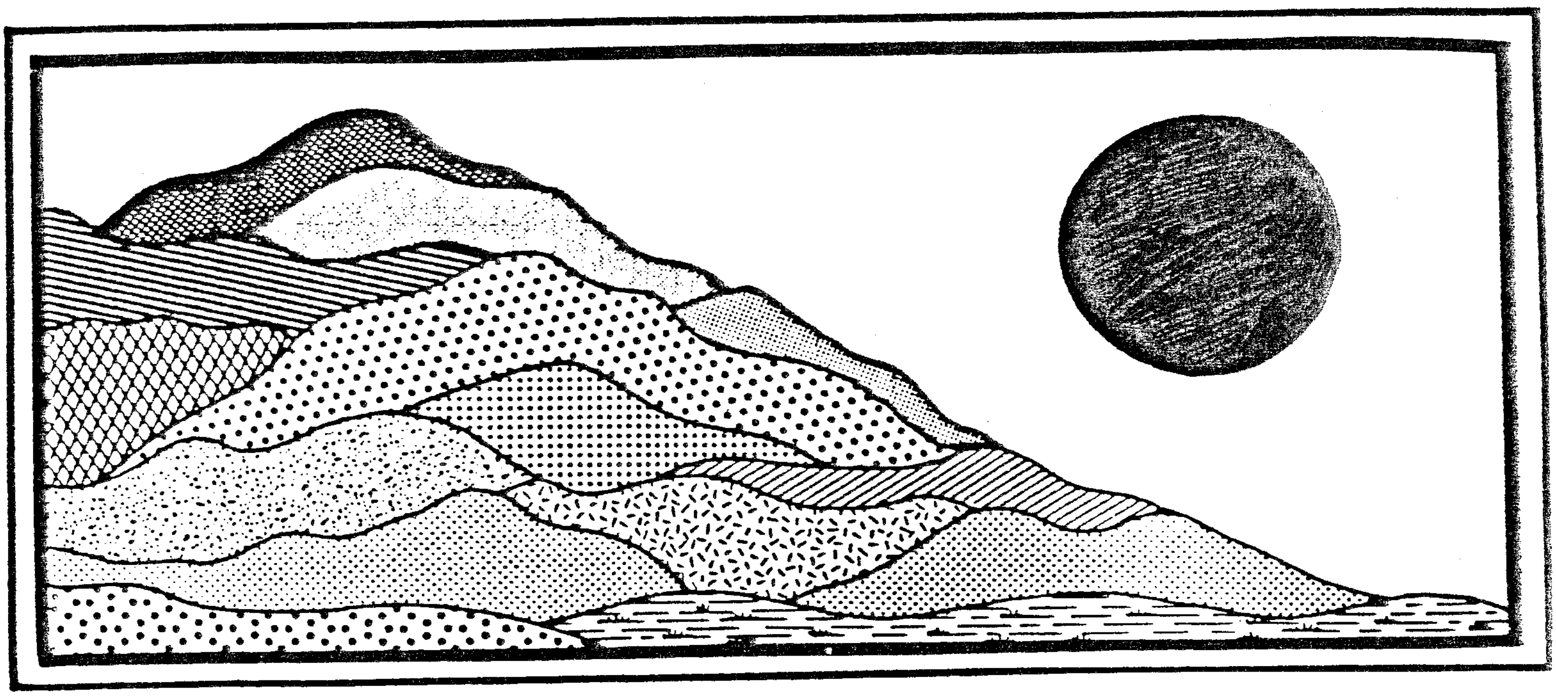
Staffordville Reservoir

Stafford, Connecticut

July 1986



ENVIRONMENTAL REVIEW TEAM REPORT

EASTERN CONNECTICUT RESOURCE CONSERVATION AND DEVELOPMENT AREA, INC.

Staffordville Reservoir

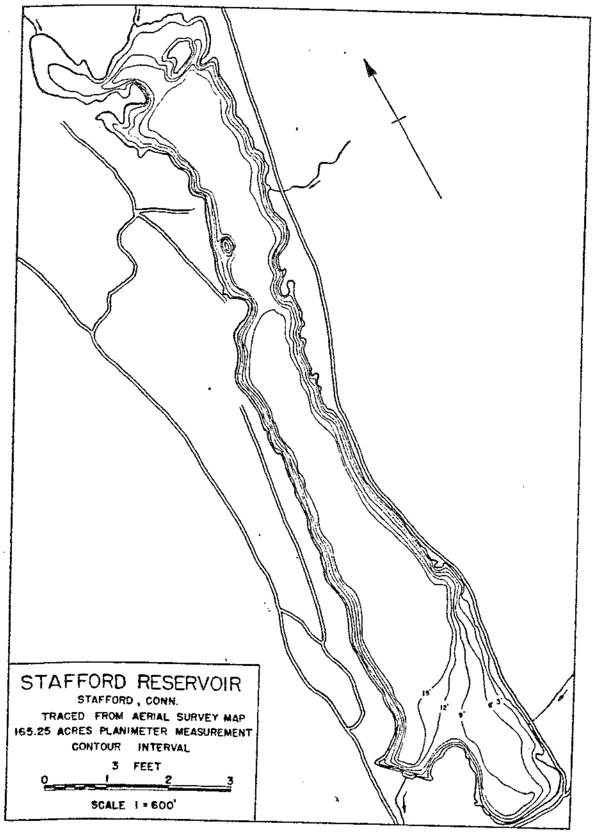
Stafford, Connecticut

Review Date: MAY 29, 1986

Report Date: JULY 1986

RC&D

ENVIRONMENTAL REVIEW TEAM
PO BOX 198
BROOKLYN, CONNECTICUT 06234

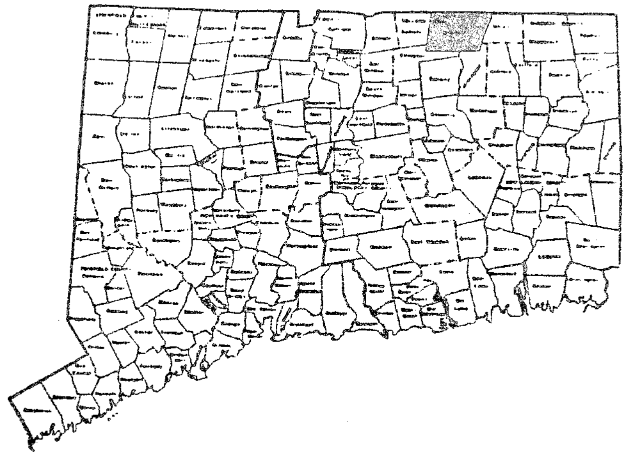


Site Location

STAFFORDVILLE RESERVOIR &

IT'S WATERSHED

STAFFORD, CONNECTICUT



EASTERN CONNECTICUT

RESOURCE CONSERVATION

& DEVELOPMENT AREA

ENVIRONMENTAL REVIEW TEAM REPORT
ON
THE STAFFORDVILLE RESERVOIR AND WATERSHED
STAFFORD, CONNECTICUT

This report is an outgrowth of a request from the Stafford Conservation Commission to the Tolland County Soil and Water Conservation District (S&WCD). The S&WCD referred this request to the Eastern Connecticut Resource Conservation and Development (RC&D) Area Executive Committee for their consideration and approval. The request was approved and the measure reviewed by the Eastern Connecticut Environmental Review Team (ERT).

The ERT met and field checked the site on Thursday, May 29, 1986. Team members participating on this review included:

Larry Johnson	--Planner - Office of Policy and Management
Nancy Marin	--Environmental Analyst - DEP, Lakes Management Unit
Joe Neafsey	--District Conservationist - U.S.D.A., Soil Conservation Service
James Parda	--Forester - CT Department of Environmental Protection
Al Roberts	--Soil Scientist - U.S.D.A., Soil Conservation Service
Eric Schluntz	--Fisheries Biologist - CT Department of Environmental Protection
Elaine A. Sych	--ERT Coordinator - Eastern CT RC&D Area
Bill Warzecha	--Geologist - DEP, Natural Resources Center
Judy Wilson	--Wildlife Biologist - CT Department of Environmental Protection

Prior to the review day, each team member received a summary of the proposed project, a list of the Town's concerns, a topographic map (scale 1:2000) outlining the watershed boundary for the reservoir and a soils map (scale 1:1320), and a map and lake description from the 1959 Connecticut Fishery Survey. During the field review the team members were given preliminary soils information. The Team met with, and were accompanied by the President of the Conservation Commission and the President of the Staffordville Reservoir Lake Association. Following the review, reports from each team member were submitted to the ERT Coordinator for compilation and editing into this final report.

This report represents the Team's findings. It is not meant to compete with private consultants by providing site designs or detailed solutions to development problems. The Team does not recommend what final action should be taken on a proposed project--all final decisions and conclusions rest with the Town and landowner. This report identifies the existing resource base and evaluates its significance to the proposed development, and also suggests considerations that should be of concern to the developer and the Town. The results of this Team action are oriented toward the development of better environmental quality and the long-term economics of land use.

The Eastern Connecticut RC&D Executive Committee hopes you will find this report of value and assistance in making your decisions on this lake and it's watershed.

