3-1) controls the type of organisms capable of utilizing this portion of the lake. The lowered levels of oxygen in waters just above the bottom sediments is due to decomposition occurring in the deep waters and sediments. Bacterial activity in the sediments of the lake bottom consumes oxygen and once the lake is stratified, the deep waters are effectively cut off from the primary source of oxygen to a lake, the atmosphere.

The chemical constituents of primary concern for Galway Lake residents would be those which promote the growth of algae and aquatic plants. These materials, notably phosphorus and nitrogenous compounds, are fertilizers in that they are present in the shortest supply relative to the amounts needed to sustain algal growth. Addition of one or both of these nutrients generally results in a reduction of water quality since the concentrations of these nutrients control the amount of plant and thus animal material capable of growing in the lake. Sources of nitrogen and phosphorus to the lake include: the atmosphere through rain, snow, etc., surface runoff of soils, septic system leachate, resuspension from the sediments of the lake, runoff of fertilizers from farm fields or lawns and gardens, and fecal material from domestic animals.

Phosphorus is generally considered to be the primary limiting nutrient to plant growth. The most readily available form of phosphorus for aquatic plants and algae is orthophosphorus. This nutrient was available in the waters of Galway Lake in a concentration of 4 part per billion (ppb). This is a relatively high concentration of this nutrient when compared to less productive lakes which generally have less than 1 part per billion orthophosphorus concentrations. Total filterable phosphorus concentrations listed in Table 3-1 indicate that the total amount of soluble phosphorus in the surface waters of Galway Lake is primarily orthophosphorus. At anyone time, most of the phosphorus is probably tied up in the cellular material of the organisms in the lake. Total phosphorus concentrations in the surface waters of the lake were 22 to 23 parts per billion. Concentrations of phosphorus entering the lake from the inlets were higher than those of the surface waters of the lake. The highest concentrations of phosphorus observed were found at inlet 1 (38 ppb). Surface runoff of precipitation, the eroded soils that it carries and the other terrestrial materials that it collects (lawn and farm fertilizers, septic materials, and pollutants) are frequently a major source of phosphorus to a lake.

Soluble phosphorus concentrations in the deeper waters of the lake (mid1ake) were comparable (5 ppb) to those of the surface waters, while total phosphorus concentrations (28 ppb) were substantially higher in the deeper waters.

The methods used to determine the amount of nitrogenous compounds in the lake water only measure materials not contained in living tissue or particUlate material. From Table 3-1, it is apparent that there are little in the way of nitrogenous compounds (ammonia and nitrates) available in the surface waters. Most of the nitrogenous material is probably bound up in living tissue (i.e. algae, plants, fish, etc.). As there was not a discernab1e algal bloom occurring at the time of sampling, the lack of available ammonia and nitrates indicates that nitrogenous material may be limiting to algal productivity in Galway Lake. The deeper waters of the lake (mid1ake sample) had measureab1e amounts of ammonia, a byproduct of the decomposition processes going on in the sediments. Considerable amounts of nitrate (0.16 mg *NIl)* were present in the waters of inlet 1. Inlet 1 drains an extensive area of wetlands prior to entering Galway Lake. Breakdown of the large amount of plant materials in these wetlands may be the source of these nitrates.

Alkalinity and pH records for Galway Lake are listed in Table 3-1. The pH at all sites was quite alkaline (pH greater than 7.0). The ability of a lake to neutralize additions of acid via acid rain or surface runoff is measured by alkalinity or the buffering capacity present in the lake water. The alkalinity of Galway Lake was 64.0 mg/L as $CaCO_3$ in the surface waters (epi1imnion). This alkalinity value is moderate and as evidenced by the alkaline pH of the lake water, it presently has an adequate capacity to buffer any acids coming into the lake. The greatest amount of acid enters the lake during the spring when rapid melting of snow occurs. This is generally the time when the most acidic pH values (less than 7) are observed in lakes and streams. Since spring water samples were not included in this study, the effects of spring snowmelt on the pH of Galway Lake remains to be determined. The alkalinity measured in the surface waters however is not indicative of a lake that would be seriously impacted by acid precipitation at present.

Secchi depth is a simple measure of water transparency. Water transparency is controlled by the density of plankton, dissolved organic materials and the amount of fine grained silts and clays present in the water. Nutrient rich lakes, for example Saratoga Lake listed in Table 3-2 for comparison, generally have large numbers of plankton in the water which result in low transparency. Shallow lakes in areas where the soils are mainly fine clays and silts also have generally low Secchi depth readings due to constant resuspension of the fine sediments via wave activity. Water transparency in Galway Lake as measured with a Secchi disk was 2.7 meters (8.9 feet). Transparency in this range is considered indicative of a lake with moderately high algal productivity.

Specific conductance is a measure of the total dissolved ions present in the water. Conductivity values in the surface waters ranged from 167 to 168 umhos. Samples taken from the hypolimnion, waters deeper than three meters, exhibited higher conductivities than other locations with a value of 171 umhos at the time of sampling. COnductivity values for waters of inlet 2 are substantially higher than lake waters. Conductivities in this range point to substantial amounts of dissolved ions present in the water.

Sedimentation via runoff of soils and terrestrially derived materials can have a major impact on lakes. The general Mfi11ing inM of a lake by these materials has the consequence of providing additional areas for the growth or aquatic plants, providing a variety of nutrients to encourage their growth, and leading to a general warming of the lake. Substantial amounts of nutrients are also contributed to the lake by these sediments increasing the overall productivity. Soft sediments were observed at the periphery of sandier delta material offshore of the mouth of the two inlets sampled.

One way of measuring the amount of solid materials suspended in water is Total Suspended Solids (TSS). The levels of suspended solids in the waters of Galway Lake was quite low, 1.5 milligrams per liter (Table 3-1). The outflow of inlet 1, however contained 3.1 mg of TSS per liter. Suspended solids generally include soil particles, plant and animal plankton and a variety of terrestrially derived materials. Elevated levels of these materials generally indicate either a very productive lake or substantial additions of materials eroding from the watershed of the lake.

Water Quality Management Options

Water quality management is generally keyed to maintenance or improvement of an accustomed use rather than what is best for a lake from a purely environmental standpoint. In the case of Galway Lake, maintenance of the lake for recreational uses such as swimming, sailing and fishing is the desired goal. The principal threat to these uses at present is excessive growth of algae and aquatic plants in the lake.

