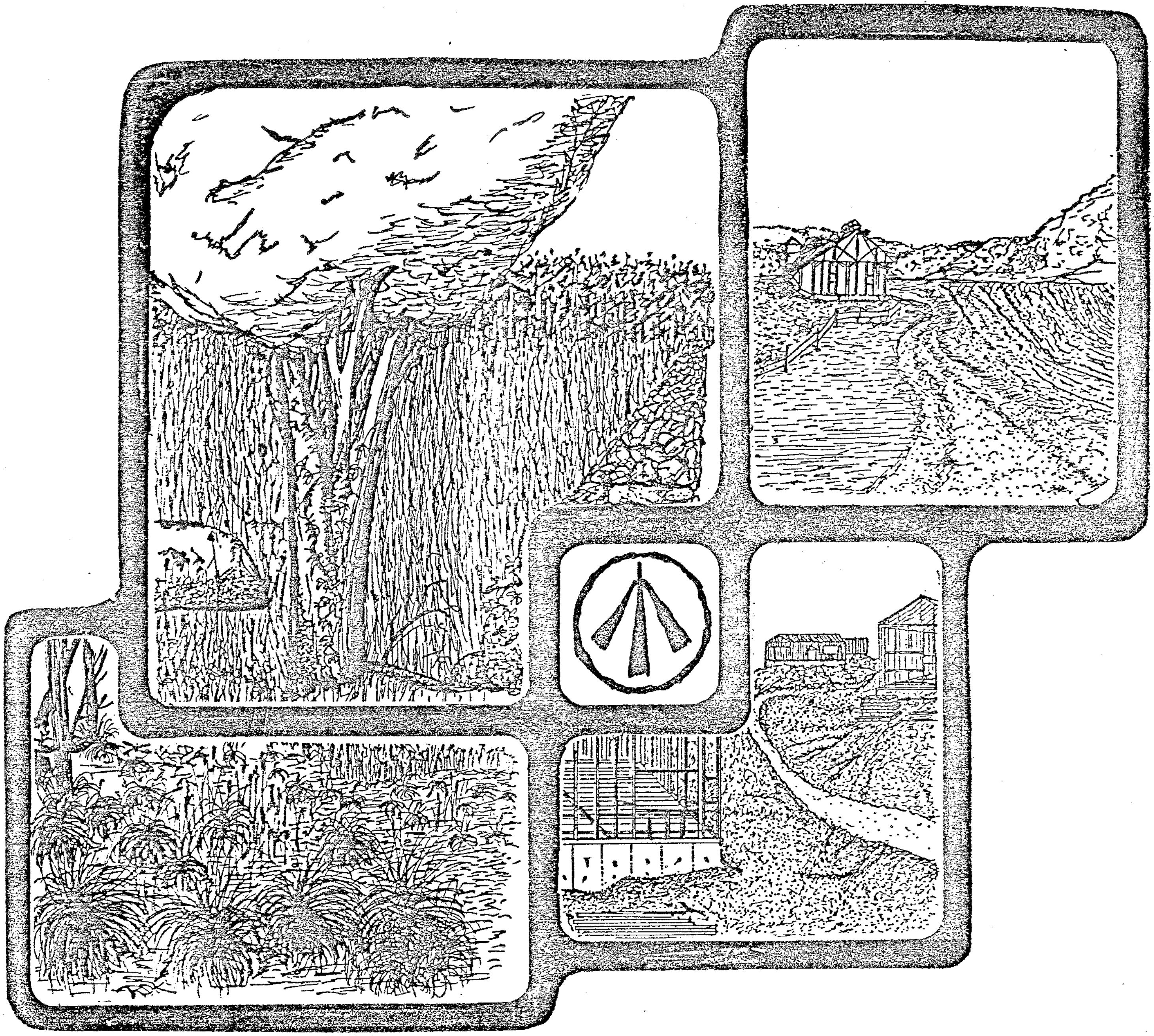
ENVIRONMENTAL REVIEW TEAM REPORT



INDIAN LAKE

Sharon, Connecticut and Northeast, New York

KING'S MARK
RESOURCE CONSERVATION & DEVELOPMENT AREA

KING'S MARK ENVIRONMENTAL REVIEW TEAM REPORT

INDIAN LAKE

Sharon, Connecticut and Northeast, New York

NOVEMBER, 1983

King's Mark Resource Conservation and Development Area
Environmental Review Team
Sackett Hill Road
Warren, Connecticut 06754

ACKNOWLEDGMENTS

The King's Mark Environmental Review Team operates through the cooperative effort of a number of agencies and organizations including:

Federal Agencies
- U.S.D.A. Soil Conservation Service

State Agencies
- Department of Environmental Protection
- Department of Health
- University of Connecticut Cooperative Extension Service
- Department of Transportation

Local Groups and Agencies
- Litchfield County Soil and Water Conservation District
- New Haven County Soil and Water Conservation District
- Hartford County Soil and Water Conservation District
- Fairfield County Soil and Water Conservation District
- Northwestern Connecticut Regional Planning Agency
- Valley Regional Planning Agency
- Central Naugatuck Valley Regional Planning Agency
- Housatonic Valley Council of Elected Officials
- Southwestern Regional Planning Agency
- Greater Bridgeport Regional Planning Agency
- Regional Planning Agency of South Central Connecticut
- Central Connecticut Regional Planning Agency
- American Indian Archaeological Institute
- Housatonic Valley Association

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FUNDING PROVIDED BY
State of Connecticut

POLICY DETERMINED BY
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Northwestern Connecticut Regional Planning Agency

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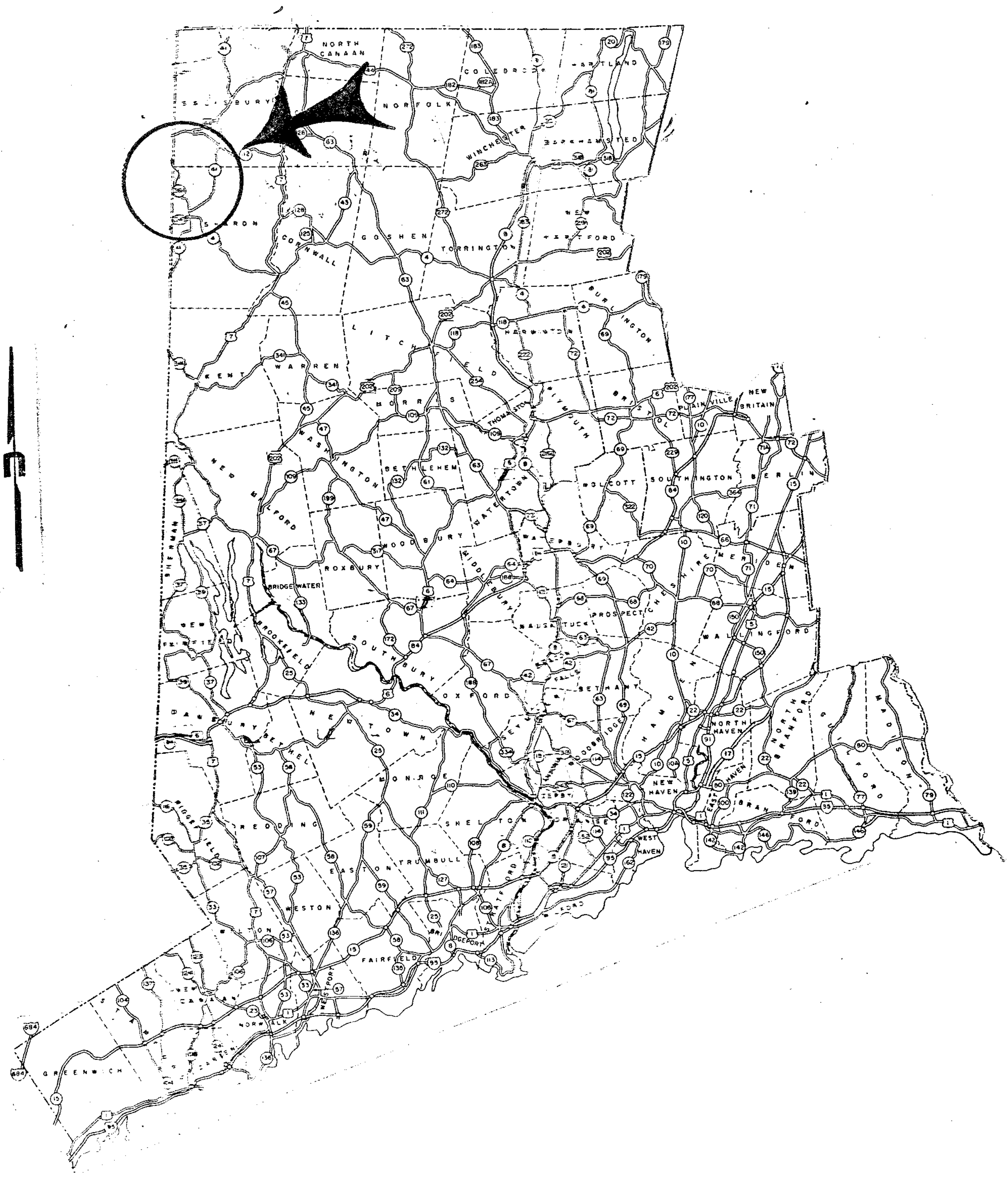
Richard Lynn, ERT Coordinator
Sandra Bausch, ERT Cartographer
Jamie Whitman, Secretary

LOCATION OF STUDY SITE



Scale 1" = 10 miles

10 0 5 10 miles

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ON
INDIAN LAKE
SHARON, CONNECTICUT AND NORTHEAST, NEW YORK

I. INTRODUCTION

Indian Lake is a shallow, natural lake located on the state line in the two towns of Sharon, Connecticut and Northeast, New York. The lake's watershed also extends into the town of Salisbury, Connecticut. The lake has a surface area of 195 acres and is fed by a watershed of 750 acres. As shown in Figure 1, the watershed is lightly developed. The eastern half of the watershed is characterized by steeply sloping wooded land while the western half is dominated by moderately sloping farmland. Connecticut Route 4 passes close by the eastern shore of the lake.