If you required any additional information, please contact:

Elaine A. Sych
ERT Coordinator
Eastern Connecticut RC&D Area
P. O. Box 198
Brooklyn, CT 06234
(203) 774-1253

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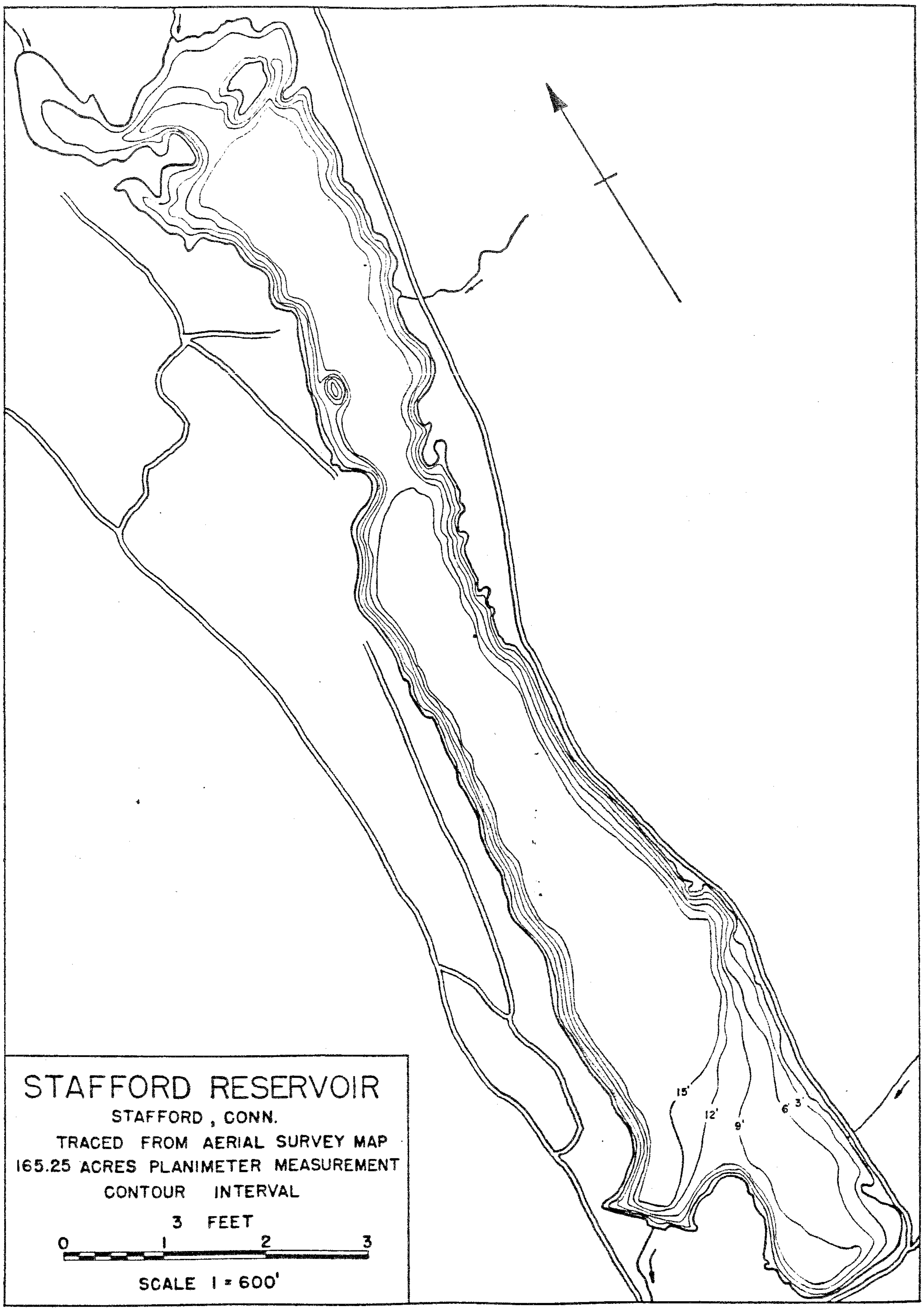
1. INTRODUCTION

The Eastern Connecticut Environmental Review Team was asked to prepare a natural resource inventory and evaluation of Staffordville Reservoir and it's watershed. The Town of Stafford is interested in the management of the watershed for future planning, and in improving and ensuring the quality of the environment of the lake and the surrounding area.

The following sections of this report cover the natural resource base of the lake and watershed area in detail. Management techniques, recommendations and summary statements may be found in each section; for this reason no final summary or highlights have been included in this report. The appendix contains copies of two (2) DEP publications concerning lake management.


STAFFORD RESERVOIR
STAFFORD, CONN.
TRACED FROM AERIAL SURVEY MAP
165.25 ACRES PLANIMETER MEASUREMENT
CONTOUR INTERVAL
3 FEET
0 1 2 3
SCALE 1 = 600'
15'
12'
9'
6'
3'

2. VITAL STATISTICS

STAFFORDVILLE RESERVOIR

Surface Area - 165 acres
Watershed Area - 5248 acres (8.2 square miles)
Depth - Maximum 16 feet, Average 9.5 feet
Volume - 500 million gallons
Political Jurisdiction - Lake: Stafford, Connecticut
Watershed: Stafford, Connecticut and Wales, Massachusetts
Public Access - Town Beach (Residents only)
Lake Association - Staffordville Reservoir Lake Association
Land Ownership - Private
Dam - Across Furnace Brook

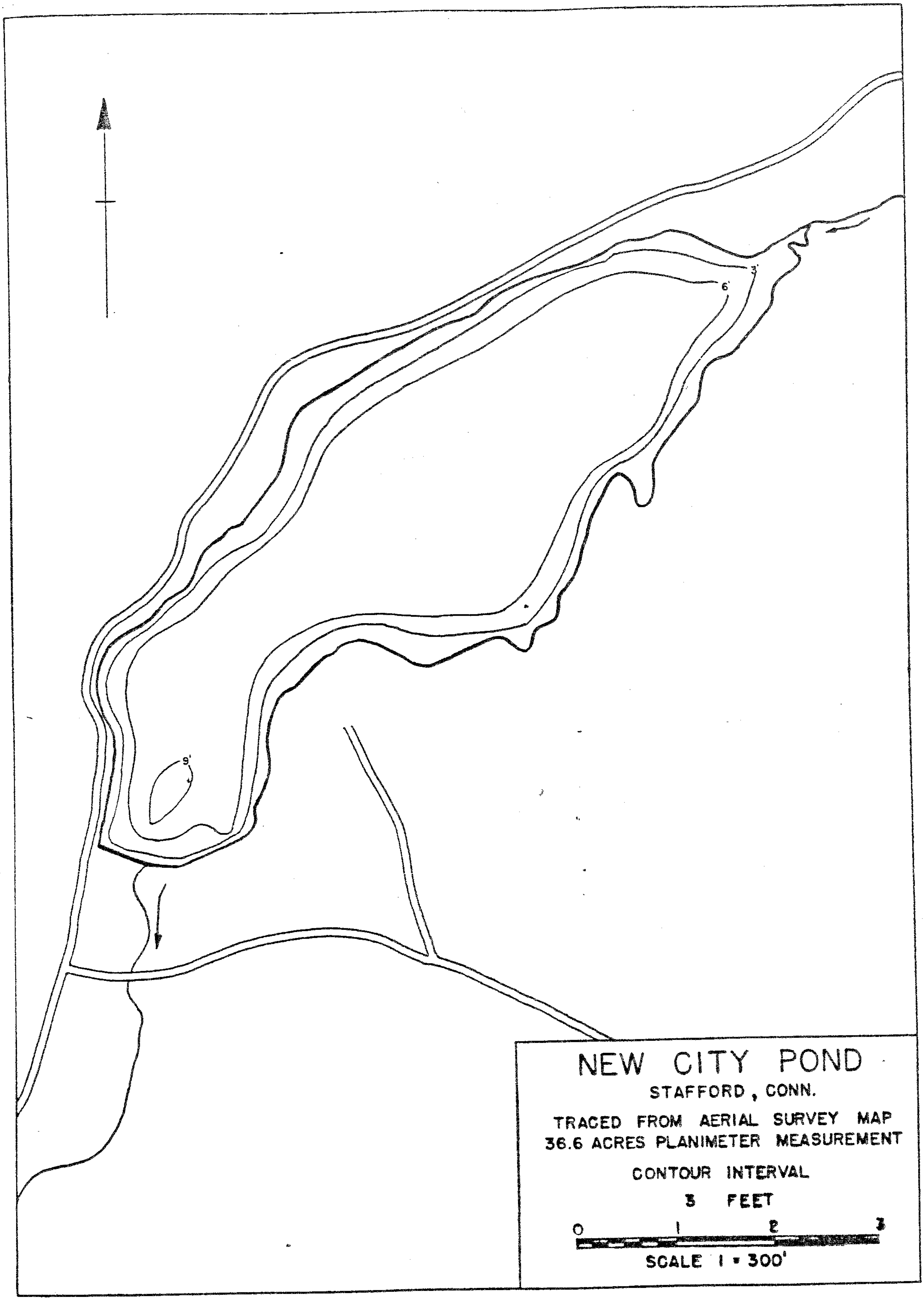
NEW CITY POND

Surface Area - 36 acres
Watershed Area - 1190 acres (1.86 square miles)
Depth - Maximum 10 feet, Average 5.7 feet
Volume - 69 million gallons
Political Jurisdiction - Lake: Stafford, Connecticut
Watershed: Stafford, Connecticut
Public Access - By courtesy of the owners for fishing
Land Ownership - Private
Dam - Across Furnace Brook