Galway Lake is a moderately productive lake in terms of algae and rooted aquatic plants, a condition which may impact on the desired use of the lake. The level of algal productivity of any lake is tied to the availability of nutrients or fertilizers in the lake water and sediments. An extensive discussion of nutrients and their relationship to plant production is included in Appendices A and B.

Reduction in the density of aquatic plants and algae, from a water quality standpoint, revolves around reduction of the amount of nutrients present in or added to the lake. A management plan to reduce nutrient concentrations in Galway Lake should include the following basic components.

EDUCATION
PREVENTION
IMPLEMENTATION OF CONTROLS
MONITORING AND EVALUATION

Edycation. In order to develop support for lake management, area residents need to understand the need for and the justification of activities relative to water quality management. They need to understand how their actions may effect the use of the lake and how they can get assistance to remedy any real or perceived problems. Education can provide understanding and enlist support for programs to improve water quality. In order to assist your lake association in developing an educational program for your members, we have included basic information as Appendices to this report.

Prevention. Reduction of nutrients within Galway Lake should start with prevention of excess nutrients from entering the lake. Nutrients enter the lake in three ways; directly with precipitation, through runoff of waters from the lake's watershed and via resuspension from the sediments of the lake. Little can be done to reduce the amount of nutrients falling directly on the lake as precipitation, at least on the local level. Substantial reductions in the nutrients carried by runoff waters can be accomplished by local residents at the grass roots level. Reduction of nutrients coming into the water column of the lake via resuspension from the sediments will generally require in-lake control.

Reductions of the amount of impermeable surfaces adjacent to the lake (paved roads and driveways, sidewalks, etc.) will slow the flow of rainwater to the lake by forcing it to Dercolate throuGhf80i1s priorito entering the lake. 8011s act as a natural 11ter remov ng much of the nitrogen and phosphorus compounds before the water reaches the lake. Eliminating stormwater drains emptying directly into the lake is also helpful. The drains may be redirected to small gravelled areas for slow dispersal of the water.

Sewage from failing or improperly located septic systems can be a major source of nutrients to a lake. In a properly maintained and located septic system, solid material is allowed to settle in the septic tank where microorganisms can decompose it into water soluble material. The water soluble components (leachate) are allowed to pass into lateral drainage fields where the liquid slowly percolates into adjacent soils. In the soil, chemical reactions and bacteria remove the nitrogen and phosphorus compounds from the water and convert it to insoluble material, cellular material and gaseous material. Thus, in a properly operating system nitrogen and phosphorus are removed or reduced before the water finally percolates back to the lake. In a system which is not operating properly, insufficient time is available for complete removal of nitrogen and phosphorus compounds before the leachate reaches the lake. Septic system failure is likely to occur when the systems are:

1) built in fill over an old wetland or natural drainage area whose water table is near the surface of the soil.

2) not of sufficient size to handle normal and peak loading rates.

3) located where the depth of soil present over bedrock is less than six feet.

4) located less than 50 feet from the shore of a lake or a stream.

5) located in soils with extremely high permeability or steeply sloping ground resulting in too rapid a movement of liquid through the system.

6) receiving excessive amounts of undigestable or slowly digested materials (i.e. plastics, bone or eggshells) without frequent pumpout.

7) older than 30 years and have never been upgraded.

Extreme septic system failures may be observed as clogged toilets and drains or puddling of water on the surface of the ground near the location of the septic leaching device of the system. Puddling is most likely to occur when the soils are quite wet primarily during the spring of the year and after periods of heavy rain in the summer. Surface pooling of water is also most common at high water usage times of day, generally in the morning. Septic inputs directly into the lake generally result in excessive growth of dense filamentous mats of algae near the point where the sewage enters the lake.

Eroding soils carry considerable amounts of nutrients into the lake. Soils generally contain much greater amounts of nitrogen and phosphorus compounds than lake water. If soils are stabilized by good vegetation cover, only small amounts of nutrients are washed into the lake. If large areas of timber are logged or if roads and developments are improperly designed, large scale erosion of soils frequently results. Soil erosion may be controlled in several ways by: 1) maintaining or planting effective ground cover vegetation (e.g. Crown Vetch) in erosion prone areas, 2) restricting the amount of acreage that may be logged at anyone time and the time of year when logging operations occur, 3) providing guidelines on road construction within the basin and methods that contractors use to develop property, and 4) maintenance of a vegetated area along the shoreline. Considerable amounts of soils are deposited in the lake by streams. Some of the soils may be kept out of the lake by minimum adjustments to the stream bed to reduce the water velocity in the stream prior to entry into the lake. Reduced water velocity in the stream will cause the bulk of the suspended soils to be deposited in the low velocity area and with occasional cleanout this area can be maintained fairly easily. Your local Soil Conservation Service representative (Appendix H) can provide valuable assistance in determining the extent of erosion problems and suggesting methods for soil conservation.

The runoff of fertilizers applied to lawns and gardens can frequently add nitrogen and phosphorus to a lake. There are a number of "common sense" methods for reducing the inputs from these sources. Don't fertilize early in the spring or at other times when soils are saturated from a recent rainstorm. Try to apply small amounts of fertilizer more frequently (i.e. twice per year add one-half the amount usually applied once per year). Don't locate vegetable gardens or other gardens that you plan to fertilize heavily close to the lake. Don't fertilize immediately before a rainstorm is forecast.

<u>Implementation of Controls.</u> A number of control techniques are available, however each has advantages and disadvantages (Appendix C). Control of nutrient inputs from the terrestrial part of the lake basin has been discussed in the previous section. In-lake controls (Appendix J), are frequently costly, large scale projects requiring permits from state and local agencies.

One in-lake control which may be suitable for Galway Lake is hypolimnetic withdrawal. This method reduces concentrations of nitrogen and phosphorus while increasing oxygen concentrations in the lake by releasing nutrient-rich deep waters of the lake during the period of summer stratification. The availability of a bottom intake to the dam, located in deep waters make this a possibility for Galway Lake. One limitation of this method would be timing of fall drawdown to a time when the deep waters of the lake have minimum concentrations of oxygen and maximum concentrations of nitrogen and phosphorus.