The recreational use of Indian Lake has been impaired in recent years by the nuisance growth of aquatic weeds. This trend is of concern to residents of the watershed who utilize the lake for recreational pursuits.

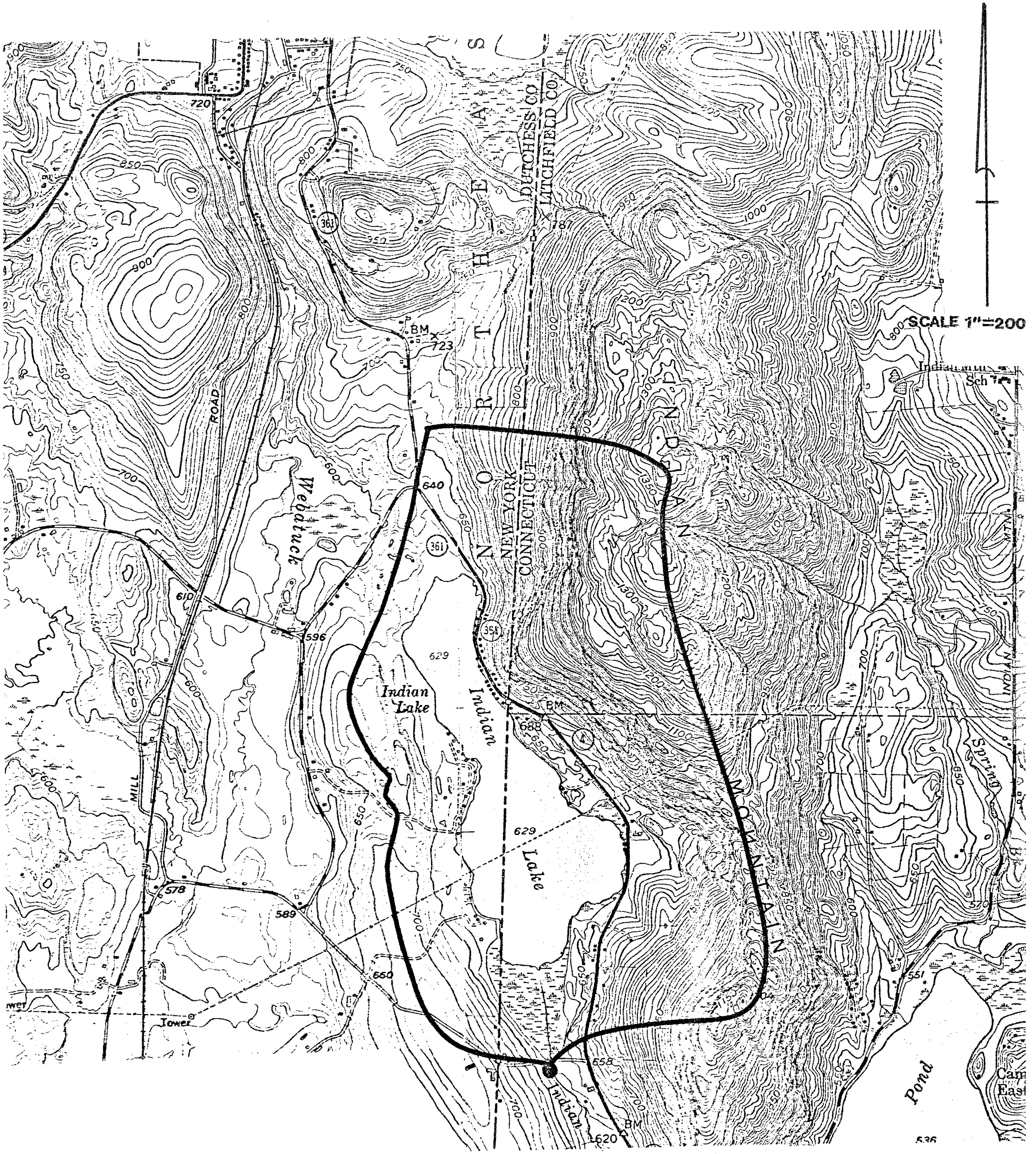
The Sharon Planning and Zoning Commission requested this ERT study to learn more about the lake and its watershed. Specifically, the Team was asked to 1) provide a natural resource inventory and evaluation of the Indian Lake watershed, 2) identify those factors contributing to the macrophyte problem at the lake, and 3) discuss alternatives available for effective lake management. The Planning and Zoning Commission requested this information to serve as a basis for decision making on how best to protect the future water quality of the lake for recreational and aesthetic purposes.

The King's Mark Executive Committee considered the town's request and approved the project for review by the Team.

The ERT met and field reviewed the watershed on August 17, 1983. Team members participating on this review included:

Norm Benson	District Manager	Dutchess County Conservation District
Chuck Boster	Regional Planner	NWC Regional Planning Agency
Art Cross	District Conservationist	USDA Soil Conservation Service
Bill Hyatt	Fishery Biologist	Conn. Department of Environmental Protection
Nancy Marin	Lake Ecologist	Conn. Department of Environmental Protection
Ron Pierce	Aquatic Biologist	New York State Department of Environmental Conservation
Bill Warzecha	Geohydrologist	Conn. Department of Environmental Protection

FIGURE 1
TOPOGRAPHIC MAP



Prior to the review day, each team member was provided with a summary of the proposed project, a checklist of concerns to address, and a detailed soil survey map and topographic map of the subject area. During the Team's field review, team members toured the Indian Lake area and met with representatives from the town to discuss the situation at Indian Lake. Following the field review, individual reports were prepared by each team member and forwarded to the ERT Coordinator for compilation and editing into this final report.

This report presents the Team's findings. It is important to understand that the ERT is not in competition with private consultants and hence does not perform design work or provide detailed solutions to land use problems. The ERT concept provides for the presentation of natural resources information and preliminary land use analyses. All conclusions and final decisions rest at the local level. It is hoped the information contained in this report will assist the town of Sharon and the Indian Lake Association in making environmentally sound decisions.

If any additional information is required, please contact Richard Lynn, (868-7342), Environmental Review Team Coordinator, King's Mark RC&D Area, Sackett Hill Road, Warren, Connecticut 06754.

* * * * *

II. HIGHLIGHTS

1. The chemical quality of groundwater and surface water within the Indian Lake watershed under natural conditions is generally good. Due to the predominance of carbonate bedrock underlying the watershed, however, Indian Lake could contain relatively hard water. Hard water is water that contains substantial amounts of mineral salts. These salts may interfere with the lathering and cleaning properties of soap, but they do not significantly affect the water quality of the lake from a eutrophication standpoint.

2. The natural water quality of Indian Lake may be adversely influenced by various non-point sources of pollution such as erosion and sedimentation, septic systems, agricultural practices and waterfowl. These sources of pollution have the potential to severely impact the environmental health of the lake.

3. Most of the land within the watershed is characterized by shallow to bedrock soils, although there are pockets of "hardpan" soils, deep and well drained soils, and inland wetland soils.

4. Due to the potential for erosion and sedimentation within the watershed, good conservation practices are essential on all agricultural land. Judicious handling of manure is equally important. The Indian Lake Association should continue to consult with the local Soil and Water Conservation Districts to obtain information on the status of agricultural activities in the lake watershed. The lake organization should also develop cooperative, working relationships with District personnel, Soil Conservation Service personnel, and local farmers in order to develop a program for the timely implementation of agricultural practices needed to protect the water quality of Indian Lake.

5. Most of the houses and cottages on the shoreline of the lake are located on soils with severe limitations for septic systems. Some pollution of the lake may be occuring from inadequately installed and maintained septic systems. As discussed in the text of this report, there are a number of steps which can be taken to reduce the potential adverse effects of existing and proposed sewage disposal systems.

6. With the possible exception of septic systems, the District Manager of the Dutchess County Conservation District believes that the New York State portion of the watershed is well managed and there are no "glaring" sources of nutrient input to the lake.

7. Surveys conducted by the Connecticut Board of Fisheries and Game in 1965 and 1970 revealed Indian Lake to be inhabited by good numbers of large mouth bass, small mouth bass, chain pickerel, bluegill sunfish, pumkinseed sunfish, redbreast sunfish, golden shiner, chub sucker and brown bullhead. Calico bass, rock bass, yellow perch and grass pickerel were also present but in lesser numbers. Any lake containing good populations of such a variety of species is potentially a valuable fishery resource.