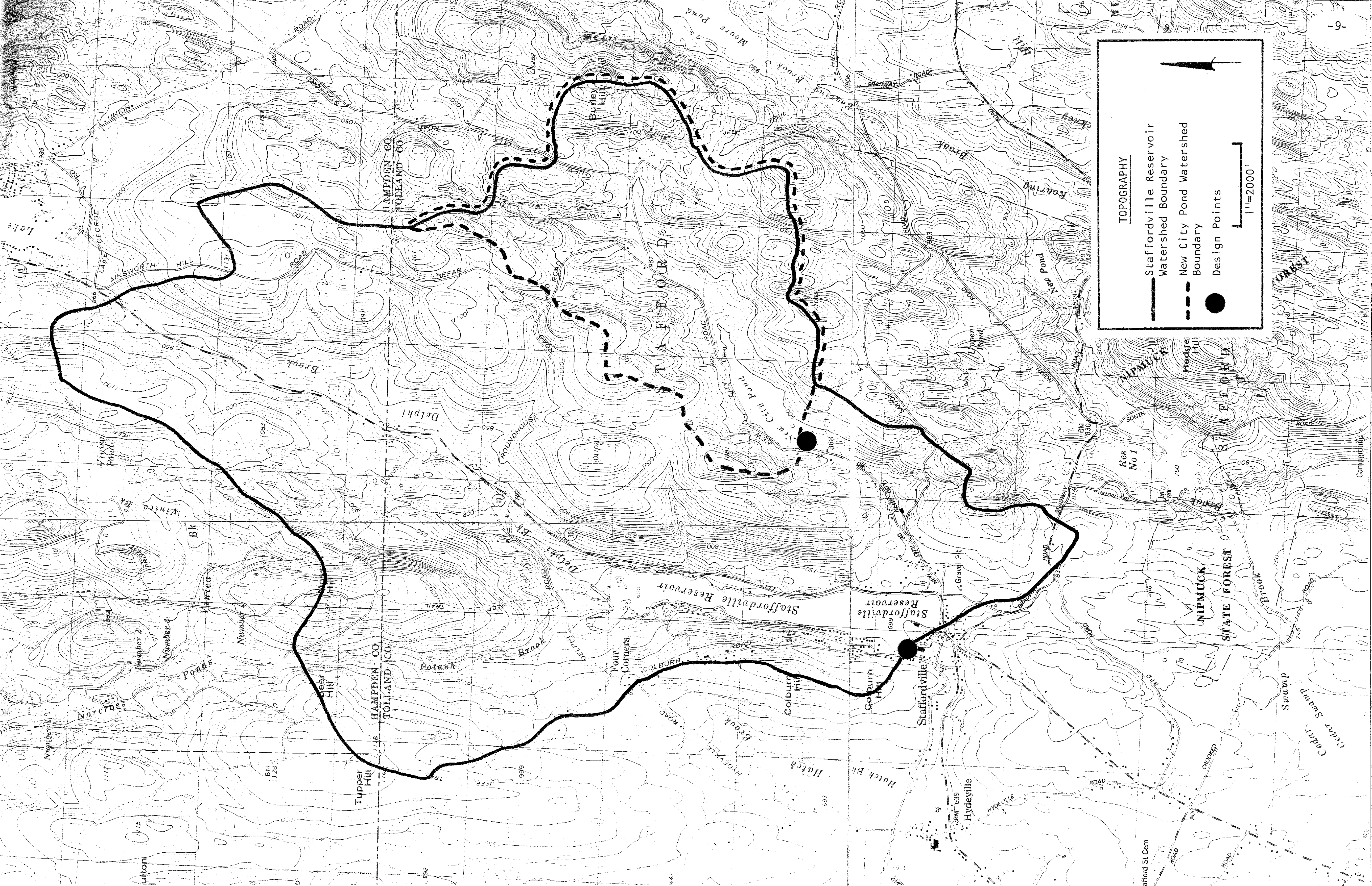
3. TOPOGRAPHY AND SETTING

Staffordville Reservoir is an artificial impoundment located in the northeast corner of Stafford. It is one of the largest surface water bodies in the town and covers about 165 acres. The reservoirs' shape is long and narrow. Its length, which is just over one and half miles long, is nearly nine times its width (about 1,000 feet).

Staffordville Reservoir has a watershed of about 8.2 square miles or about 5,248 acres. Approximately three quarters of the watershed lies within the town of Stafford while the remaining quarter lies within the township of Wales, Massachusetts. A watershed may be defined as the entire area that contributes surface water runoff to a stream or streams from the headwater region of the stream(s) to a designated cross-section. For this study, the designated cross-section for Staffordville Reservoir Watershed would be the spillway or outlet point for the Reservoir.



3'
6'
9'
NEW CITY POND
STAFFORD, CONN.
TRACED FROM AERIAL SURVEY MAP
36.6 ACRES PLANIMETER MEASUREMENT
CONTOUR INTERVAL
3 FEET
0
1
2
3
SCALE 1 = 300'


TOPOGRAPHY
Staffordville Reservoir Watershed Boundary
New City Pond Watershed Boundary
Design Points
1"=2000'
Staffordville Reservoir
Staffordville
New City Pond
Burley Hill
STAFFORD
NIPMUCK STATE FOREST
HAMPDEN CO.
TOLLAND CO.
Four Corners
Colburn Hill
Bear Hill
Tupper Hill
Hydeville
Delphi Brook
Potash Brook
Roaring Brook
Moore Pond
Upper Pond
New Pond
Res No 1
Hedge Hill
Cedar Swamp
Norcross
Vinica Pond

Another major surface water body in the watershed is New City Pond. It is located in the eastern parts of the Staffordville Reservoir watershed and has a surface area of about 36 acres. The watershed for New City Pond is approximately 1,190 acres or 1.86 square miles. The watershed boundary is depicted on an accompanying map. The outlet stream for the pond enters Staffordville Reservoir at its southern limits.

Land use in the Staffordville Reservoir watershed consists of a mixture of residential, agricultural, forested land and one industrial building. Residential land-use in the watershed is heaviest around the Reservoir, particularly on the west side. Moderately dense residential land use characterizes those areas along Colburn Road in the western parts, along New City Road in the southern parts of the watershed and along Route 19 into Massachusetts. It should be noted that a moderately sized mobile home park, which appears to be in the expansion stages, is located in Massachusetts on the east side of Route 19 just over the Connecticut state line.

The remaining portions of the watershed are characterized in very low density residential land use, which is mainly forested.

Elevations in the watershed range from a low of about 698 feet above mean sea level at the surface of Staffordville Reservoir to a high of about 1,315 feet above mean sea level at the top of Burley Hill in the easternmost part of the watershed.

Topographic conditions throughout the watershed area are diverse with moderate to steep slopes prevailing throughout.

4. GEOLOGY

The study area is encompassed by four U. S. Geological Survey topographic quadrangle maps; these are the Monson, Wales, Stafford Springs and Westford quadrangles. Bedrock geologic maps of all but the Stafford Springs have been published by the U. S. Geological Survey. It should be pointed out that preliminary bedrock geologic information for the Stafford Springs quadrangle is available for review and may be reproduced at the Department of Environmental Protection's Natural Resources Center, in Hartford. Surficial geologic maps of all but the Wales quadrangle have been published by the U. S. Geological Survey. No surficial geologic information is available to date for the Wales quadrangle. The Team's geologist referenced the soils survey for Tolland County for this section of the report.

BEDROCK GEOLOGY

METAMORPHIC ROCKS

HAMILTON RESERVOIR FORMATION

Upper schist member

Rusty-weathering quartzofeldspathic gneiss and sillimanite schist with minor hornblende and pyroxene gneiss and granulite -- Medium- to coarse-grained, thick-layered, quartz-(plagioclase)-(potassium feldspar)-biotite-(garnet)-(sillimanite)-(cordierite) gneiss and subordinate schist. Sillimanite ranges from sparse to absent in gneiss to abundant in schist. Gneiss and schist are chiefly sulfidic, graphitic, weather moderate-red, reddish-brown, and yellowish-orange. Unit includes common but very subordinate light- to dark- gray thin- to medium-layered fine- to medium-grained plagioclase-quartz-(orthopyroxene)-(clinopyroxene)-biotite-(horneblende) granulite and gneiss; commonly contains sparse iron sulfide and graphite.

Lens of pyroxene and hornblende gneiss and granulite with interlayered rusty- and nonrusty-weathering quartzofeldspathic gneiss in southwest corner of quadrangle -- Medium-gray thin- to mediumlayered, locally schistose, fine- to medium-grained plagioclase-orthopyroxene-biotite-horneblende-clinopyroxene gneiss and granulite and light-grey thin- to thick-layered medium-grained plagioclase-quartz-biotite-garnet-(potassium feldspar)-(sillimanite) gneiss. Subordinate dark-grey amphibolite.

Lenses of pyroxene and hornblende gneiss and granulite -- Medium-light- to dark-grey thin- to medium-layered fine- to medium-grained plagioclase-pyroxene-biotite-(hornblende)-(quartz) gneiss and granulite. Commonly contains orthopyroxene, locally contains clinopyroxene, orthopyroxene, and hornblend. Locally biotite-rich, schistose. Commonly sulfidic.

Three lenses of highly sulfidic, thin- to medium-layered fine- to medium-grained calc-silicate granulite and amphibolite -- Calc-silicate granulite is greenish-gray plagioclase-diopside-(hornblende)-(scapolite)-(calcite)-(quartz) rock, locally rich in sphene. Amphibolite is medium dark grey, composed of brown hornblende, plagioclase, and diopside. Both rocks are rust stained.

MOUNT PISGAH FORMATION

Quartzofeldspathic gneiss and sillimanite schist characterized by non-rusty to moderately rusty weathering -- Light- to medium-grey thin to very thick layered fine to very coarse grained quartz-plagioclase-potassium feldspar-(garnet)-biotite-(sillimanite)-(cordierite) gneiss and schist. Sillimanite ranges from sparse or absent in gneiss to abundant in schist. Garnet, locally absent in schist, is commonly as coarse as 1-2 cm in gneiss. Fine-grained garnetiferous quartzofeldspathic gneiss also present. Rocks commonly contain sparse graphite and iron sulfide but chiefly weather grey or greyish orange, less commonly moderately rusty (reddish orange).