<u>Monitoring and Evaluation.</u> Continued monitoring of Galway Lake water quality by your association is desirable. A chemical assay program as extensive as that presented in this report is not necessary on an annual basis. Campers Association members in conjunction with their water quality committee can make certain measurements that will prove useful in observing any long-term trends in water quality. The Fresh Water Institute currently assists the Lake George Association in operating a Lay Monitoring Program on Lake George. A similar program could be beneficial to Galway Lake. Association members are provided with Secchi disks

and thermometers to record the transparency and temperature of the lake once per week during the summer months. At the end of the year, the data is gathered and compared to results from previous years to provide a measure of any significant changes in water clarity.

On a three of five year basis, more complete chemical assays and observations of the lake may be advisable. These analyses will act as a "report card" to determine how sucessful control techniques have been. Collection of samples can be done by lake association members and then analysed by consulting laboratories (Appendix E) or an assessment similar to that contained in this report can be contracted to consultants.

Findings

1. The transparency and phosphorus concentration of Galway Lake waters indicates that the lake should be classified as mesotrophic to eutrophic.

2. Water quality in Galway Lake is currently adequate for the primary use of its' residents, namely recreation.

3. The moderate alkalinity of Galway Lake makes it resistant, at the present time, to acidification by precipitation.

4. The deeper waters of the lake (hypolimnion) show low dissolved oxygen concentrations and elevated nutrient levels during the latter part of summer stratification.

5. The two inlets tested were found to be contributing substantial amounts of sediments, nutrients, and dissolved materials to the lake.

Recommendations

1. Establishment of a lay monitoring program to continue data collection started by this assessment should be actively pursued. With some basic training, lake association members can collect information which can be used to signal any sudden shifts in water quality or aquatic plant populations. This information is crucial for rapid response and remediation activities.

2. Encouragement of an active lake association with ties to regional and state lake federations is an important step. A water quality committee could organize education, prevention, control and evaluation activities. A thorough review of your town's zoning and planning laws with respect to mitigations of stormwater and wastewater controls should also be considered. A number of the things which threaten the lake are more regional or national problems, such as runoff of sediments, nutrients, salt and corrosion products from area roads. Solutions for these problems will probably require political action.

3. Sedimentation and the nutrients these sediments carry are the greatest threat to water quality. Agricultural and development activities within the lake basin make erosion of soils a serious problem. Contact with the Saratoga County Soil and Water Conservation Service (see Appendix G) to review appropriate erosion control techniques (BMPs) is a necessary first step. Many techniques can be applied on an individual homeowner basis such as planting of erosion resistant species, maintenence of a green strip along the lakeshore, and altering the flow of runoff water to name a few.

4. The use of hypolimnetic withdrawl of nutrient-rich waters during the latter part of summer stratification can aid in reducing nutrient concentrations in the lake. These in turn can reduce the abundance of algae and aquatic plants.

Table 3-1. Chemical Water Quality Characteristics of Galway Lake.

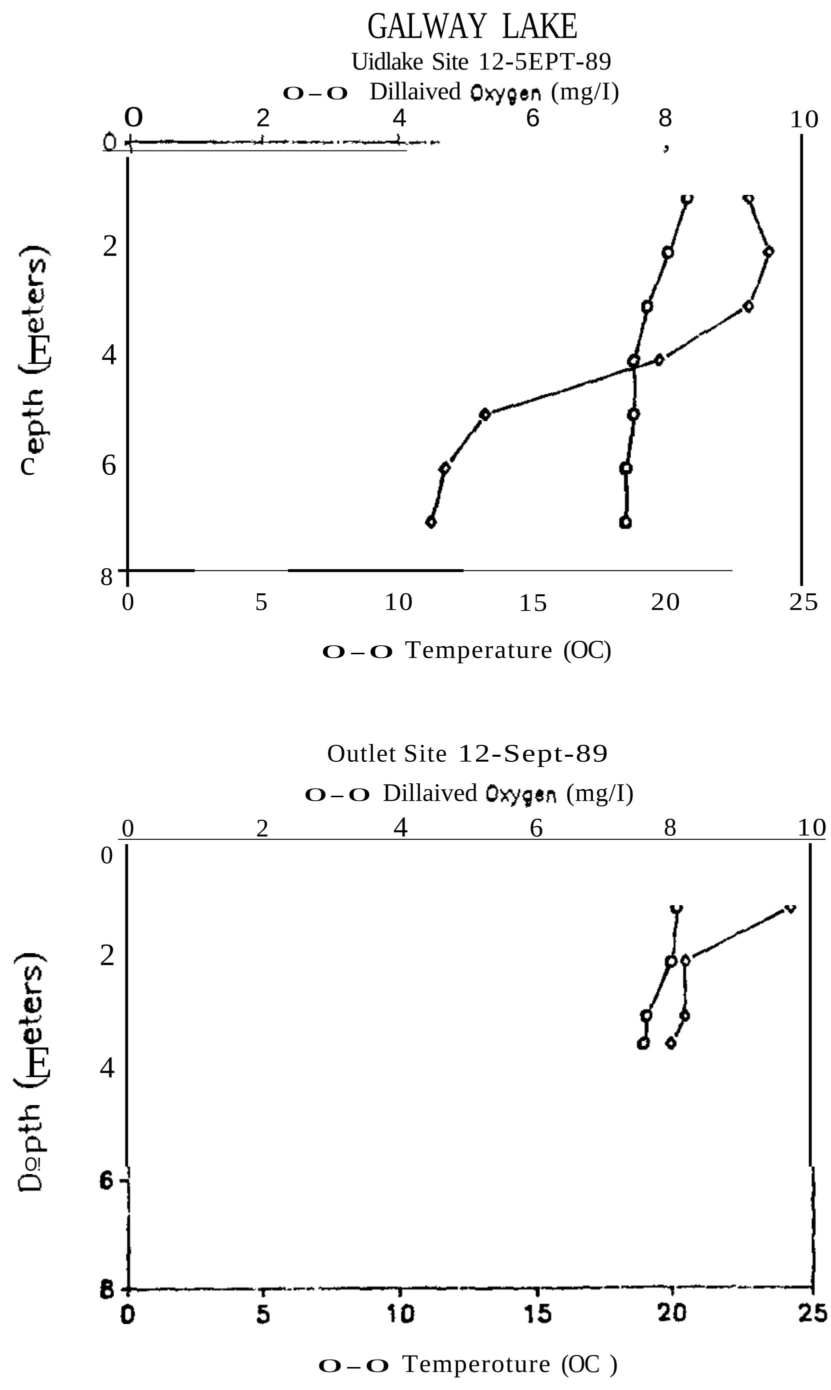
Galway Lake
SaMples Collected SEPT 12 1989