8. Any increase in the nutrients flowing into the lake would only serve to worsen its value from a recreational and aesthetic standpoint. Effects on the fish populations would probably not be severe as Indian Lake is currently inhabited by warm-water species only. Some increase in the overcrowding and stunting process already occuring would probably occur however. Mechanical *weed removal, as proposed during the ERT's field review, is a highly efficient means of providing immediate aesthetic improvement and may result in an increase in growth for both predator and prey species of fish. Additionally, so long as the plant material is taken a safe distance from the water so as to prevent any return of leachate to the lake, this method will lessen the nutrient content of the system. Neither chemical treatment or winter drawdown are capable of achieving this result. It should be recognized however that some weeds should be allowed to remain in the lake in order to provide fish cover and spawning habitat.*

9. It appears that management efforts at Indian Lake can best be directed towards both in-lake management and watershed management. The in-lake management measures which look most promising include: 1) weed harvesting, 2) use of herbicides, and 3) lowering the lake level during the winter months to kill off weeds. Watershed management should be directed towards minimizing the controllable nutrient inputs to the lake from agricultural land, septic systems, erosion and sedimentation, and waterfowl. If weed harvesting is being seriously considered as a management tool, the Indian Lake Association may wish to contact the village of Wappingers Falls concerning leasing their weed harvester. Through such an arrangement, it may be possible to considerably reduce the expenses incurred in implementing a weed harvesting program at Indian Lake.

II. TOPOGRAPHY AND GEOLOGY

The topography of the Indian Lake Watershed largely follows the shape of the underlying bedrock. It consists of a single, central valley, which comprises Indian Lake, bounded to the west by moderately rolling hillsides and to the east by steep to very steep terrain. The eastern half of the watershed consists largely of the west-flank of Indian Mountain. The watershed's maximum elevation, which is approximately 1,400 feet above mean sea level, is reached at the top of Indian Mountain in the northeast section of the watershed; the lowest elevation in the watershed is represented by the surface of Indian Lake, which is normally about 629 feet above mean sea level.

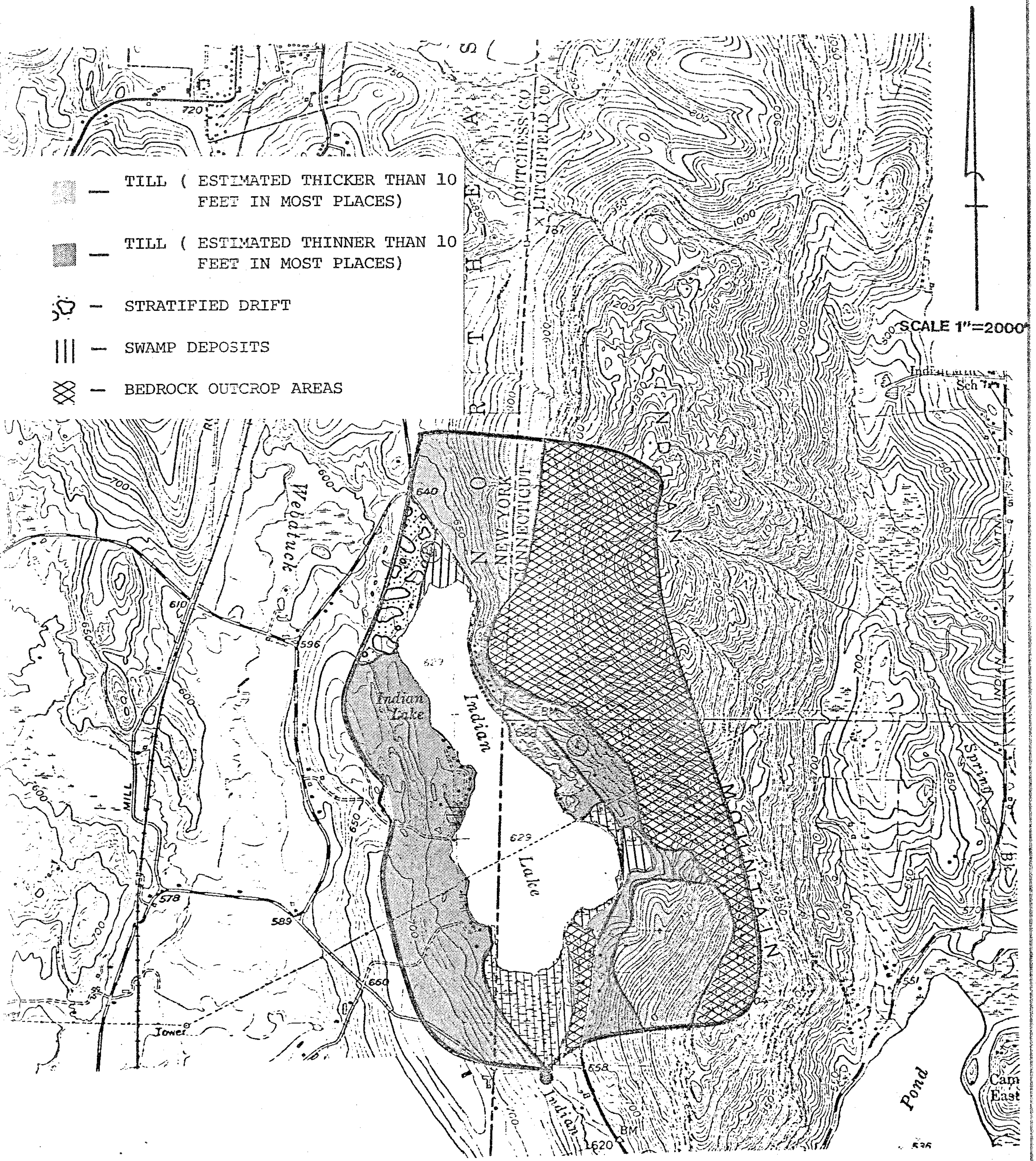
The Indian Lake Watershed is located within the Sharon, Connecticut-New York and Millerton, New York topographic quadrangles. A bedrock geologic map of the Sharon quadrangle has been prepared by Robert M. Gates and published by the U.S. Geological Survey (Map QR-38); however, the surficial geologic map for the quadrangle has not been completed to date. Both the bedrock and surficial geologic maps for the Millerton, New York topographic quadrangle have not been completed to date.

The predominant surficial geologic material covering most of the watershed is till. Till, which is derived mainly from crystalline (schists, gneisses and marble) rock, is a poorly sorted mixture of rock particles ranging in size from clay to boulders. The rock materials were scraped and plucked from pre-existing bedrock and soil surfaces by glacier ice and were redeposited directly from the ice without significant reworking by meltwater streams. The till, which is commonly referred to as "hardpan", has a texture that is highly variable ranging from a sandy, friable and very stony variety to a silty compact variety. The thickness of the till deposits is generally thin throughout the entire watershed, particularly in the eastern half. However, there are some areas where thicker deposits of till, perhaps greater than ten feet, can be found. Figure 2 shows the approximate thicknesses of the till in the watershed, and the location of bedrock outcrops in the eastern half of the watershed. The thicknesses of till were mapped based on topography, outcrop distribution and soils information. As such, this information is approximate, and is not expected to be completely accurate. As mentioned earlier, no information was available to the Team geologist regarding the surficial geologic material of the western half of the watershed. Nevertheless, based on visual inspection and aerial photographs, till deposits appear to cover most of the western half of the watershed.

Another type of surficial geologic material found in the watershed, which appears to be minor in terms of thickness and aerial extent is stratified drift. Stratified drift, which was deposited by meltwater streams flowing from wasting ice, consists predominantly of sorted and layered sand and gravel. Based on the topographic map and aerial photographs, it appears there may be small pockets of stratified drift found in a few isolated areas in the northwestern section of the watershed.

A third type of surficial deposit found within the watershed, primarily in the southern portions, is swamp sediment. Swamp sediments consist of a mixture of sand, silt, clay and organic materials that have been deposited in stagnant or slow-moving, well-vegetated bodies of water.

FIGURE 2
SURFICIAL GEOLOGIC MAP



Bedrock which underlies and/or outcrops throughout the western half of the watershed consists of three subunits of the Stockbridge Formation. Each subunit has been designated in the accompanying bedrock geologic map (see Figure 3). Subunit 'A' consists of the massive, white to light gray, fine grained calcitic to dolomitic marble. Subunit 'B' consists of an assemblage of light gray, dolomitic and calcitic marbles which includes a rusty-weathering quartzite, quartzitic marble and mica-rich, quartz marble. Lastly, subunit 'C' consists of a coarse grained, mottled white and gray or salmon colored calcite marble. Because bedrock in all of the above subunits contain the relatively soft minerals calcite and dolomite, it is highly susceptible to weathering. The combination of normal weathering processes as well as the relatively recent periods of glaciation have worn the marble down considerably so that surface exposures of marble throughout the western half of the watershed are generally scarce. Nevertheless, there are some areas of marble outcrops in the southern portion of the watershed.

The eastern limit of the watershed forms part of the west flank of Indian Mountain. Bedrock, which crops out on and underlies this portion of the watershed, is composed largely of various schists. Schists are more resistant to the elements of weathering than the carbonate bedrock in the western portion and therefore, outcrops are much more extensive. These rocks are classified by Gates as part of the Walloomsac and Everet Formation. Figure 3 shows their approximate distribution. "Schists" are crystalline, metamorphic rocks (rocks that have been geologically altered by high temperatures and/or pressure) predominantly composed of elongate, platy or flaky minerals that are arranged into parallel layers or sheets. Schists can commonly be split into slabs quite easily.