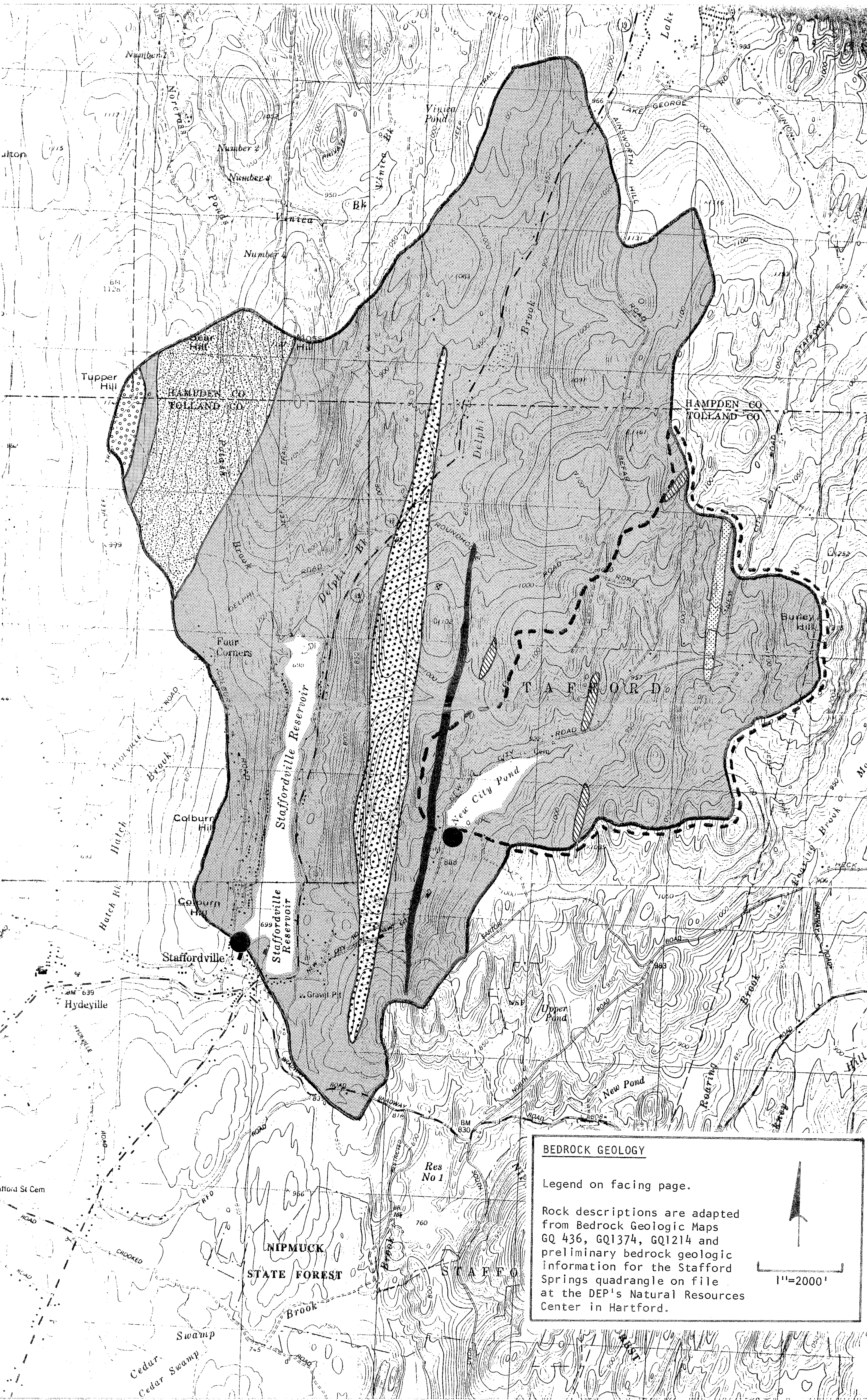
INSTRUSIVE IGNEOUS ROCKS

FOLIATED GRANITE (UPPER DEVONIAN?)

Single large sill of leucocratic plagioclase-quartz-potassium feldspar-biotite gneiss. Gneiss is medium grained and homogeneous; weathers light grey to tan.

HORNBLENDE NORITE

Thin concordant sheet of coarse to very coarse grained hornblende norite. Composed of calcic plagioclase (near An_{90}), reddish-brown hornblende, and orthopyroxene. Some orthopyroxene is poikilitically enclosed by both plagioclase and hornblende.


BEDROCK GEOLOGY
Legend on facing page.
Rock descriptions are adapted from Bedrock Geologic Maps GQ 436, GQ1374, GQ1214 and preliminary bedrock geologic information for the Stafford Springs quadrangle on file at the DEP's Natural Resources Center in Hartford.
1"=2000'
HAMPDEN CO
TOLLAND CO
STAFFORD
Staffordville Reservoir
Staffordville Reservoir
New City Pond
Staffordville
Hydeville
Colburn Hill
Four Corners
Tupper Hill
Bear Hill
Burley Hill
NIPMUCK
STATE FOREST
Upper Pond
New Pond
Res No 1
Delphi Brook
Roaring Brook
Moore Pond
Vinica Pond
Norcross Ponds
Cedar Swamp
Hatch Brook

Below is a list of the quadrangles, type of map, identification number for the map and the authors:

Bedrock Geologic Map

Quadrangle Name	Identification Number	Authors
Wales	GQ-436	Victor Seiders (1976)
Munson	GQ-1374	John D. Peper (1977)
Stafford Spring	On file at DEP's Natural Resources	Maurice H. Pease, Jr.
Westford	GQ-1214	John D. Peter and Maurice H. Pease, Jr. (1975)

Surficial Geologic Map

Quadrangle Name	Identification Number	Authors
Wales	None	-----
Munson	GQ-1374	John D. Peper (1977)
Stafford Springs	GQ-1216	Maurice H. Pease, Jr.
Westford	GQ-1214	John D. Peter and Maurice H. Pease, Jr. (1975)

Bedrock is at a near ground surface in a good portion of the watershed. Based on the bedrock geologic maps sited earlier, the predominant bedrock type in the watershed is the Hamilton Reservoir Formation. These rocks, which mainly outcrop or underlie the central and eastern portions of the watershed, consist largely of gray, rusty-weathering, medium to coarse grained interlayered schists and gneisses.

Rocks comprising the Mount Pisgah Formation underlie or outcrop in the western parts of the watershed. These rocks are described as gray, medium grained micaceous (mica bearing) quartzites and schists.

All of the rocks mentioned above are crystalline metamorphic rocks, that form generally north-south trending belts. Metamorphic rocks are rocks which have been geologically altered by great heat and pressure deep within the earth's crest. The rocks have been intensely folded and cut by northeast/southwest trending faults, which are now inactive. Gneisses are rocks in which thin bands of elongate, platy or flaky minerals alternate with bands or layers of more rounded mineral grains. "Schists" are rocks with pronounced foliation. This foliation or layering in the rock was caused by stresses (heat and pressure) that aligned platy, flaky and elongate minerals into thin sheets. As a result of this mineral alignment, the rock is commonly slabby (parts relatively easily along surfaces of mineral alignment) and weathers easily.

The foliation or layering in the bedrock underlying most of the watershed dips moderately to steeply to the west.

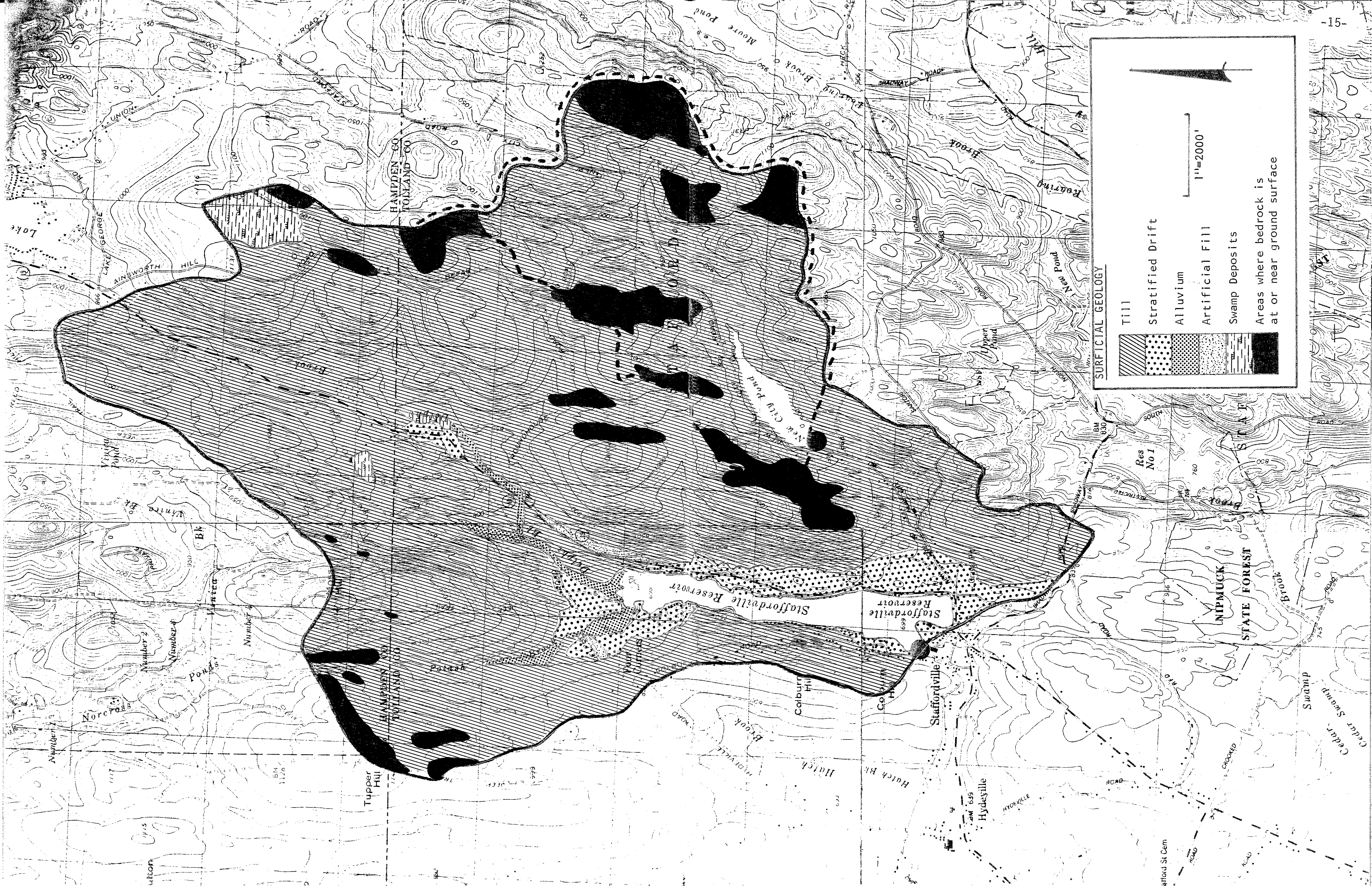
Also, underlying the study area are two rock types which intruded the metamorphis rocks described above following their formation. These rocks are called igneous rocks. They formed from the solidification of molten material or magma. The two (2) intrusive igneous rocks underlying the site are (1) a foliated granite and (2) a hornblende norite.

Accompanying this report is a bedrock geologic map of the watershed which shows the distribution of the rocks mentioned earlier and also gives a detailed mineralogic description of each rock type. This map is adapted from the published and partially completed bedrock geologic maps for the four (4) quadrangles.

Depth to bedrock in the watershed ranges from zero in places where the bedrock breaks ground surface to perhaps as much as 40 feet on top of some of the streamlined till hills in the watershed.