Site	Depth (I)	pH	Condo IUlhoa)	Alk.	TSS (Iglll	Secchi (I)	OP (ugfl)	TFP (ug/1)	TP (uglll	DO (Ig/ll	Nitrate (mg/l)	Ammonia (lg/1)
Inlat 1	0.5	8.64	17T	66	3.1		5	6	38		0.16	<0.01
Inlet 2	0.5	8.08	225	83	0.5		16		27		<0.01	<0.01
Hidlake	0.5	8.99	167	64	1.5	2.65	4	4	22		<0.01	<0.01
Hidlake	6.5	8.12	171	66	2.3		4	5	28	5.2	<0.01	0.01
Outlat	0.5	8.94	168	64	1.5	2.7	4	5	23		<0.01	<0.01

Table 3-2. Surface Water Chemistry for Selected Lakes.

Lake	Secchi Transparency (meters)	Alkalinity (ppm as CaCDa)	Total Phosphorus (ppb)
Lake George, NY New York	8.0	26.0	5
Eagle Lake New York	8.0	30.0	7
Lake Luzerne New York	4.7	17.5	8
Galway Lake New York	2.7	64.0	23
Saratoga Lake New York	2.2	77.0	100

Figure 3-1. Dissolved oxygen and temperature profiles for Galway Lake.



SECTION 4

VEGETATION IN GALWAY LAKE

The discussion of aquatic plant communities and their management will begin with a brief description of the submersed aquatic plant species found in Galway Lake, followed by a description of vegetation along each of the five transects discussed with a summary of semi-quantitative data. The third sub-section will discuss the distribution of Eurasian Watermilfoil in the lake. The fourth sub-section will examine management needs and alternatives, followed by some recommendations. At the end of section four, a summary of findings and recommendations will be presented, some of which will also be found in the Executive Summary.

Submersed Plant Species

A list of all submersed plant species found during our survey of Galway Lake is given in Table 4-1. A total of 19 submersed species is indicated (benthic alg.. not included). Benthic algae are microscopic filamentous green algae that form dense growths on bottom sediments. In this case, we believe they are predominantly of the genera Spirogyra and Mougeotia. A species diversity of 19 is relatively high for most lakes, but substantially lower than most nearby Adirondack lakes (Mad_n et al., 1989). The species listed here are a subset of those found in Lake George (Madsen et al., 1989); no species _re found in Galway Lake that are not also in Lake George. Therefore, Galway Lake has a plant community not unlike those lakes, with a reduction due to increased nutrient status and decreased transparency, winter drawdown, the abundance of invasive species, and past water-level changes.

Of the 19 submersed species, seven are in the genus Potamogeton. Pondweeds (genus Potamogeton) are a common component of many mesotrophic littoral zone communities. Of the 19 species, 17 are native to North America, and only two are exotic species. These two, however, are the two most common nuisance plants of temperate North American lakes: Eurasian Watermilfoil (Myriophyllum spicatum) and Curly-leaf Pondweed (potamogeton crispys). More information on these two species is found in Appendix 3 (Eichler et al., 1990; FWI Report '90-3), the companion volume to this report. During our investigations in August, Eurasian Watermilfoil was common, even a nuisance in some areas, while Curly-leaf Pondweed was sparse. However, Curly-leaf Pondweed is generally only a nuisance during May through mid-July in most temperate locations.

One additional concern to address in developing a management plan is the presence of any rare or endangered species. Only one plant (Isoetes mac[Q§DOra) of the species observed in Galway Lake is on the New York Rare Plant list (Mitchell, 1986; C1emante, 1989). The listing of this plant as "rare" may be due more to the rarity of people looking for it, rather than to its actual distribution. Since it often occurs in relatively deep waters (5m or mor.), it is rarely seen by casual observations. However, it is a common component of plant communities in many of the Adirondack lakes we have studied; e.g., Lak. George (RFWI et al., 1988), Eagle Lake (Eichler and Madsen, 1990a), Schroon Lake (Taggett, 1989), and Twitchel Lake (Taggett, 1989). Therefor., formal protection of this species to the point of negatively impacting a lake management plan is probably not warranted.

Vegetation Transects

Transect A, located on the northeastern shore (see Figure 2-1) was situated off of a point with a hard sand-silt substrate (Table 4-2). In addition to benthic filamentous algae, fifteen species of submersed plants were observed. Shallow waters (0-2meters) were dominated by potamogeton gromin.us, with abundant Myriophyllum spicatum from 3 to 4 meters and Potamogeton prM10naus frOll 3 to 5 meters. Eurasian Wat.rmi1foi1 occurred as a relatively narrow band of dense plants from 2.5m to 4.5m.

Transect B (Table 4-3) was located in a shallow, silty area in the northern and of the lake. sedimentation from tributaries was evident. Ten submersed speci.s were observed, with dense, abundant growth of Heteranthera dubia from 0-2 meters, Elodea conadensis from 2-4 meters, and .p. prae10ngus from 3-6 meters. Euresian Watermilfoil was common, but did not form the dense growths .vident elsewhere in the 1ak••

Transect C (Table 4-4) was located in the western bay of Galway Lake. At this location, the bottom had a shallow slope, with the littoral zone extending well out from shore. In addition to dense benthic algae in 0-1m, ten submersed plant species were observed. Ceratophy11ym demersum was abundant from 1-4 meters, Va11isneria ,,.ricona from 1-2 meters, and E. canadensis was abundant or common frOil 1 to 6 meters. Eurasian Watermilfoil formed a dense band of growth from 3-4 meters, but was common from 1-6 meters. potamoseton prae10ngue was abundant from 4-6 metere, and Nite11a was found from 5-6 _tere. Submersed plant growth, both native and exotic, was dense probably due to sedimentation from tributaries emptying into this shallow bay.