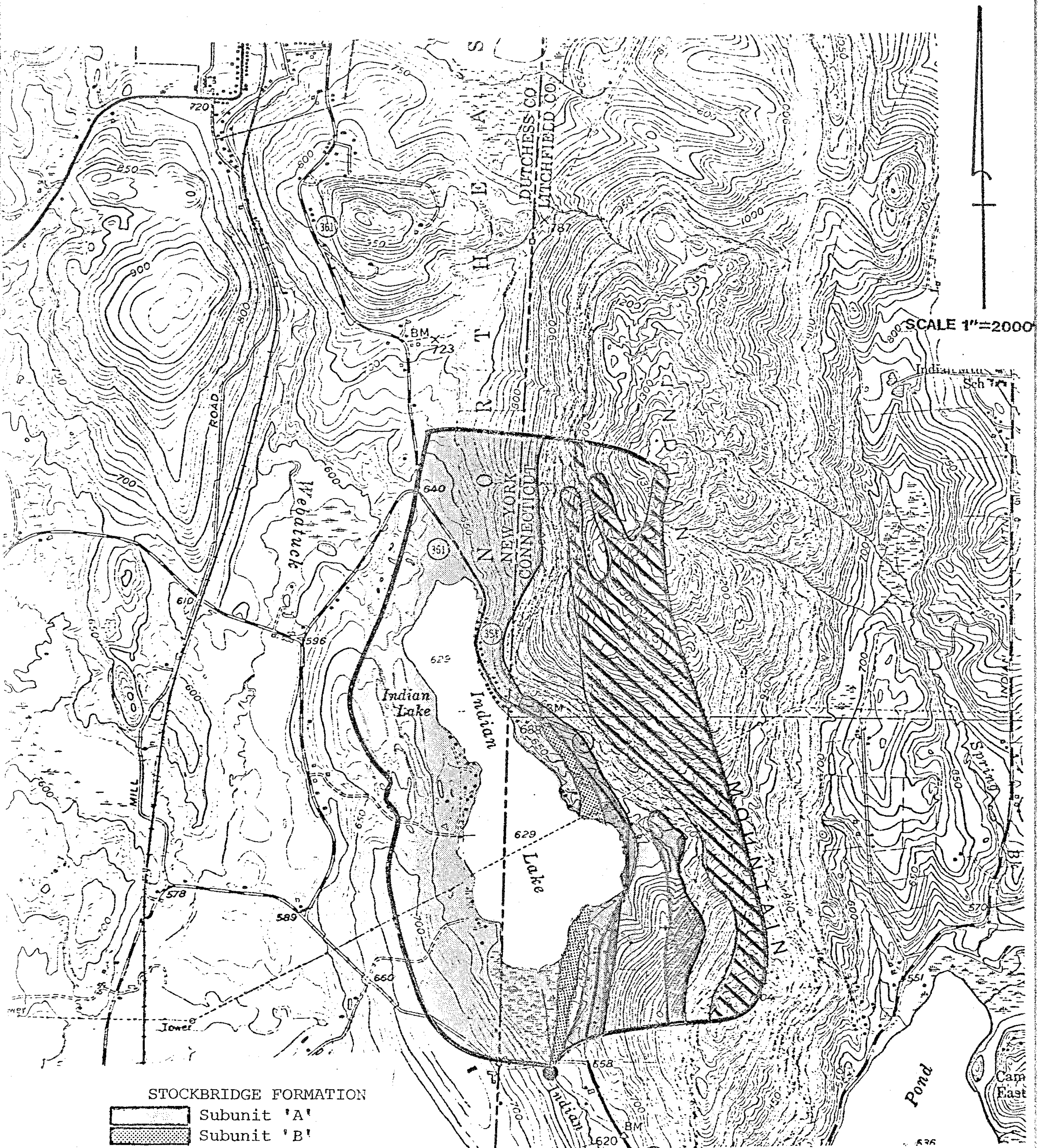
The Walloomsac Formation consists of a dark gray to black, flaggy, muscovite-biotite-plagioclase-quartz schist. The Everett Formation consists of a pale, greenish-gray, fine grained chlorite muscovite-quartz schist. Mica, chlorite, quartz and feldspar are the most abundant minerals in the Everett Formations. Mica, feldspar and quartz are the most abundant minerals in the Walloomsac Formation.

Due to the predominance of carbonate bedrock underlying the watershed, it seems likely that Indian Lake could contain relatively hard water, although no information regarding chemical quality of the water was available to the team geologist. "Hard water" is water that contains substantial amounts of mineral salts. These salts may interfere with the lathering and cleansing properties of soap, but they do not significantly affect the water quality of the lake from a eutrophication standpoint.

III. HYDROLOGY

The watershed of Indian Lake is relatively small and comprises approximately 750 acres (1.13 square mile). The lake is a natural water body and is the only major surface water body in the watershed. The lake has a surface area of approximately 195 acres (more or less 1/3 square mile). The lake is supplied almost entirely by groundwater (i.e., springs) and surface runoff and has no major perennial inlet streams. Occasionally, intermittent drainage, primarily from the north and northeast section of the watershed, does flow into the lake. Also, intermittent drainage emanating from a wetland area in the eastern portion of the watershed flows into the lake. Indian Lake Creek, the outlet stream for the watershed, flows in a southward course into the Town of Kent.

FIGURE 3
BEDROCK GEOLOGIC MAP



STOCKBRIDGE FORMATION

- Subunit 'A'
- Subunit 'B'
- Subunit 'C'

EVERETT FORMATION

WOLLOMSAC FORMATION

See text for bedrock descriptions

By definition, the watershed of Indian Lake comprises all land areas from which water drains into the lake. A raindrop falling on the watershed boundary would have a 50 percent chance of passing into or out of the watershed. As shown by the accompanying topographic map, the watershed boundary or drainage divide tends to follow the crests of local hills and ridges (e.g., Indian Mountain).

At the present time, there is no gaging station within the Indian Lake watershed nor on Indian Lake Creek. Nevertheless, it is possible to estimate the outflow from the watershed based on a method that uses long term stream flow records for a standard 30-year reference period. The reference source is "Streamflow Information for Connecticut With Application to Land Use Planning" by Michael A. Cervione, Jr., U.S. Geological Survey. Based on this method, an estimated 1.687 cubic feet per second (CFS) or 1.08 million gallons per day (mgd) would flow out of the watershed. It should be noted that this estimate may be high since water stored in the lake, streams, wetlands, soil and surface of vegetation may be removed by evapotranspiration to the atmosphere.

Precipitation falling within the watershed is either shed quickly across the land surface as runoff, retained temporarily by vegetation or absorbed into the soil. Part of the absorbed water is utilized by plants, part is evaporated from soil and part percolates down to the watertable (the upper surface of the saturated zone). Water in the zone of saturation moves down slope until it re-emerges at the surface in the form of springs, wetlands or streams. Therefore, the quality of surface water depends in part upon the route by which precipitation has been "transformed". More particularly, water quality is determined by the nature of the materials with which the water comes in contact and by the length of time in which contact occurs. The natural mineral composition of the surficial geologic deposits and underlying bedrock throughout the watershed largely determines the chemical quality of Indian Lake. The chemical quality of groundwater and surface water within the Indian Lake watershed under natural conditions is generally good. The natural water quality in a watershed can, however be adversely influenced by various non-point sources of pollution such as erosion and sedimentation, septic systems, agricultural practices, and runoff from roads. These sources of pollution, either singularly or in combination, can severely impact the environmental health of a lake and are discussed in more detail in a later section of this report.

Being a predominantly till covered area, the Indian Lake watershed contains no significant available groundwater resources (i.e. aquifers). The rate at which groundwater moves through various earth materials (i.e., till, stratified drift, bedrock) depends, in part, upon the size, the percentage and the degree of interconnection of the pore spaces or fractures in the material underlying the watershed. Coarse grained materials, such as gravelly stratified drift and bedrock fracture systems, tend to transmit groundwater more rapidly than other surficial geologic materials such as till, lake deposits and organic deposits. However, since there does not appear to be any suitable sand and gravel aquifer present within the watershed, it seems likely that the underlying bedrock would be the most important source of ground water in the watershed.

Bedrock wells are commonly capable of providing small but reliable yields. The yield of bedrock wells depends upon the number and size of water-bearing fractures the wells intersect. Since the fractures are distributed irregularly through the rock, it is difficult to predict what the yield of a well will be. Nevertheless, based on statistical information in Water Resource Bulletin #21 (Upper Housatonic River Basin), of those wells studied tapping a carbonate type bedrock (the type underlying the western part of the watershed), 90% yielded almost 3 gallons per minute, 80% yielded 4 gallons per minute, 50% yielded 11 gallons per minute and 10% yielded 50 gallons per minute or more. On the other hand, of those wells tapping schist (the type underlying the eastern portion of the watershed), 90% yielded just over one gallon per minute and only 10% yielded 18 gallons per minute. In most of the Indian Lake Watershed, the quality of water may be affected by excessive hardness. This is true because most of the local bedrock is carbonate. Several filtration or softening systems are available to overcome hardness problems, but the use of some such systems may cause salt contamination of groundwater. Also, there is a possibility that wells tapping the Walloomsac or Everett formation schist may experience elevated levels of iron and/or manganese. If levels are excessive, filtration may be required to remove objectionable water color and taste.

IV. SOILS AND LAND USE

As shown in Figure 4, most of the land within the watershed is characterized by shallow to bedrock soils. The southeastern corner of the watershed is underlain by "hardpan" soils, however, and the northwest and southwest corner consist of deep, well-drained soils. Wetland soils are located at the northern and southern tip of the lake and are also found scattered along the eastern and western shore areas. A detailed description of each soil type in the watershed can be found in the Litchfield County Soil Survey (USDA Soil Conservation Service, 1970) and the Soil Survey of Dutchess County (USDA Soil Conservation Service, 1955).

Figure 5 shows the current land use in the watershed. Soil related concerns with regard to land use and water quality are presented below.

A. Soils east of the state line

1. Soils used for agriculture (± 70 acres)

   Cornland (± 6 acres) - The soil underlying this area is mapped as well drained Stockbridge loam on average slopes of 15%. Due to slopes, erosion can be excessive; however, a crop rotation is followed on this particular site which helps minimize potential problems.