The surficial geology of the Staffordville Reservoir watershed is shown by the surficial geologic map in this report.

Surficial geologic materials consist of those unconsolidated rock particles and fragments, organic matter, or other loose debris that overlie bedrock (also known as "ledge"). The predominant surficial unit in the watershed is till. Till consists of rock debris and occasional organic materials which were accumulated by a moving sheet of glacier ice and which were later redeposited directly from the ice. Because the ice was indiscriminate in collecting and redepositing its constituent particles, till contains a nonsorted mixture of clay, silt, sand, gravel and boulders. Two (2) different tills have been identified in Connecticut. One type is generally thin, relatively loose, and low in fines (silt and clay); the other is tough, compact, relatively high in fines and often thick. Where the two (2) tills are exposed together, the compact variety underlies the looser variety. In most parts of the watershed the till deposit is probably less than 25 feet thick. In a few places, however, very thick till (40 feet or more) has been molded by ice to form steamlined hills. One example of this type of geologic setting is Colburn Hill in the western parts of the watershed. The till in this area is probably about 40 feet thick.


SURFICIAL GEOLOGY
Till
Stratified Drift
Alluvium
Artificial Fill
Swamp Deposits
Areas where bedrock is at or near ground surface
1''=2000'
Staffordville Reservoir
Staffordville
Hydeville
NIPMUCK STATE FOREST
New City pond
Upper Pond
Res No 1
Moore Pond
Tupper Hill
Colburn Hill
Four Corners
Potash
Norcross Ponds
Cedar Swamp
HAMPDEN CO
TOLLAND CO
AINSWORTH HILL

Another type of glacial sediment is found in the watershed mainly around Staffordville Reservoir, in the northern, southern and eastern parts. It is also found in scattered areas along Delphi Brook.

Called stratified drift, the sediment was depostied by meltwater that flowed from wasting ice during a period of glacial regression. Stratified drift is typically well-sorted by grain size, and sand and gravel are commonly the predominant components. The largest body of stratified drift is found along the east side of Staffordville Reservoir and at the northern end of the Reservoir. The stratified drift in the limits of the watershed has been mined as a source of construction aggregate.

Several other types of surficial geologic materials are present in the watershed. These deposits consist of swamp sediments, alluvium and artificial fill. Swamp sediments consists of post glacial materials which have been deposited in wet depressional areas. These sediments consist largely of decomposed plant material with sand, silt and clay intermixed to various extents. Moderately well-sorted sand, silt and gravel have been deposited in channels and on floodplains by the streams in the watershed. Such deposits are called alluvium. Where some of the streams emerge from hillslopes into flatter areas, fan-shaped deposits of gravel and sand have accumulated. Finally, man-made deposits of earth materials are located in a few areas in the watershed. These last deposits are shown on the accompanying surficial geologic map only where they are of substantial thickness (5 feet or more) and aerial extent.

Some geologic concerns that may be associated with bedrock or surficial deposits in the watershed will be discussed in the Hydrology Section.

5. SOILS

This section contains soil descriptions and soil maps of the Staffordville Watershed Area. The watershed extends into the Town of Wales in Massachusetts. Descriptions and names of soil map units from Massachusetts were combined with those used in Connecticut to avoid confusion.

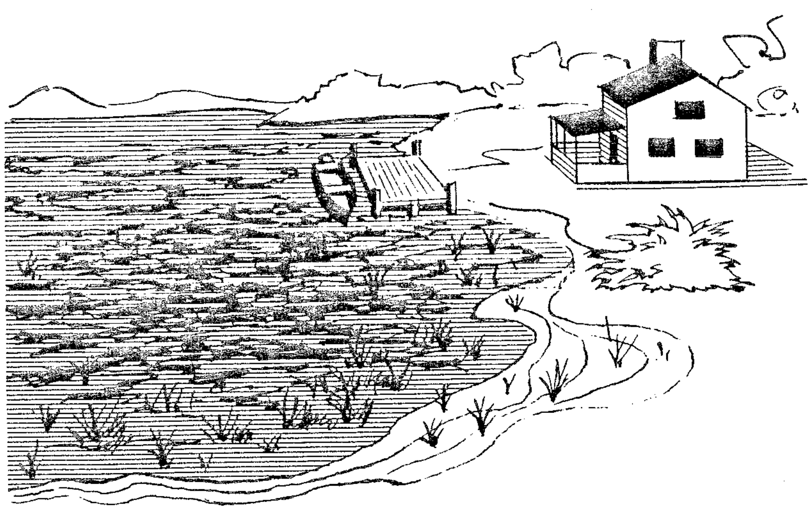
The Staffordville Reservoir Watershed Area consists mostly of steep, hilly, and rolling topography. The soils derived mainly from bedrock of schist and gneiss. Those soils with brownish and reddish colors are from brown micaceous schist and gneiss.

Areas of sandy and gravelly outwash soils are spread throughout the watershed along major stream channels and waterways. Large areas of these soils are in the south end of the watershed and serve as sources of sand and gravel for contractors, builders, and the Town of Stafford.

Wetlands in Connecticut are identified by soils and are those poorly drained, very poorly drained, and floodplain soils marked on the attached legend with an asterisk. It may be prudent to note that wetlands in Massachusetts are identified using different criteria. Other wetland areas not shown on the soil map must be identified in the field through on-site investigations if and when any specific activity is planned. Numerous small streams or tributaries dissect the landscapes and have with them associated wetlands.

Broad soil delineations have inclusions of similar soils and a variety of slopes. The soils have been field reviewed and it has been determined that for the purpose of general planning and this report, the current soil mapping is adequate. A more detailed soil study will be needed on some areas when and if specific uses are identified.

The attached soil legend was consolidated for simplicity. Soil map unit descriptions were combined where there were similarities in interpretations. Also, soil names used in Massachusetts were purposely not listed for the same reasons mentioned above. Soil symbols are as they appear in the published Soil Survey of Tolland County, but soil names reflect how these areas are currently being interpreted.



SOIL LEGEND STAFFORDVILLE RESERVOIR WATERSHED AREA
TOLLAND COUNTY, CONNECTICUT

MAP SYMBOL	SOIL NAME
*Am	Fluvaquents-Udifluvents, frequently flooded
*Aa, 45	Adrian and Palms mucks
BvC, ByC, BnC, 18C	Brookfield-Brimfield complex, 3 to 15 percent slopes, very rocky
ByD, BnD	Brookfield-Brimfield complex, 15 to 45 percent slopes, very rocky
BpC, 6C	Brimfield-Brookfield-Rock outcrop complex, 3 to 15 percent slopes
BpD, 6E	Brimfield-Brookfield-Rock outcrop complex, 15 to 45 percent slopes
BtB, CaB	Canton and Charlton soils, 3 to 8 percent slopes
CaC	Canton and Charlton soils, 8 to 15 percent slopes
ChB	Canton and Charlton soils, 3 to 8 percent slopes, very stony
ChC	Canton and Charlton soils, 8 to 15 percent slopes, very stony
GeC, 115B, 115C	Canton and Charlton soils, 3 to 15 percent slopes, extremely stony
GeD, GeE, ChD, 115D	Canton and Charlton soils, 15 to 35 percent slopes, extremely stony
Tg, JaC, HmC, HkC	Hinckley gravelly sandy loam, 3 to 15 percent slopes
CrC	Charlton-Hollis complex, 3 to 15 percent slopes, very rocky
CrD, HrE	Charlton-Hollis complex, 15 to 45 percent slopes, very rocky
*Le, 32A, 32B	Ridgebury, Leicester and Whitman soils, extremely stony
MyB	Merrimac sandy loam, 3 to 8 percent slopes
PbA, PbB	Paxton and Montauk soils, 3 to 8 percent slopes
PbC	Paxton and Montauk soils, 8 to 15 percent slopes
PdB	Paxton and Montauk soils, 3 to 8 percent slopes, very stony
PdC	Paxton and Montauk soils, 8 to 15 percent slopes, very stony
PeC, 124B, 124C	Paxton and Montauk soils, 3 to 15 percent slopes, extremely stony

*Indicates inland wetland soils as described by Connecticut Public Act 155.

SOIL LEGEND STAFFORDVILLE RESERVOIR WATERSHED AREA
TOLLAND COUNTY, CONNECTICUT

MAP SYMBOL	SOIL NAME
PeD, 124E	Paxton and Montauk soils, 15 to 35 percent slopes, extremely stony
*Pk, 46	Carlisle muck
Rk	Rock outcrop-Hollis complex, 3 to 45 percent slopes
*Ru	Rippowam fine sandy loam
SvB	Sutton fine sandy loam, 3 to 8 percent slopes
SwB	Sutton fine sandy loam, 2 to 8 percent slopes, very stony
SxA, SxB	Sutton fine sandy loam, 3 to 15 percent slopes, extremely stony
WxB	Woodbridge fine sandy loam, 3 to 8 percent slopes
WyA, WyB	Woodbridge fine sandy loam, 2 to 8 percent slopes, very stony
83B, 83C	Woodbridge fine sandy loam, 3 to 15 percent slopes, extremely stony
83E	Woodbridge fine sandy loam, 15 to 25 percent slopes, extremely stony

*Indicates inland wetland soils as described by Connecticut Public Act 155.