Transect D (Table 4-6) was located at the southern end of the lake, where there was firm substrates, extending to 7 meters of depth. A total of t_lve submersed species _re ob_rved. Ceratophyllum demersum was found along the entire transect, to a depth of over 6 meters, with Elodea canadensis also found throughout most of the transect. Dense growths of M. spicatum appeared at 2-3 meters, and extended to 6 meters. At thia depth, M. spiclt , . growth ended with the exception of some scattered fragments found at deeper reaches of the transect. Submersed plants were not found beyond 8m depth, and _re probably only viable at somewhat shallower depths (5m or less).

Transect E (Table 4-8) was located near a tributary at the aouthern end of the lake. A total of nine submersed species were obaerved. Nitella was abundant from 0-2 metera, and again occurred at 6-7 meters. Eurasian Watermilfoil formed den_ beda from 2-4 meters. Beyond 4m, only M. spicatum fragments _re found. Potamogeton proelongys was abundant from 4-6 meters.

Data for all species listed alphabetically from the five transects examined is summarized in Table 4-7, indicating the relative abundance for each 1 meter depth interval and averaged for all depths. The nine spaciea from Table 4-1 not listed on Table 4-7 _re those observed in the lake, but not seen along a given transect. Their absence from the list in Table 4-7 would indicate that they are relatively rare and of limited abundance.

Table 4-8 is a list of species from Table 4-7, but ordered by relative total abundance. The profusion of Eurasian Watermilfoil in Galway Lake, and percaivad nuisanca problem, is supported by its eati_tion as tha most abundant species. The relatively high abundance of C. demersum and E. canadensis is typical of more productive lakas. The lower number of species and relative scarcity of some nativa plants (a.g., Vallisneria) was poasibly due to the abundance of M. spicAtym.

The depth distribution of species observed in Galway Lake is presented in Figure 4-1. Most of the diversity of species was found in the mixed native community from 0 to 3 meters, before the peak in abundance of Eurasian Watermilfoil. Of special interest was the bimodal distribution of Nitella, found from 0-3 meters and again from 4-7 meters, a 1 meter gap in the depth interval where it was found. abundance. Eurasian Watermilfoil occured as a dense, near-homogeneous community from 2 to 4 meters. Ceratophyllym and Elodea were found throughout all depth intervals. Potamogeton Draelongys was only abundant in a narrow depth range (3-4 _ters) beyond the peak occurrence of Eurasian Watermilfoil. Undoubtedly, Eurasian Watermilfoil has displaced native species, restricting their depth range more than before invasion. Most native plants are restricted to somewhat shallower depths and P. Droelongys to somewhat deeper depths.

Eurasian Watermilfoil in Galway Lake

Although some Eurasian Watermilfoil was found throughout the lake, particularly large areas of dense beds were observed in the southern and western basins (Figure 4-2). Dense growths of Eurasian Watermilfoil in these areas create a nuisance to recreational activiti...

Our observations of the depth distribution of Eurasian Watermilfoil in Galway Lake tend to place dense growths between 2.618 (8') to 4.5m (14'). with scattered plants found from 1m to 618 (3' to 18.6'). A f_ fragments were observed as deep as 6.618 (18'), but these may not have had the potential to survive and establish at these depths. The depth range observations were consistent with those taken by Galway Lake residents (J. Aronstein. correspondence 7/23/89). The observed depth range is also .i.ilar to that observed for Lake George (Madsen et al•• 1989) and L.ke Luzerne (Eichler and Madsen, 1990b). despite the diff.rence. in water transparency.

Eurasian Watermilfoil Management

A long-term management plan should be developed and implemented, including the following aspects:

- Education
- Prevention
- Implementation of Controls
- Evaluation
- Monitoring

A long-term plan is needed, since complete .radication of Eurasian Watermilfoil is unlik.ly. and Galway Lake i. a site conducive to nuisance growth of Eur_ian Watermilfoil and other exotic species. Even if eradication is accomplished, continued vigilance is nec••••ry to prevent any future problems from arising. See Appendix B and C for further details on a plant management plan.

Edycation. To develop .upport for management efforts. and carry out some aspects of a management program, sducation of lake-u_rs is imperative. Homeowners and lake users must know what Eurasian Watermilfoil is and .ct to prevent further introductions and spread (Appendix B,C).

Prevention. once control has been successful, efforts must be made to prevent reintroduction and slow the growth and spread of Eurasian Watermilfoil. Prevention efforts might include education, non-point pollution control, erosion management and even encouraging native plants to become reestablished.

Implementation of Controls. A wide variety of control techniques are available, none of which provide a perfect solution. However, Galway Lake is among a small group of lakes in which an effective and inexpensive control technique is available - n_ly drawdown. Drawdown of the lake over the winter months is a particularly effective control technique, particularly on Eurasian Watermilfoil.

Drawdown has been used in a variety of lakes to control nuisance populations of aquatic plants. Drawdown is very species-specific in terms of response. Some species are strongly affected by drawdown (e.g., Water lily and Muskgrass), some are actually stimulated by drawdown (e.g., Naiads), and others have a variable reeponse, or no discernible response (e.g., Elodea or Myriophyllum; Cooke, 1980). Overwinter drawdown is generally effective for control of Eurasian Watermilfoil species, in a survey of lake management techniquee perfor_d in 1974 (Dunet et al., 1974). OVerwinter drawdown for Eurasian Watermilfoil control is particularly effective and cost-efficient, especially if sediments can remain exposed during heavy freezing events (Geiger, 1983; Siver et al., 1988). Simple exposure to air and dessication, such as with a summer drawdown, is not particularly effective as a control for Mvriophyllum species (Tarver, 1980).

Drawdown should be used only every two to four years at a maximum, to prevent the selection of resistance nuisance aquatic plants (Nichols, 1976 a,b) and to minimize the impact on the fish populations (Dunst et al., 1974).

Several other control techniques can also be used, particularly between years in which drawdown is used. For instance, hand pulling of small patches of Eurasian Watermilfoil could be done in intervening years, probably without a permit (check with NYSDEC Regional Permit Administrator).