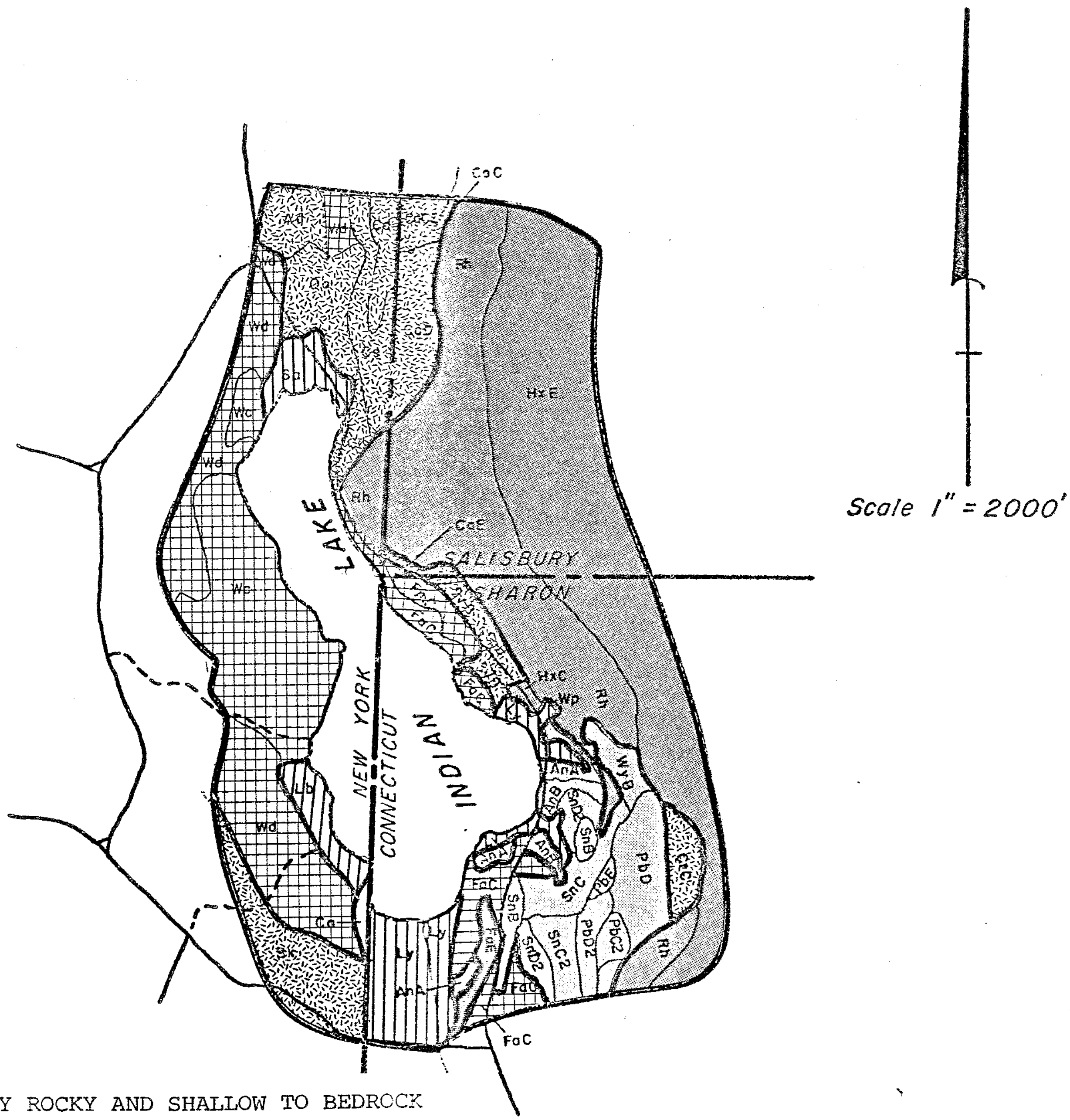
   Hay and pasture land (± 62 acres) - the soils are mapped as predominantly Stockbridge loam and Paxton fine sandy loam on slopes mostly over 15%. Considerable erosion can take place if used for cropland unless the fields are contoured, strip cropped, cover cropped, rotated, etc.

   If lime and fertilizer is applied according to soil needs (as determined by soil tests), and the land remains in hay and pasture with dense sod cover and good conservation practices, erosion and nutrient runoff will be minimal.

   Livestock confinement area (barns, etc.) (± 2 acres) - Manure spread on frozen ground over winter months, and manure stock piled in areas not protected from surface water runoff, can be a non-point source of pollution to the lake.

   A manure storage facility and spreading of manure on non-frozen ground could reduce the pollution hazard.

FIGURE 4
GENERAL SOILS MAP



— EXTREMELY ROCKY AND SHALLOW TO BEDROCK SOILS ON STEEP SLOPES

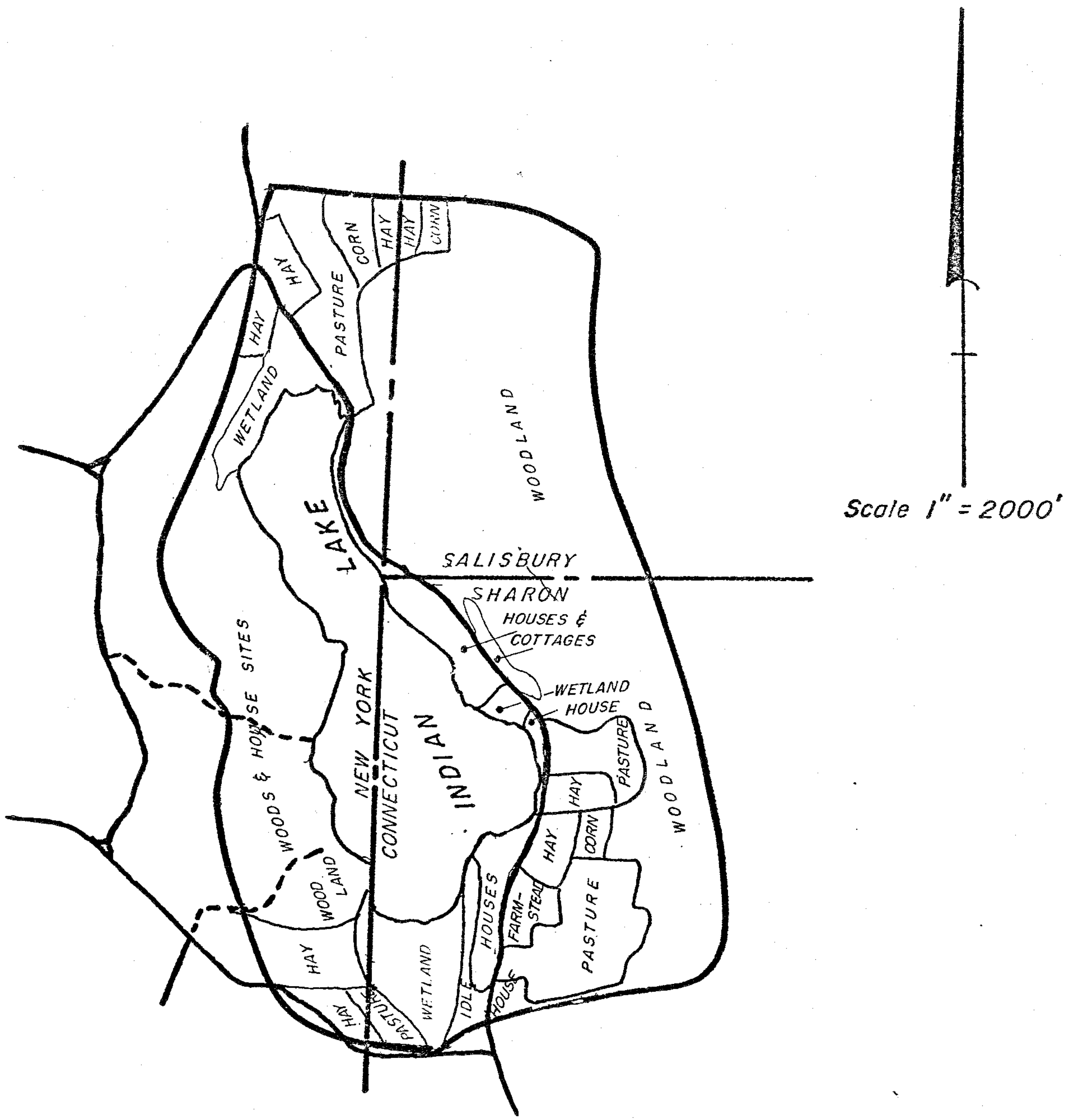
— SHALLOW TO BEDROCK SOILS WITH SLOPES 5 to 15%

— POORLY AND VERY POORLY DRAINED SOILS

— SOILS UNDERLAIN BY HARDPAN

— MODERATE TO WELL DRAINED SOILS, NO HARDPAN WITHIN ± 3 - 5 feet

FIGURE 5
LAND USE MAP



2. Soils used for houses/cottages (year round and seasonal) (± 33 acres)-

The great majority of ± 20 houses and cottages are located close to the lake shore on soil mapped as Farmington very rocky silt loam, 3-15% slopes. This soil is generally less than 20 inches deep to bedrock. The limitation for septic tank leaching fields is severe due to the depth to bedrock and slopes.

Management practices to overcome the severe limitation are:

a. Control of housing density
b. Addition of fill
c. Enlarge leaching area
d. Serial tile distribution
e. Land shaping and/or stone removal
f. Avoid construction when wet to prevent soil smearing which can lessen soil permeability and decrease effectiveness of leaching fields.