United States Department of Agriculture

Soil Conservation Service

TOLLAND COUNTY USDA-SCS
Agricultural Center
24 Hyde Avenue
Rockville, CT 06066
875-3881

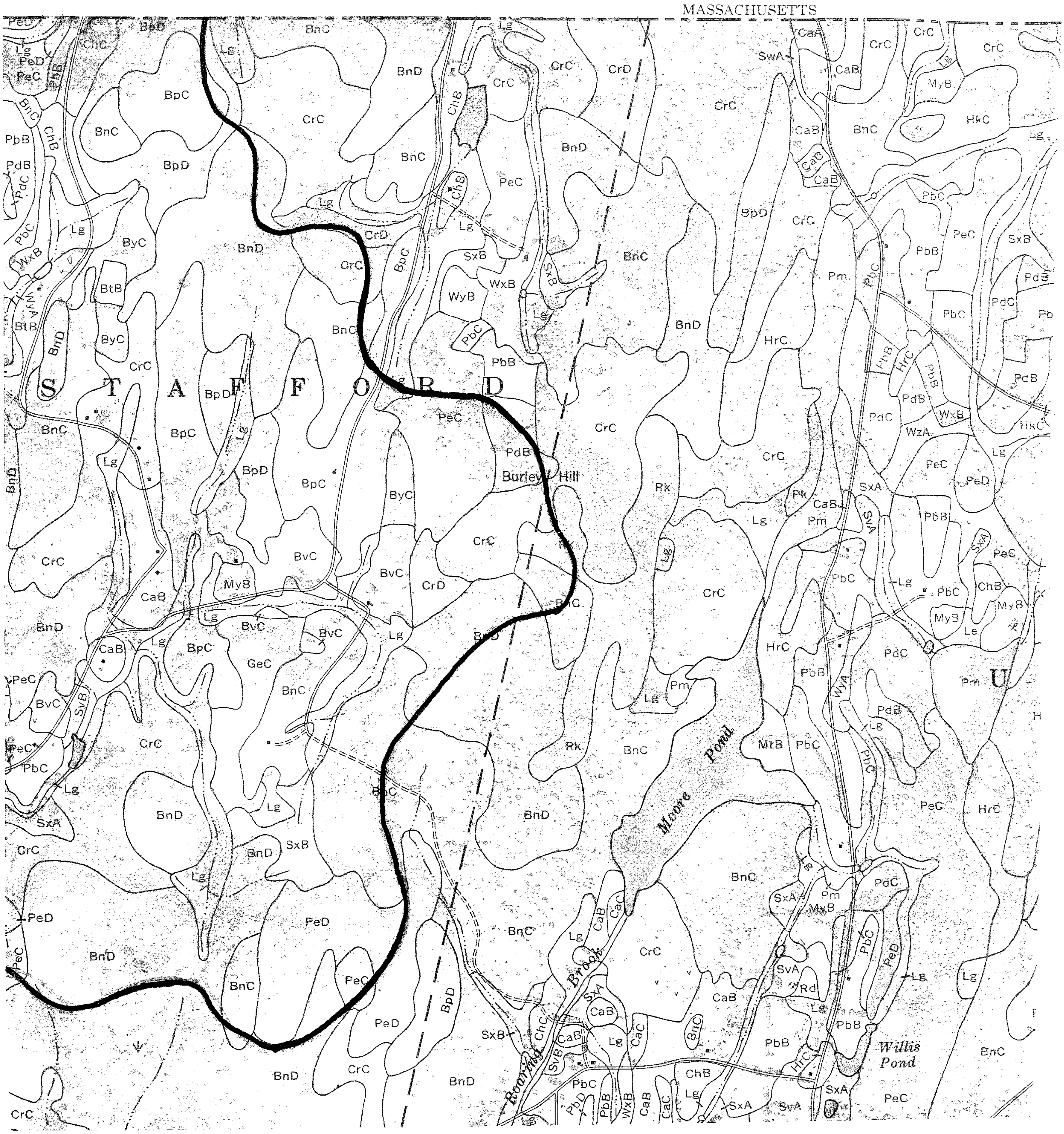
Tolland County Soil Survey Sheet #4 Scale 1:15840 Watershed Boundary

United States
Department of
Agriculture

Soil
Conservation
Service

TOLLAND COUNTY USDA-SCS
Agricultural Center
24 Hyde Avenue
Rockville, CT 06066
875-3881

Tolland County Soil Survey Sheet #5   Scale 1:15840   Watershed Boundary

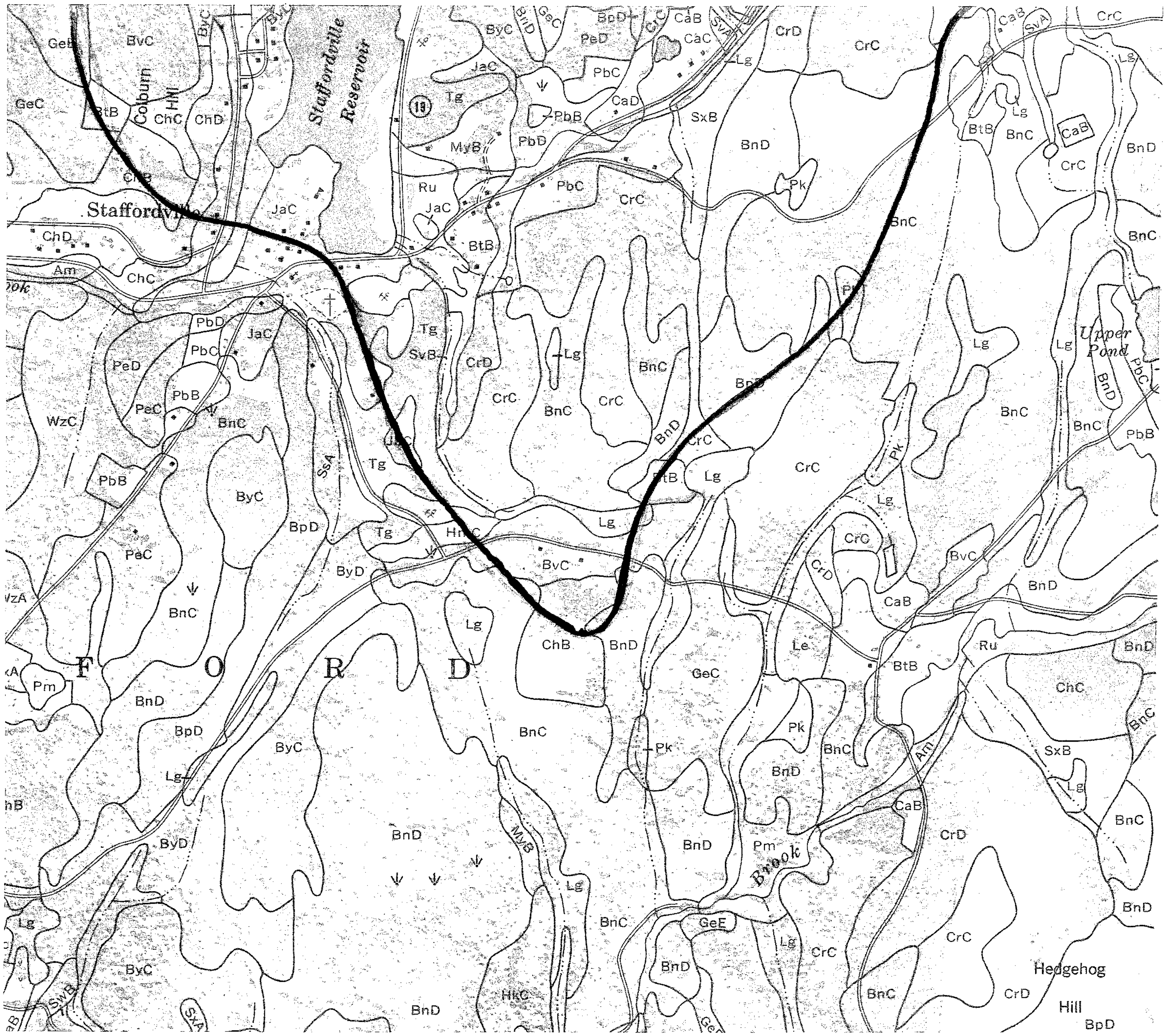


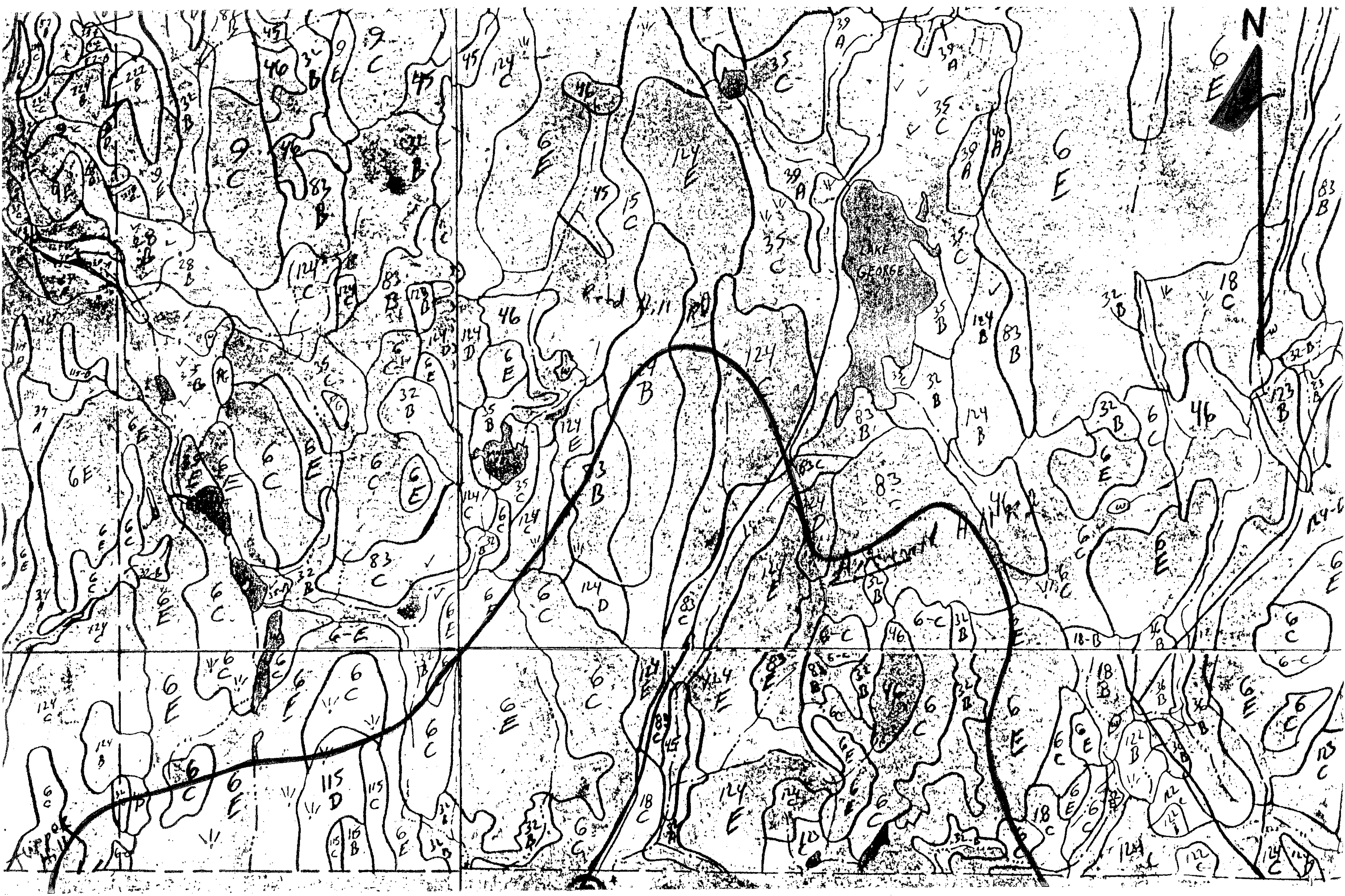
United States Department of Agriculture | Soil Conservation Service