Evalyation. In the year following drawdown, some evaluation of its effectiveness should be performed. Evaluation could consist of a range of activities, from lay monitoring by lake residents to a quantitative study by consultants. At a minimum, the vegetation control cOllllllittse of the lake aesociation should arrange for lay monitors to visually inspect kn_n paet locations for recurrence of Eurasian Watermilfoil, and established transects should be examined using an echolocator (ae done in 1989 by lay monitors) on biweekly or monthly intervals during the summer, to check for the reestablishment of dense Eurasian Watermilfoil.

Monitoring. As part of an overall lake monitoring program, lay monitors should watch for dense growths of Eurasian Watermilfoil and measure the height of dense beds as mentioned above. In addition, annual samples of plants can be taken to document the introduotion of n_ nuisance plants. The Fresh Water Institute will identify plant specimens free of charge (Appendix G). Other lay monitoring activities are discussed elsewhere.

The lake association vegetation control committee should supervise monitoring and control efforts, with annual evaluations of current oontrol plans. An ongoing effort in monitoring, education, and prevention will greatly facilitate gathering information and making decisions on future management directions.

Findings

1. A total of 19 submersed aquatic plant species, and a profusion of benthic algae, were observed in Galway Lake. Eleven of these species were observed along five transects. The 5 most abundant species in order of importance in the lake were MyrioPhYllum spicatum, CerUoDhyllym demersum, Elodea canadensis, Potamogeton Draelongys, and Nitella sp.

2. Euraeian Watermilfoil wae found throughout the lake, but formed particularly dense beds in the southern and western bays. Depth distribution of dense beds wae frOlll 2.5m (8') to 4.6m (15'). Scattered plants were found frOlll 1m to 6m, but plants found beyond 5m were generally fragments that were not likely to establish and survive.

Recommendations

1. An active aquatic plant control committee should develop and implement an aquatic plant management plan, as part of an overall lake management plan. In addition to selecting and implementing control tachniques, the oOllllllittee should develop education, prevention, evaluation and monitoring activities.

2. An active lay monitoring progr.. for Eurasian Watermilfoil should be developed.

3. Overwinter drawdown should prove to be an effective and inexpensive large-scale control technique. However, this technique should not be over-utilized, and other control techniques should be used in intervening years between drawdown episodes.

Table 4-1.

MACROPHYTE SPECIES PRESENT IN GALWAY LAKE

SCIENTIFIC NAME	COMMON NAME
Benthic Alga	
Ceratophyllum d...rsum	Coontail
Eleocharis acicularis	Spike Rush
Elodea canadensis	Waterweed
Heteranthera dubia	Water Star Gr..e
Isoetes macrospora	Quillwort
Myriophyllum spicatum	Eurasian Mil1'oil
Myriophyllum tenellum	Water Milfoil
Nitella app.	Muskgrass
Najas flexilis	Naiad
Potamogeton crispua	Ourly-leaved Pondweed
Potamogeton gramineus	Lea1'y Pondweed
Potamogeton obtusifolius	Pondwead
Potamogeton perfoliatus	Pondweed
Potamogeton praelongua	Pondweed
Potamogeton vaseyii	Pondweed
Potamogeton zosteriformis	Flat-stemmed Pondweed
Sagittaria graminea	Arrowhead
Sparganium epp.	Bur-Read
Valli.neria americana	Duck Celery

Table 4-2.

GALWAY LAKE VEGETATION DATA: TRANSECT A

SPECIES	DEPTH INTERVAL (METERS) 0-1	1-2	2-3	3-4	4-5	5-6	6-7
Benthic alga	A	A	P				0
C. demersum	P	C	C	C	P	P	
E. acicularis	C						
E. canadensis	P	P	P				
I. macrospora	P	C	C				
M. spicatum			P	A	C		
M. tenellum		P					
Nitella	P	P	A				
N. flexilia	P	A	C	P			
P. gramineus	A	C	C				
P. praelongus			P	A	A	P	
P. vaeeyii	p						
P. zosteriformis			0	C			
Sparganium	R	P					
S. graminea	P						
V. americana			C	C			

ABUNDANCE CODES:

LETTER	LABEL	PERCENTAGE RANGE
A	ABUNDANT	>50%
C	COMMON	25-50%
P	PRESENT	15-25%
O	OCCASSIONAL	5-15%
R	RARE	<5%

Table 4-3.

GALWAY LAKE VEGETATION DATA: TRANSECT B

SPECIES	DEPTH INTERVAL (METERS) 0-1	1-2	2-3	3-4	4-6	5-6	6-7
C. demersum			C	C	P		
E. canadeneis	C	C	A	A			
H. dubia	A	A	C	P			
M. spicatum	P	C	C	C	P		
Nitella	A	P					
N. flexilie	C	A					
P. perfoliatus	P	C					
P. pr_longue			C	A	A		
P. vaseyii		P					
P. zosteriformis			P	P			

ABUNDANCE CODES:	LETTER	LABEL	PERCENTAGE RANGE
	A	ABUNDANT	>50%
	C	COMMON	25-50%
	P	PRESENT	15-25%
	O	OCCASSIONAL	5-15%
	R	RARE	<5%

Table 4-4.

GALWAY LAKE VEGETATION DATA: TRANSECT C

SPECIES	DEPTH INTERVAL (METERS) 0-1	1-2	2-3	3-4	4-6	6-8	8-7
Benthic alga	A						
C. demersum	C	A	A	A	C		
E. canadensis	P	A	C	C	A	P	
M. ap1catum	P	C	C	A	C		
Nitella						P	
N. flexilis	C	C					
P. crispus				R	P		
P. obtusifolius		P		P			
P. praelongus			R	C	A		
P. zosteriformis		P	P	P			
V. americana		A	P				

ABUNDANCE CODES:	LETTER	LABEL	PERCENTAGE RANGE
	A	ABUNDANT	>50%
	C	COI.ION	25-50%
	P	PRESENT	15-25%
	O	OCCASSIONAL	5-15%
	R	RARE	<5%

Table 4-6.