Some pollution of the lake may be occurring from inadequately installed and maintained septic systems if the preceding management practices were not implemented.

Future development within the lake's watershed should consider the individual soil limitations and plan accordingly (e.g. control housing density, implement necessary management practices for septic tank leaching fields, control cuts and fills for driveways, implement erosion controls, etc.)

3. Soils in forest (± 360 acres)- approximately 310 acres are mapped as either Rockland or Hollis extremely rocky fine sandy loam on slopes of 15 to 35% and greater. Exposed bedrock occupies more than 50% of the soil surface. Limitations are very severe for any use. The growth of trees is poor and management is very difficult. These lands best serve a purpose in their natural state as watershed and wildlife habitat.

It should be noted that there are 20-30 acres of idle, brush and weed land located at the southeast end of the lake (see Figure 5).

4. Wetland soils (± 42 acres) - All of the wetland soils are adjacent to the lake and are mapped as Lyons silt loam. As far as the lake is concerned, the most important function of these wetlands is their ability to absorb nutrients and purify water. These wetlands should be preserved.

B. Soils west of the state line

The predominant soils on the western side of Indian Lake within the lake's watershed are Wassaic Gravelly Loam and Wassaic Stony Loam (see Figure 4). Wassaic Gravelly Loam is a moderately deep, medium textured, acid to neutral, well drained till soil with under lying limestone bedrock usually less than three feet. These soils have scattered bedrock outcrops, moderate permeability, and moderate available moisture capacity. The water runoff from this soil type is quite rapid due to the inability of the soil to absorb large quantities of water. The Wassaic Stony Loam is exactly the same as Wassaic Gravelly Loam except that it contains many loose stones within the surface soil layer. The land use is woodland and farmland except for a few residential homes north of the power lines near the shore of the lake.

The woodland and pasture land is totally vegetated so thereby does not generate any significant siltation to the lake. With land used as woodland and pasture there is no use of herbicides, insecticides or commercial fertilizers. There is no farm manure stored within the watershed on the western side of Indian Lake. There is very little cropland within the western side of the watershed and that is separated by a wide filter strip of woodland between the cropland and the water of Indian Lake.

The land north of Indian Lake and east of Dutchess County 62 is used as cropland below the wooded area. The soil type in the bottom crop field is Ondawa Gravelly Loam, alluvial fan phase (a deep, gravelly, medium textured, acid, well drained, alluvial fan soil from granitic material with moderately rapid permeability and good moisture holding capacity). This land lays level and poses no erosion problems when covered with a hay crop. When planted to corn, a fall cover crop of rye should be planted by early September. The upper fields are Charlton Gravelly Loam soils (a deep gravelly, medium textured, acid, well drained till soil from schist, with moderate permeability and high available moisture capacity). This land has contour stripcropping to keep soil erosion to a minimum and has a diversion ditch constructed across the field for runoff water control. The corn strips in the stripcropping system should be planted to a rye cover crop by early September.

The northerly swampy end of Indian Lake is underlain by Saco Silt Loam which is a deep, acid, and very poorly drained alluvial soil. This soil type with the existing vegetation makes an excellent filter for runoff waters entering the lake. A major factor in this portion of the lake filling up is the dense growth of cattails that grow and die back every fall to create a dense mat or organic matter made up by the cattails themselves. The George Culver's, who own most of the land around the north end of the lake, use good soil conservation practices and have very strict soil conservation use restrictions in their leases for rented land. This practice helps keep the lake clean.

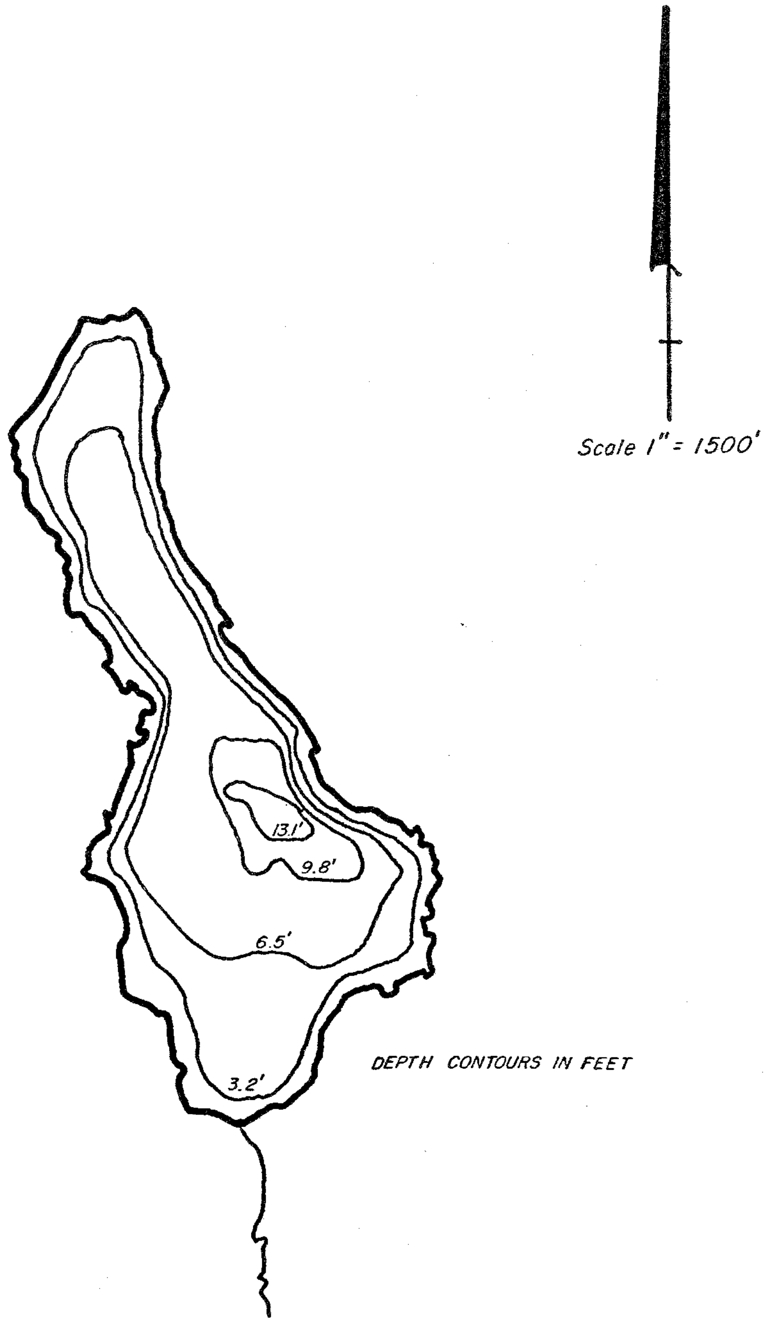
The camps on the eastern side of the lake between the waters and Dutchess County Route 62 are on Charlton Gravelly Loam soil type (which is described above) and steep, shallow to bedrock soils. These camps should be used only as summer and weekend homes due to the closeness to the water and the steepness of the slope and the very limited space for septic systems to operate properly.

To conclude, with the possible exception of septic systems, the District Manager of the Dutchess County Conservation District believes that the New York State portion of the watershed is well managed and there are no "glaring" sources of nutrient input to the lake.

V. FISHERIES

Surveys conducted by the Connecticut Board of Fisheries and Game in 1965 and 1970 revealed Indian Lake to be inhabited by good numbers of large mouth bass, small mouth bass, chain pickerel, bluegill sunfish, pumkinseed sunfish, redbreast sunfish, golden shiner, chub sucker and brown bullhead. Calico bass, rock bass, yellow perch and grass pickerel were also present but in lesser numbers. Large mouth bass growth rates determined from samples taken in 1959-60 were slightly below the Connecticut state average (Indian Lake - 163 fish in sample - Age II average = 7.7 inches, Age III = 10.5 inches, Age IV = 11.6 inches, Age V = 14.5 inches).

FIGURE 6
BATHYMETRIC MAP



• Adapted from Connecticut State Board of Fisheries and Game Map, 1962

Any lake containing good populations of such a variety of species is potentially a valuable fishery resource.

Moderate macrophyte (i.e. lake weed) growth is generally considered beneficial in that it provides shelter for some fish and spawning areas for pickerel and yellow perch. However, extensive growth may prevent efficient predation on forage species by bass and pickerel, often resulting in overcrowded, stunted populations of perch and sunfish and depressed growth rates in bass. Partial removal of the heavy emergent weed beds located along the southeastern and northern shores and intermittent along portions of the western shore may result in an increase in growth for both predator and prey species. Bass and pickerel growth should improve due to an increase in the available food supply as panfish (i.e. a small food fish) hiding cover is reduced. Panfish growth may also improve as their population size is reduced by bass predation, resulting in a greater available food supply per individual fish.

Any increase in the nutrients flowing into the lake would only serve to worsen its value from a recreational and aesthetic standpoint. Effects on the fish populations would probably not be severe as Indian Lake is currently inhabited by warm-water species only. Some increase in the overcrowding and stunting process already occuring would probably occur however.

Mechanical weed removal, as proposed during the ERT's field review, is a highly efficient means of providing immediate aesthetic improvement. Additionally, so long as the plant material is taken a safe distance from the water so as to prevent any return of leachate to the lake, this method will lessen the nutrient content of the system. Neither chemical treatment or winter drawdown are capable of achieving this result. It should be recognized however that some weeds should be allowed to remain in the lake in order to provide fish cover and spawning habitat.