TOLLAND COUNTY USDA-SCS
Agricultural Center
24 Hyde Avenue
Rockville, CT 06066
875-3881

Tolland County Soil Survey Sheet #10

Scale 1:15840 ▭▭▭▭▭ Watershed Boundary





HAMPDEN COUNTY, MASSACHUSETTS SOILS
SCALE 1:25000 — WATERSHED BOUNDARY

MAP SYMBOL	SOIL NAME
Am -	Fluvaquents - Udifluvents, frequently flooded - The soils in this mapping unit are nearly level to level and range in drainage from well to very poorly drained. They are on the lowest parts of the flood plains of streams and their tributaries. Textures range from sand to silt loam. Inclusions in this soil unit are the named soil components. The well drained and moderately well drained soils are on the high knobs along the streams and are usually sandy. The lower areas have the wetter soils which usually have finer textures. These soils have seasonal high water tables at varying depths. They are subject to frequent flooding, mainly from fall to spring. Frequent flooding and the seasonal high water tables are major limitations of soils in this unit for community development.
45, Aa -	Adrian and Palms mucks - This mapping unit consists of very poorly drained soils with an organic layer at least 16 inches thick, but not more than 51 inches thick over sandy and loamy mineral soil materials. These soils are on the landscape commonly in low depressions and along drainageways of outwash plains and glacial till uplands. Slopes are commonly less than one percent. Adrian and Palms soils have a high water table at or near the surface for most of the year. Permeability is moderately rapid in the organic layers and moderately slow to rapid in the underlying mineral materials. Included in these soils in mapping are small areas of soils with organic material less than 16 inches thick and small areas with organic materials greater than 51 inches thick. These soils are generally not suited to agricultural use or building site development without major reclamation.
18C, BnC, BvC, ByC -	Brookfield-Brimfield complex, 3 to 15 percent slopes, very rocky - This complex consists of gently sloping to sloping, somewhat excessively drained and well drained soils on ridges and glacial till plains. This unit is about 45 percent Brookfield soils, 25 percent Brimfield soils, 20 percent other soils, and 10 percent exposed bedrock. Stones and boulders cover 1 to 8 percent of the surface, which is marked by a few narrow, intermittent drainageways and small, wet depressions. Brookfield soils have a surface layer of dark brown fine sandy loam 1 inch thick. The subsoil is dark reddish brown, yellowish red, and strong brown fine sandy loam and gravelly fine sandy loam 28 inches thick. The substratum is yellowish brown gravelly fine sandy loam to a depth of 60 inches or more.

Brimfield soils have a surface layer of dark brown fine sandy loam 1 inch thick. The subsoil is reddish brown and yellowish red gravelly fine sandy loam 17 inches thick. Hard unweathered schist bedrock is at a depth of 18 inches.

Included with this unit in mapping are small areas of well drained Canton, Charlton, and Paxton soils; moderately well drained Sutton and Woodbridge soils; and poorly drained Leicester soils. Also included are many small areas where bedrock is 20 to 40 inches from the surface.

The water table in this unit is commonly below a depth of 6 feet. The permeability of both soils is moderate to moderately rapid. Runoff is medium to rapid.

The areas of exposed bedrock outcrops and the depth to bedrock in the Brimfield soils are the main limitations for community development, especially for onsite septic systems and building sites. The stones and boulders on the surface limit landscaping.

BnD, ByD - Brookfield-Brimfield complex, 15 to 45 percent slopes, very rocky - This complex consists of moderately steep to steep, somewhat excessively drained and well drained soils on ridges and glacial till uplands.

The soils of this unit are the same as those described for the Brookfield-Brimfield complex, 3 to 15 percent slopes, very rocky unit except for slope gradient.

Slope, exposed bedrock outcrops, and the depth to bedrock limit these soils for community development, especially for onsite septic systems and building sites. The stones and slopes limit landscaping.

6C, BpC - Brimfield-Brookfield-Rock outcrop complex, 3 to 15 percent slopes - This complex consists of gently sloping to sloping, somewhat excessively drained and well drained soils, and areas of exposed bedrock on ridges and glacial till plains. The unit is about 40 percent Brimfield soils, 25 percent Brookfield soils, 15 percent exposed bedrock, and 20 percent other soils. The Brimfield soils, Brookfield soils, and exposed bedrock are in such a complex pattern on the landscape that it was not practical to map them separately.

Brimfield soils typically have a surface layer of dark brown fine sandy loam about 1 inch thick. The subsoil is reddish brown and yellowish red gravelly fine sandy loam 17 inches thick. Hard unweathered schist bedrock is at a depth of 18 inches.

Brookfield soils typically have a surface layer of dark brown fine sandy loam about 1 inch thick. The subsoil is dark reddish brown, yellowish red, and strong brown fine sandy loam and gravelly fine sandy loam 28 inches thick. The substratum is yellowish brown gravelly fine sandy loam to a depth of 60 inches or more.

Included with this unit in mapping are areas of somewhat excessively drained Hollis soils; well drained Canton, Charlton and Paxton soils; moderately well drained Sutton and Woodbridge soils; and poorly drained Leicester and Ridgebury soils. Also included are many small areas where bedrock is 20 to 40 inches from the surface.

The water table in these soils is deep. The permeability of both soils is moderate to moderately rapid. Surface runoff is medium to rapid.

Surface stoniness and shallow depths to bedrock are the major limitations for community development on soils of this map unit.

6E, BpD - <u>Brimfield-Brookfield-Rock outcrop complex, 15 to 45 percent slopes</u> - This complex consists of moderately steep to steep, somewhat excessively drained and well drained soils and areas of exposed bedrock on hills and ridges of glacial till uplands. The soils of this map unit are the same as those described for the Brimfield-Brookfield-Rock outcrop complex, 3 to 15 percent slopes except for slope gradient.

Steep slopes, surface stoniness, and shallow depths to bedrock are the major limitations for community development.

CaB, BtB - <u>Canton and Charlton soils, 3 to 8 percent slopes</u> - This unit consists of gently sloping, deep well drained soils on ridges, hills, and side slopes of glacial till uplands. The areas are mostly rectangular or irregular in shape. Slopes are generally smooth and convex and 200 to 400 feet long. About 45 percent of this unit is Canton soils, 40 percent is Charlton soils, and 15 percent is other soils. Some areas of this unit consist almost entirely of Canton soils, some almost entirely of Charlton soils, and some of both. The soils were mapped together because they have no significant differences in use and management.

Typically, the Canton soils have a surface layer of very dark grayish brown fine sandy loam 2 inches thick. The subsoil is yellowish brown fine sandy loam, gravelly fine sandy loam, and gravelly loamy sand to a depth of 60 inches or more.

Typically, the Charlton soils have a surface layer of dark yellowish brown fine sandy loam 5 inches thick. The subsoil is yellowish brown fine sandy loam and sandy loam 20 inches thick. The substratum is light yellowish brown and light brownish gray sandy loam to a depth of 60 inches or more.

Included with these soils in mapping are small areas of somewhat excessively drained Gloucester and Hollis soils, well drained Paxton soils, and moderately well drained Sutton soils. Also included are a few large, nearly level areas and a few areas that have a compact substratum at a depth of 40 to 50 inches.

The water table in these Canton and Charlton soils is commonly at a depth of more than 6 feet. The permeability of the Canton soils is moderately rapid in the surface layer and subsoil and rapid in the substratum. The permeability of the Charlton soils is moderate or moderately rapid. Both soils have medium to rapid runoff, have moderate available water capacity.

Instability of some excavations in the Canton soils is the main limitation of these soils for community development.

CaC - <u>Canton and Charlton soils, 8 to 15 percent slopes</u> - This mapping unit consists of sloping, deep well drained soils on ridges, hills, and side slopes of glacial till uplands. Slopes are mainly smooth and convex and less than 200 feet long. The soils of this unit are the same as those described for the Canton and Charlton soils, 3 to 8 percent slopes except for slope gradient. Included with these soils in mapping are a few areas with slopes greater than 15 percent.

Slope is the main limitation of these soils for community development, especially for onsite septic systems. Excavations in these soils are unstable.

ChB - <u>Canton and Charlton soils, 3 to 8 percent slopes, very stony</u> - This mapping unit consists of gently sloping well drained deep soils on ridges, hills, and side slopes of glacial till uplands. Stones cover 1 to 8 percent of the surface. Except for surface stones, the soils of this unit are described the samel as the soils of the Canton and Charlton soils, 3 to 8 percent slopes. Instability of some excavations in the Canton soils is the main limitation of these soils for community development.

ChC - <u>Canton and Charlton soils, 8 to 15 percent slopes, very stony</u>. This mapping unit consists of sloping, well drained soils on ridges, hills, and side slopes of glacial till uplands. The areas are mostly rectangular or irregular in shape. Slopes are generally smooth and convex and less than 200 feet long. About 45 percent of this unit is Canton soils, 40 percent is Charlton soils, and 15 percent is other soils. In some areas, this unit will consist almost entirely of Canton soils or almost entirely of Charlton soils. The soils were mapped together because they have no significant differences in use and management. Stones cover 1 to 8 percent of the soil surface.