GALWAY LAKE VEGETATION DATA: TRANSECT D

SPECIES	0-1	1-2	2-3	3-4	4-5	5-6	8-7
			DEPTH INTERVAL (METERS)				
C. demersum	C	C		P	P	R	0
E. acicularia	P						
E. canadenaia	P	C	P	P	P	P	
I. macrospora	P						
M. spicatum		P	P	A	A	R	
Nitella		e	C		P		
N. fl.xilia			P				
P. gramineus	e	e					
P. praelongus			P	P			
P. zosteriformis			P				
Sparganium	P						
V. americana		A	e				

ABUNDANCE CODES:

LETTER	LABEL	PERCENTAGE RANGE
A	ABUNDANT	>50%
C	COMMON	25-50%
P	PRESENT	15-25%
O	OCCASSIONAL	5-15%
R	RARE	<5%

NOTES: M. spicatum starts at
M. apicatum max 14'
max 18'- no plants

Table 4-8.

GALWAY LAKE VEGETATION DATA: TRANSECT E

SPECIES	DEPTH INTERVAL (METERS) 0-1	1-2	2-3	3-4	4-6	6-8	8-7
C. d_rsUIII		P	P	A	C	P	
E. canadensis	P	C	P	P			
H. dubia	P	P	C				
M. spicatum	P	C	A	A	P	P	
Nitella	A	A	C			P	0
N. flexilis		P	C				
P. pr.longus				p	A		
P. zosteriformis		P			R		
V. americana		C					

ABUNDANCE CODES:

LETTER	LABEL	PERCENTAGE RANGE
A	ABUNDANT	>50%
C	COMMON	25-50%
p	PRESENT	15-25%
O	OCCASSIONAL	5-15%
R	RARE	<5%

NOTES: Only M. spicatuM fragments after 16'
8' M. spicatum, max 12'

Table 4-7.

MACROPHYTE SPECIES ABUNDANCE IN GALWAY LAKE

SCIENTIFIC NAME	DEPTH INTERVAL (m) 0-1	1-2	2-3	3-4	4-5	5-6	8-7	TOTAL
Benthic Alga	30	15	4	0	0	0	0	7
Ceratophyllum demersum	19	34	34	49	27	11	3	25
Eleocharis acicularis	12	0	0	0	0	0	0	2
Elodea canadenaia	24	42	36	31	19	10	0	23
Heteranthera dubia	19	19	15	0	0	0	0	8
Isoetes macrospora	8	8	8	0	0	0	0	3
Myriophyllum spicatum	12	27	38	88	38	6	0	27
Myriophyll.. tenellum	0	4	0	0	0	0	0	1
Nitella spp.	34	31	30	0	4	10	3	18
Naj_ flexilis	19	42	19	4	0	0	0	12
Potamogeton crispua	0	0	0	1	4	0	0	1
Potamogeton gramineus	23	15	8	0	0	0	0	8
Potamogeton obtuaifoliu8	0	4	0	4	0	0	0	1
Potamogeton perfoliatus	4	8	0	0	0	0	0	2
Potamogeton praelongus	0	0	18	48	80	5	0	18
Potamogeton v_eyii	4	4	0	0	0	0	0	1
Potamogeton zosteriformis	0	8	14	18	1	0	0	5
Sagitteria graminea	4	0	0	0	0	0	0	1
Sparganium spp.	5	4	0	0	0	0	0	1
Vallisneria americana	0	38	18	8	0	0	0	9

Table 4-8

RELATIVE IMPORTANCE OF MACROPHYT& SPECIES IN GALWAY LAKE.

SCIENTIFIC NAME	DEPTH (II) 0-1	1-2	2-3	3-4	4-5	6-.	.-7	SUM
M. 8picatum	12	27	38	88	38	8	0	27
C. demersum	19	34	34	49	27	11	3	26
E. canaden8i8	24	42	35	31	19	10	0	23
P. praelongu8	0	0	18	46	80	5	0	,.
Nitella 8pp.	34	31	30	0	4	10	3	18
Naja8 flexi118	19	42	19	4	0	0	0	12
V. americana	0	38	18	8	0	0	0	9
H. dubia	19	19	15	0	0	0	0	8
Benthic Alga	30	15	4	0	0	0	0	7
P. gramineus	23	15	●	0	0	0	0	8
P. zosteriformi8	0	8	14	18	1	0	0	5
I. macr08pora	8	8	8	0	0	0	0	3

Figure 4-1. **Depth distribution of the twelve most common aquatic plant species in Galway Lake. 1M, ISoetes mocrosDora; PZ, PPtamogeton zosteriformis; PG, P. gramineus; FA, filamentous algae; HB, Heteronthera dubia; VA, Vallisneria americana; NF, Naias flexilis; NSP, Nitella sp.; PP, Potamogeton Draelongus; EC, Elodea canadensis; Qeratophyllum demersum; MS, Myriophyllum spicatum.**