VI. LAKE FEATURES AND EUTROPHICATION

A. Lake Features

The approximate morphological characteristics of Indian Lake are as follows:

Surface Area = 195 acres

Maximum Depth = 15 feet

Mean Depth = 10 feet

Volume = 84,942,000 cubic feet

Watershed Area = 750 acres

Retention Time = 1.6 years (568 days)

The lake is fed by bottom springs and surface runoff. There are no perennial tributaries entering the lake. The outflow, Indian Lake Creek, exits the lake on its south shore.

The physical, chemical and biological data being generated by the Lake Association's environmental consultant will document the current trophic status of the lake. At this stage, it is assumed by the ERT that Indian Lake is a eutrophic lake.

B. Eutrophication

Eutrophication is the natural process of lake aging by nutrient enrichment. As a lake eutrophies, many water quality changes occur. Fertility increases and macrophyte (weed) beds become denser and more extensive. Algae blooms occur more frequently and water clarity decreases. Organic matter accumulates on the lake bottom from decaying plants and animals. The lake gradually fills in. Decomposition of lake bottom material reduces oxygen levels in the bottom waters. In general, as these changes occur, recreation opportunities decline.

The eutrophication process can be accelerated by man's activities in the lake watershed which increase nutrient inputs to the lake. The major nutrients of concern are phosphorus, nitrogen and carbon. Phosphorus has been found to be the usual limiting nutrient in the eutrophication process. Therefore, most restoration strategies focus on phosphorus control to reduce the supply to a level where it becomes limiting.

Undisturbed woodland contributes lower nutrient loads to a lake than other land uses. The nutrient loading from agricultural land is generally about five times greater than woodland. Residential and commercial land typically contribute more than ten times the nutrient loading that results from woodlands. Thus, as woodland is converted to other uses, or as agricultural land is converted to residential land, the nutrient contribution to the lake increases, advancing the eutrophication process. Although much of this increase in nutrient export from the watershed is inevitable and unavoidable, best management practices can provide for some degree of mitigation.

It should be noted that the Connecticut DEP has recently (1982) released a report entitled "A Watershed Management Guide for Connecticut Lakes". The DEP's report discusses in detail the process of eutrophication and methods of control. According to the DEP's report, the following factors may contribute nutrients to a waterbody and therefore accelerate the eutrophication process: erosion and sedimentation, septic systems, lawn and garden fertilizers, yard and garden vegetation disposal, agricultural land, timber harvesting, stormwater runoff, waterfowl, atmosphere, lake sediments. The key to controlling the eutrophication process is controlling the nutrient enrichment from these sources. The DEP's "Watershed Management Guide" is recommended reading and is available from the Department at 566-2588.

Indian Lake is presently experiencing algae blooms and nuisance aquatic weed growth which has diminished recreational opportunities to some degree in recent years. Additional residential development or agricultural activities which do not employ best management practices will serve to worsen these conditions. Local agencies should consider developing and implementing watershed management practices to mitigate the effects of land-use changes in the watershed. The nutrient sources believed to be the most significant at Indian Lake are discussed in the next section of this report.

VII. MANAGEMENT ALTERNATIVES

A. Watershed Management

As previously discussed, the watershed of Indian Lake is that land area which drains to the lake. The watershed is therefore the source of water for the lake. The water quality of the lake, to a large extent, is determined by qualities imparted to water by the watershed as the water drains to the lake. If eutrophication of the lake is to be controlled, its watershed must be prudently managed to protect the quality of the water which enters the lake. For this reason, the Indian Lake Association should consider developing a watershed management program for the lake.

Watershed management should be aimed at identifying and controlling existing and potential watershed characteristics which ultimately influence the lake's trophic condition. Since phosphorus is the nutrient which governs the productivity of algae and aquatic plants, watershed management should first and foremost be concerned with reducing phosphorus enrichment. An important secondary consideration is reducing sediment inputs which contribute to the physical filling of the lake.

The DEP's "Watershed Management Guide for Connecticut Lakes" identifies a number of nutrient sources which may contribute to eutrophication. The DEP Guidebook also discusses appropriate measures to control such nutrient sources. At Indian Lake, the biggest nutrient contributors appear to be septic systems, waterfowl, erosion and sedimentation, agricultural land, and lake sediments. Discussion in this report will therefore focus on these factors.

SEPTIC SYSTEMS

A septic system can fail if it is not properly designed, installed, or maintained. A failing system will either result in the backflow of wastewaters into the house, or the breakout of wastewaters on the surface of the ground. A failing septic system can contribute phosphorus and other pollutants to lake waters. A far more important consideration, however, is that a failing septic system is a public health hazard. The public health threat is an overriding concern which demands correction of the problem, irrespective of lake eutrophication.

Residential development around the shores of Indian Lake, at the present time, is relatively light. The greatest concentration of dwellings are cottages located primarily along the western and northeast shores of the lake. According to lake association members present during the review, the greatest percentage of these dwellings are lived in only during the summer months as opposed to year around. Based on visual inspection of the cottages clustered along the shore in the northeast section of the watershed, they appear to have been constructed on undersized lots which are very close to the shore of the lake. Also, because of steep slopes, and shallow to bedrock conditions present in the area, it seems the lots would be unfavorably suited for on-site sewage disposal systems. Therefore, during periods of heavy usage by residents, i.e., summer months and/or during heavy precipitation, it seems likely that these existing systems could malfunction and discharge septage effluent into the lake. Such a discharge could ultimately threaten the water quality of the lake as well as to create a public health nuisance condition.

The correction of individual or scattered failing septic systems is the responsibility of town health officials. There are a number of steps which can be taken to reduce the potential adverse effects of existing and proposed sewage disposal systems in the Indian Lake watershed. These include:

1) Conducting sanitary surveys to identify potential sources of pollution.

This may include the introduction of fluorescence dye in residential toilet systems during the wet spring months in order to determine proper system function.

2) Strict enforcement of the Public Health Code requirements with respect to new construction in the Indian Lake watershed.

3) Educating lakeside residents about the proper operation and maintenance of septic systems via an information pamphlet. The pamphlet should advise homeowners about the consequences of failures, list materials which should not be disposed of in a septic system, state water conservation measures, and stress the need for routine septic tank pumping. An excellent pamphlet for these purposes was developed by the Northeastern Connecticut Regional Planning Agency and the Northeast District Department of Health entitled, "Homeowner's Guide to Septic System Maintenance - Or How to Save Thousands of Dollars".

4) Encouraging lakeside residents to use nonphosphate laundry detergents. The phosphorus passing through a residential septic system can be reduced 30-40% by the use of nonphosphate laundry detergents.

5) Considering adopting a town ordinance which requires the installation of sewage disposal systems meeting all health code requirements at the time of building conversion from seasonal to year round use.

EROSION AND SEDIMENTATION

The transport of eroded soil to a lake contributes to eutrophication in several ways. Most importantly, phosphorus and other plant nutrients associated with soil particles are introduced into the lake. Erosion and sedimentation can therefore be a dominant cause of phosphorus enrichment of lake waters. Another important effect is the physical presence of solid particles in the lake. Sedimentation reduces water depths, creating shallow shoals which are conducive to the growth of aquatic plants. In addition, organic matter associated with soil particles is decomposed by lake bacteria, contributing to the depletion of oxygen in waters overlying the lake sediments.

Due to steep slopes in the Indian Lake watershed, sediment and nutrient inputs due to erosion are a particularly important concern. Erosion control practices should be implemented to correct any known problem areas and to prevent future problems due to new construction. Methods for controlling erosion and sedimentation are described in detail in the "Erosion and Sediment Control Handbook for Connecticut", U.S. Dept. of Agriculture Soil Conservation Service, 1976. This publication is available at the U.S.D.A. Soil Conservation Service Office in Litchfield (567-8288).

WATERFOWL

Indian Lake Association members have indicated that a resident population of ± 50 geese typically utilize the lake as a resting and feeding area during the summer months. This could be an important factor in the eutrophication process of Indian Lake. In a study of Lake Wonoscopomuc in Salisbury, Connecticut, the Connecticut Agricultural Experiment Station estimated that the phosphorus in the waste from four geese in one month would be equivalent to the total annual loading of phosphorus from 2.5 acres of watershed land. In order to quantify the impact of waterfowl on Indian Lake it would be necessary to develop detailed information on population numbers, feeding habits, resting areas and periods of occupancy. It should be recognized that large flocks of migratory waterfowl which stay at the lake even for a few weeks could contribute a substantial nutrient load to the lake.

Waterfowl can be controlled by methods which discourage large flocks from frequenting the lake. The U. S. Fish and Wildlife Service regulates all migratory bird activities that involve handling the birds, such as trapping, banding, and hunting. This agency also provides information on methods of harassment. These activities include mechanical barriers, landscaping techniques, scarecrows and other foreign objects, automatic exploders, flashing lights, ballons, and chase dogs. Information on these methods can be obtained from U. S. Fish and Wildlife Service, 4 Whalley Street, Hadley, Massachusetts 01035.

The DEP Wildlife Bureau lends assistance and cooperation when possible concerning nuisance goose control. The DEP is studying the potential of special goose hunting by certified, competent hunters to control nuisance populations in areas where safety considerations are not prohibitive. Assistance regarding special goose hunting can be obtained from the DEP Wildlife Bureau in Hartford.

AGRICULTURAL LAND

As previously discussed, major portions of the Indian Lake watershed consist of agricultural land. Agricultural sources of phosphorus and sediment are associated with cropland, with pasture land and feedlots, and with manure storage and handling.

The Connecticut 208 Program conducted a statewide study of agricultural non-point sources of pollution and developed a program for the implementation of Best Management Practice (BMP) controls. The most effective agricultural BMP's identified by the Connecticut 208 Program are cover crops, field border filter strips, critical area planting, diversions, grassed waterways, streambank protection, animal waste management, optimum manure and fertilizer application rates, and changing from cultivated crops to permanent vegetation. Additional effective practices, very effective in some areas, are contour farming, contour strip cropping, no-till planting, conservation cropping, pasture and hayland management, planned grazing, protection of heavy use areas, subsurface drainage, roof gutters in barn areas, mulching, fencing to keep livestock from streams and stream banks, proper manure spreading and fertilization techniques, and prompt incorporation of manure into soils.

Implementation of the statewide agricultural BMP Program is being managed by the Connecticut Council on Soil and Water Conservation. The program relies on voluntary participation through education and incentives, resorting to regulatory authority only in major problem areas where voluntary initiative is unsuccessful. Technical expertise is provided by the USDA Soil Conservation Service and State Soil and Water Conservation Districts. A primary source of federal cost sharing for BMP's is the USDA Agricultural Stabilization and Conservation Service, which can provide up to 75% funding for erosion and sedimentation controls, animal waste controls, and soil and water conservation.

The Indian Lake Association should continue to consult with the local Soil and Water Conservation Districts to obtain information on the status of agricultural activities in the lake watershed. The lake organization should also develop cooperative, working relationships with District personnel, Soil Conservation Service personnel, and local farmers in order to develop a program for the timely implementation of agricultural BMP's needed to protect lake water quality.

LAKE SEDIMENTS

Under certain conditions, sediments on the lake bottom can release phosphorus and nitrogen to overlying waters. Lake sediments may thus serve as a significant source of enrichment of lake waters. The identification of internal enrichment can only be made through detailed lake water quality monitoring. Control of this source involves in-lake technology (hypolimnetic withdrawal, dredging, or artificial aeration) which is typically expensive to implement.

B. In-Lake Management

Management of algae blooms and macrophyte beds in the lake may be necessary as an adjunct to watershed management in order to improve recreation opportunities. Methods for controlling algae blooms include algicide treatments, artificial aeration, chemical precipitation, and bottom water withdrawal. Each of these is described below.

Algicide treatments are commonly conducted in Connecticut lakes to provide temporary, cosmetic relief from nuisance algae blooms. This method does not correct the source of the problem - nutrient enrichment - and usually needs to be repeated annually. One treatment at Indian Lake would cost approximately $1,000. A DEP pesticides permit must be obtained prior to each treatment. The permit specifies treatment conditions which will protect aquatic life and recreation activities.

Artificial aeration is a high cost method which is employed to increase oxygen levels in a lake's water column to prevent anoxic recycle of plant nutrients from the lake sediments. Further investigation is required to determine if anoxic conditions exist in the lake's bottom waters and if so, then determine if the condition is causing significant recycle of nutrients from the sediments.

Chemical precipitation of nutrients is an experimental approach which utilizes metals, usually aluminum, to precipitate soluble phosphorus from lake waters. This method is most effective when a significant fraction of phosphorus occurs as soluble forms which can be removed from the water column. It is also most effective when a lake has a hydraulic residence time of several years, so that treated water is not rapidly replaced with untreated, enriched water. More information on the nutrient characteristics of Indian Lake must be developed before consideration of chemical precipitation can be made.

Bottom water withdrawal is a high cost, experimental method which may provide relief from algae blooms in lakes where nutrients recycled from sediments contribute to algae blooms. More research on this method, and more detailed water chemistry information for Indian Lake, would need to be developed in order to evaluate its applicability.

It is apparent from this cursory discussion of alternatives that further investigations into nitrogen and phosphorus concentrations and dissolved oxygen data are required before the appropriate management alternative can be chosen.

Methods which are commonly considered for control of macrophytes include overwinter drawdown, herbicides, harvesting, and dredging. Over-winter drawdown involves lowering the lake level for several weeks to expose plants to dessication and freezing. This is a low cost alternative where feasible since drawdown requires negligible labor and no equipment or chemicals. Some species are resistant to this method, but excellent control of *Myriophyllum* and other species has been achieved in Connecticut. The feasibility of this method depends on an evaluation of several factors, including the presence and condition of drawdown facilities, stresses on lake fisheries, lake refill rate, potential for downstream flooding during drawdown, and potential hydraulic effects on well water levels along the lake shore. There is no dam on Indian Lake for control of the pond's water level; however siphoning or pumping may be feasible.

In comparison to drawdown, other macrophyte control methods have higher costs but more predictable success. Herbicides provide for effective control of macrophytes by killing plants in local areas of application. The effects are cosmetic and temporary, and repeated treatments on an annual basis would be required to maintain control. Treatment of watermilfoil with Diquat would require the application of two gallons per acre, with a present chemical cost of approximately $100 per acre. A DEP pesticides permit must be obtained prior to each treatment. The permit specifies treatment conditions which will protect aquatic life and recreation activities.

Harvesting is a method which physically removes plants from the lake with specialized barges equipped with harvesting machinery. This is a cosmetic method which needs to be repeated when macrophyte beds recover from cutting. Recent harvesting experiences in Connecticut indicate that costs can exceed $250 per acre for one cutting.

Dredging is a high cost "last resort" method which is considered for recreational lakes with severe macrophyte problems. The objective is to eliminate macrophyte habitat by removing sediment and increasing water depth. This is accomplished by either drawdown and excavation, or hydraulic dredging. A recent drawdown and excavation project in Connecticut conducted with town resources incurred a cost of approximately $1.75 per cubic yard, or $4,000 per acre. A hydraulic dredging project being planned for another Connecticut lake has an estimated cost of $3.00 per cubic yard, or $15,000 per acre. Long term control of macrophytes is a benefit of dredging which is not obtained by other methods.

During the ERT's field review, the possibility of raising the level of the lake by raising the elevation of the outlet control structure was discussed. Conceivably, by increasing the depth of the lake, macrophyte growth could be deterred. Due to the presence of homesites so near the lake shore, however, and the existing conditions at the lake's outlet, it appears that only a rise of 12-18" could be effectively achieved. In the opinion of the Team's ecologist, a rise in lake level of 12-18" would <u>not</u> have a significant effect on controlling aquatic vegetation in the lake. In addition, such a change would alter the ecology of the wetland at the south end of the lake.

To conclude, it appears that management efforts at Indian Lake can best be directed towards both in-lake management and watershed management. The in-lake management measures which look most promising include: 1) weed harvesting, 2) use of herbicides, and 3) lowering the lake level during the winter months to kill off weeds. Watershed management should be directed towards minimizing the controllable nutrient inputs to the lake from agricultural land, septic systems, erosion and sedimentation, and waterfowl. If weed harvesting is being seriously considered as a management tool, the Indian Lake Association may wish to contact the village of Wappingers Falls concerning leasing their weed harvester. Through such an arrangement, it may be possible to considerably reduce the expenses incurred in implementing a weed harvesting program at Indian Lake.

References for additional lake management information include those references listed in the Appendix of this report. The "Lake Unit" of DEP is also available to provide assistance at 566-2588.

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APPENDIX

References

(1) Lake Restoration - Proceedings of a National Conference, USEPA, March 1979 (EPA 440/5-79-001).

(2) Restoration of Lakes and Inland Waters USEPA December 1980 (EPA 44/5-81-010).

(3) Phase I Diagnostic/Feasibility Study Middle and Lower Bolton Lakes, DEP Water Compliance Unit, 1979.

(4) Lake Waramaug Watershed Management Plan, Lake Waramaug Task Force and Northwestern Regional Planning Agency, 1978.

(5) A Watershed Management Guide for Connecticut Lakes, Connecticut Department of Environmental Protection, 1982.

ABOUT THE TEAM

The King's Mark Environmental Review Team (ERT) is a group of environmental professionals drawn together from a variety of federal, state, and regional agencies. Specialists on the team include geologists, biologists, foresters, climatologists, soil scientists, landscape architects, recreation specialists, engineers, and planners. The ERT operates with state funding under the aegis of the King's Mark Resource Conservation and Development (RC&D) Area - a 47 town area in western Connecticut.

As a public service activity, the team is available to serve towns and developers within the King's Mark Area --- free of charge.

PURPOSE OF THE TEAM

The Environmental Review Team is available to help towns and developers in the review of sites proposed for major land use activities. To date, the ERT has been involved in the review of a wide range of significant activities including subdivisions, sanitary landfills, commercial and industrical developments, and recreation/open space projects.

Reviews are conducted in the interest of providing information and analysis that will assist towns and developers in environmentally sound decision-making. This is done through identifying the natural resource base of the project site and highlighting opportunities and limitations for the proposed land use.

REQUESTING A REVIEW

Environmental Reviews may be requested by the chief elected official of a municipality or the chairman of an administration agency such as planning and zoning, conservation, or inland wetlands. Requests for reviews should be directed to the Chairman of your local Soil and Water Conservation District. This request letter must include a summary of the proposed project, a location map of the project site, written permission from the landowner/developer allowing the team to enter the property for purposes of review, and a statement identifying the specific areas of concern the team should address. When this request is approved by the local Soil and Water Conservation District and the King's Mark RC&D Executive Committee, the team will undertake the review. At present, the ERT can undertake two reviews per month.

For additional information regarding the Environmental Review Team, please contact your local Soil Conservation District Office or Richard Lynn (868-7342), Environmental Review Team Coordinator, King's Mark RC&D Area, P.O. Box 30, Warren, Connecticut 06754.