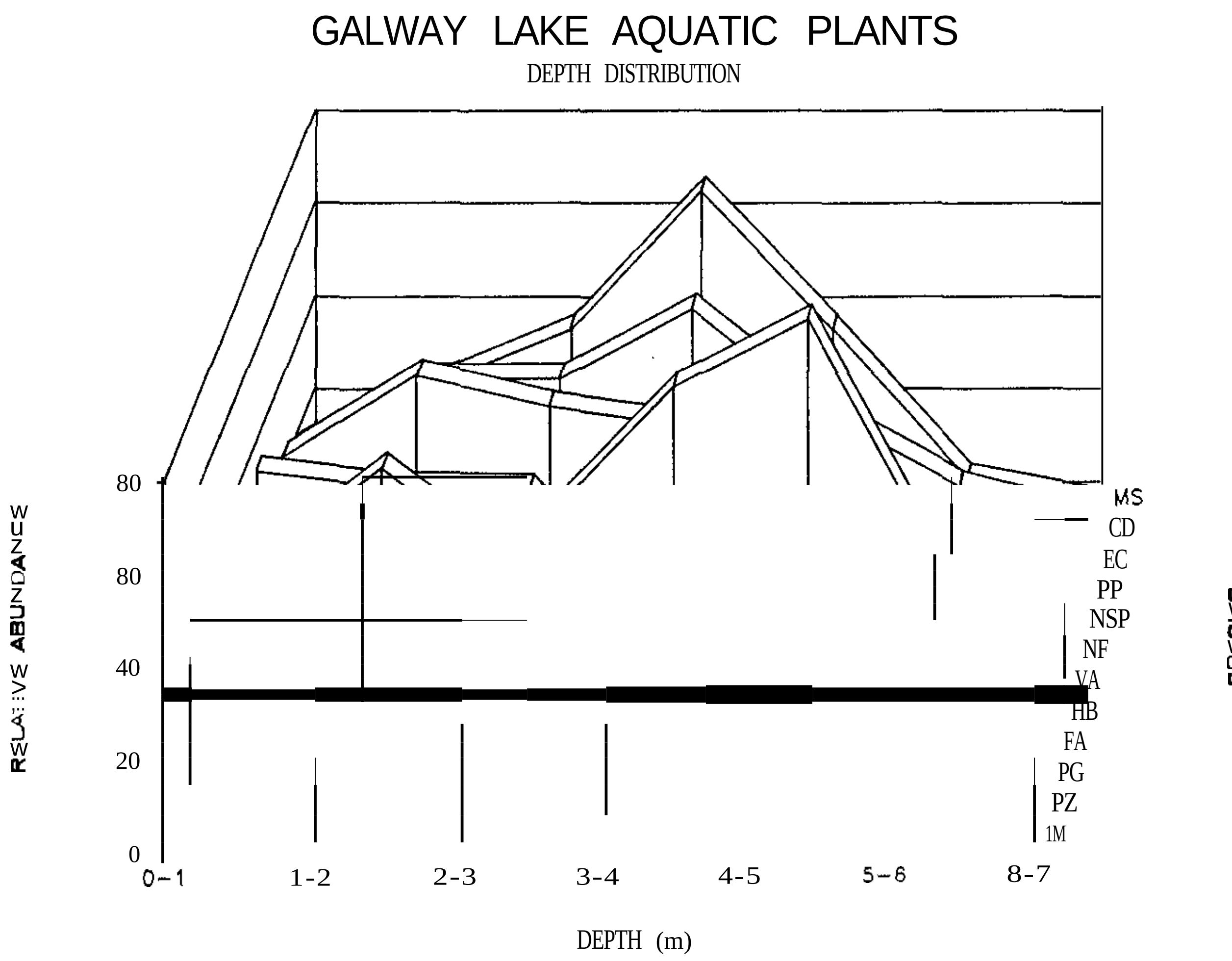
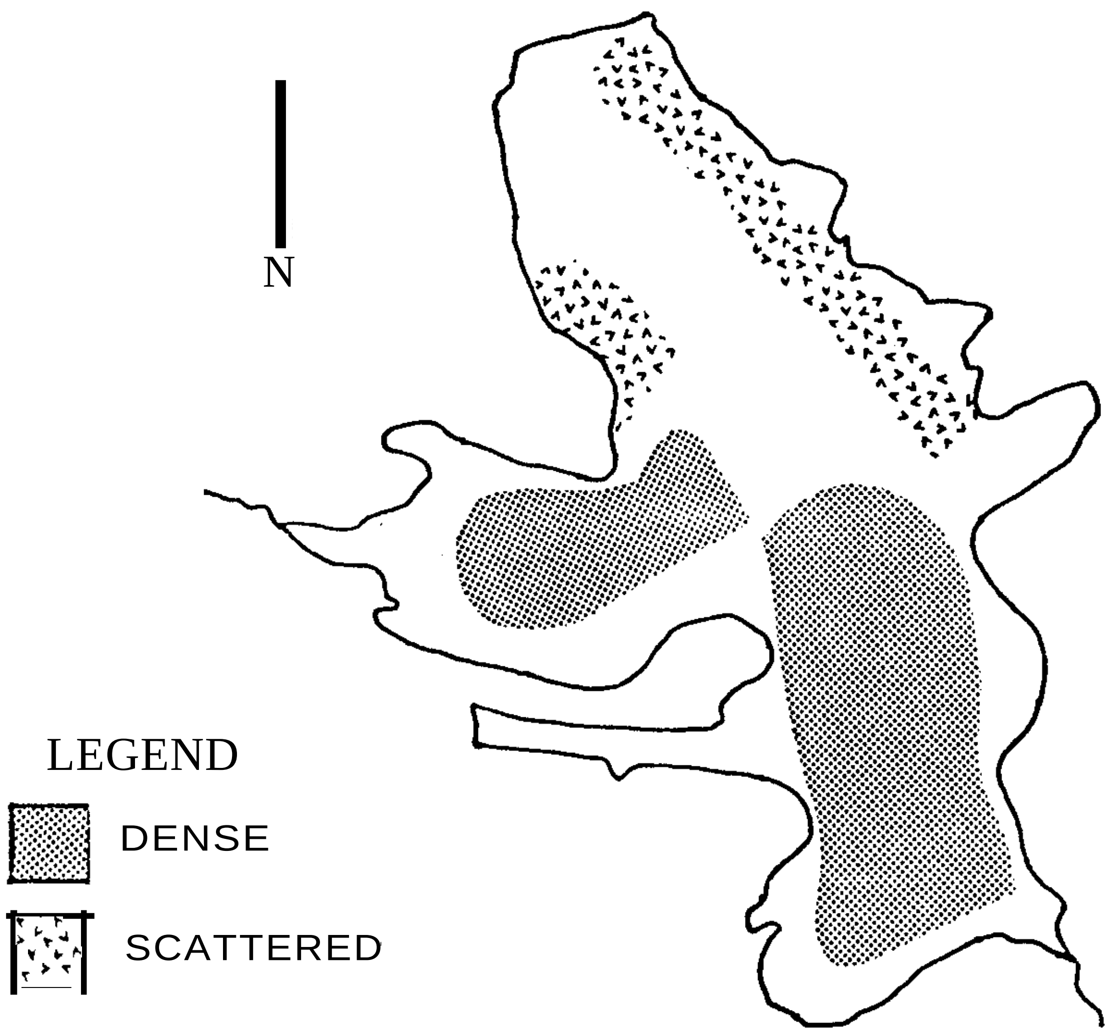


Figure 4-2. Location of dense and scattered Eurasian Watermilfoil populations in Galway Lake.

EURASIAN WATERMILFOIL LOCATIONS

GALWAY LAKE



SECTION 5

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SECTION 6

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