Typically, the Canton soils have a surface layer of very dark grayish brown fine sandy loam 2 inches thick. The subsoil is yellowish brown fine sandy loam, gravelly fine sandy loam, and gravelly sand loam 21 inches thick. The substratum is pale brown gravelly loamy sand to a depth of 60 inches or more.

Typically, the Charlton soils have a surface layer of dark yellowish brown fine sandy loam 5 inches thick. The subsoil is yellowish brown fine sandy loam and sandy loam 20 inches thick. The substratum is light yellowish brown and light brownish gray sandy loam to a depth of 60 inches or more.

Included with these soils in mapping are small areas of somewhat excessively drained Gloucester and Hollis soils; well drained Paxton soils; and moderately well drained Sutton soils. Also included are a few areas that have a compact substratum at a depth of 40 to 50 inches.

The water table in these soils is commonly at a depth of more than six feet. The permeability of the Canton soils is moderately rapid in the surface layer and subsoil and rapid in the substratum. The permeability of the Charlton soils is moderate or moderately rapid. Both soils have medium to rapid runoff, and have moderate available water capacity.

Instability of some excavations in the Canton soils is the main limitation for community development.

115B, 115C GeC - <u>Canton and Charlton soils, 3 to 15 percent slopes, extremely stony</u> - This mapping unit consists of gently sloping to sloping, well drained soils on ridges, hills, and side slopes of glacial till uplands. The areas are oval or irregular in shape. Slopes are mostly smooth and convex and are 100 to 600 feet long. Stones cover 8 to 25 percent of the surface. About 45 percent of this unit is Canton soils, 40 percent is Charlton soils, and 15 percent is other soils. Some areas of this unit consist almost entirely of Canton soils, some almost entirely of Charlton soils, and some of both. The soils were mapped together because they have no significant differences in use and management.

Typically, the Canton soils have a surface layer of very dark grayish brown fine sandy loam 2 inches thick. The subsoil is yellowish brown fine sandy loam, gravelly fine sandy loam, and gravelly sandy loam 21 inches thick. The substratum is pale brown gravelly loamy sand to a depth of 60 inches or more.

Typically, the Charlton soils have a surface layer of dark yellowish brown fine sandy loam 5 inches thick. The subsoil is yellowish brown fine sandy loam and sandy loam 20 inches thick. The substratum is light yellowish brown and light brownish gray sandy loam to a depth of 60 inches or more.

Included with these soils in mapping are small areas of somewhat excessively drained Gloucester and Hollis soils, well drained Paxton soils, and moderately well drained Sutton soils. Also included are a few nearly level areas and a few areas that have a compact substratum at a depth of 40 to 50 inches.

The water table in these Canton and Charlton soils is commonly at a depth of more than 6 feet. The permeability of the Canton soils is moderately rapid in the surface layer and subsoil and rapid in the substratum. The permeability of the Charlton soils is moderate or moderately rapid. Both soils have moderate available water capacity and medium to rapid runoff.

Slope is the main limitation of these soils for community development, especially for onsite septic systems. Slopes of excavations in these soils are unstable. The stones on the surface hinder landscaping.

115D, ChD, GeD, GeE - Canton and Charlton soils, 15 to 35 percent slopes, extremely stony - This mapping unit consists of moderately steep to steep, well drained soils on ridges, hills, and side slopes of glacial till uplands. The areas are mostly long and narrow. Slopes are smooth and convex and are mainly less than 200 feet long. Stones cover 8 to 25 percent of the surface. About 45 percent of this unit is Canton soils, 40 percent is Charlton soils, and 15 percent is other soils. Some areas consist almost entirely of Canton soils, some almost entirely of Charlton soils, and some of both. The soils were mapped together because they have no significant differences in use and management.

Typically, the Canton soils have a surface layer of very dark grayish brown fine sandy loam 2 inches thick. The subsoil is yellowish brown fine sandy loam, gravelly fine sandy loam, and gravelly sandy loam 21 inches thick. The substratum is pale brown gravelly loamy sand to a depth of 60 inches or more.

Typically, the Charlton soils have a surface layer of dark yellowish brown fine sandy loam 5 inches thick. The subsoil is yellowish brown fine sandy loam 20 inches thick. The substratum is light yellowish brown and light brownish gray sandy loam to a depth of 60 inches.

Included with these soils in mapping are small areas of somewhat excessively drained Gloucester and Hollis soils and well drained Paxton soils. Also included are a few large areas where stones cover less than 8 percent of the surface and areas with a compact substratum at a depth of 40 to 50 inches.

The water table in these Canton and Charlton soils is commonly at a depth of more than 6 feet. The permeability of the Canton soils is moderately rapid in the surface layer and subsoil and rapid in the substratum. The permeability of the Charlton soils is moderate or moderately rapid. Both soils have moderate available water capacity and rapid runoff.

Slope limits the soils of this unit for community development, especially for onsite septic systems. Slopes of excavations in the soils are unstable and the stones on the surface hinder landscaping.

Tg, JaC, HmC, HkC - Hinckley gravelly sandy loam, 3 to 15 percent slopes. This is a gently sloping to sloping, excessively drained soil on terraces of stream valleys and on glacial outwash plains. The areas of this soil are oval or irregular in shape. Slopes are convex or undulating and are mostly less than 200 feet long.

Typically, the surface layer is very dark grayish brown gravelly sandy loam 2 inches thick. The subsoil is dark yellowish brown, yellowish brown, and brownish yellow gravelly sandy loam and gravelly loamy sand 16 inches thick. The substratum is pale yellow gravelly sand to a depth of 60 inches or more.

Included with this soil in mapping are small areas of excessively drained Windsor soils: somewhat excessively drained Merrimac soils: well drained Agawam soils: and moderately well drained Sudbury soils.

The water table in this Hinckley soil is commonly below a depth of 6 feet. The available water capacity is low. Runoff is rapid. This soil has rapid permeability in the surface layer and subsoil and very rapid permeability in the substratum.

This soil is generally suited to community development, but the rapid permeability imposes a hazard of groundwater pollution in areas used for septic tanks. The slopes in some excavated areas are unstable.

CrC - Charlton-Hollis complex, 3 to 15 percent slopes, very rocky - This complex consists of gently sloping to sloping, somewhat excessively drained and well drained soils on hills and ridges of glacial till uplands. The areas of this unit are mostly irregular in shape. Slopes are mostly complex and are 100 to 200 feet long. Stones cover 1 to 8 percent of the surface.

This unit is about 55 percent Charlton soils, 20 percent Hollis soils, 15 percent other soils, and 10 percent exposed bedrock. The Charlton and Hollis soils are in such a complex pattern that it was not practical to map them separately.

Typically, the Charlton soils have a thick, fine sandy loam topsoil and subsoil over a sandy loam substratum. The soils are commonly deeper than 60 inches.

The Hollis soils have fine sandy loam topsoil and subsoil from 10 to 20 inches thick over hard, unweathered schist bedrock.

Included with these soils in mapping are small areas of well drained Canton and Paxton soils; moderately well drained Sutton and Woodbridge soils; and poorly drained Leicester soils. Also included are small areas with bedrock at a depth of 20 to 40 inches.

The water table of these soils is commonly at a depth of more than 6 feet. The available water capacity is moderate in the Charlton soils and very low or low in the Hollis soils. Both soils have moderate or moderately rapid permeability and medium to rapid runoff.

The areas of exposed rock and the depth to bedrock in the Hollis soils limit the use of these areas for community development, especially as a building site or as a site for onsite septic systems. The stones on the surface restrict landscaping.

HrE, CrD - <u>Charlton-Hollis complex, 15 to 45 percent slopes, very rocky</u> - This complex consists of moderately steep to steep, somewhat excessively drained and well drained soils on hills and ridges of glacial till uplands. Areas of this unit are mostly long and narrow or oval in shape. Slopes are mainly convex and are 100 to 500 feet long. Stones and boulders cover 1 to 8 percent of the surface. This unit is about 55 percent Charlton soils, 20 percent Hollis soils, 15 percent other soils, and 10 percent exposed bedrock. The Charlton and Hollis soils are in such a complex pattern that it was not practical to map them separately.

Typically, the Charlton soils have a surface layer of dark yellowish brown fine sandy loam 5 inches thick. The subsoil is yellowish brown fine sandy loam and sandy loam 20 inches thick. The substratum is light yellowish brown and light brownish gray sandy loam to a depth of 60 inches or more.

Typically, the Hollis soils have a surface layer of dark grayish brown fine sandy loam 2 inches thick. The subsoil is yellowish brown gravelly fine sandy loam 12 inches thick. Hard, unweathered schist bedrock is at a depth of 14 inches.

Included with these soils in mapping are small areas of well drained Canton and Paxton soils; and moderately well drained Sutton and Woodbridge soils. Also included are areas with bedrock at a depth of 20 to 40 inches and a few small areas with slopes of more than 35 percent.

The water table of these soils is commonly at a depth of more than 6 feet. The available water capacity is moderate in the Charlton soils and very low or low in the Hollis soils. Both soils have moderate to moderately rapid permeability and rapid runoff.

The slope, exposed rock, and the depth to bedrock in the Hollis soils limit these areas for community development, especially as a site for onsite septic systems and buildings.

Le, 32A, 32B - Ridgebury, Leicester, and Whitman soils, extremely stony - This mapping unit consists of nearly level, poorly drained, and very poorly drained soils in depressions and drainageways of glacial till uplands. The areas are mostly long and narrow or irregular in shape. Slopes range from 0 to 3 percent and are mainly 100 to 300 feet long. Stones cover 8 to 25 percent of the surface. About 40 percent of this unit is Ridgebury soils, 25 percent is Leicester soils, 15 percent is Whitman soils, and 10 percent is other soils. Some areas of this unit will consist of one of these soils, and other areas will consist of two or three. The soils of this unit were mapped together because they have no significant differences in use and management.

The Ridgebury soils have a seasonal high water table at a depth of about 10 inches from fall through spring. The permeability of the soils is moderate to moderately rapid in the surface layer and the subsoil and slow to very slow in the substratum. Runoff is slow. The Ridgebury soils have a moderate available water capacity.

The Leicester soils have a seasonal high water table at a depth of about 10 inches from fall through spring. The permeability of the soils is moderate or moderately rapid throughout. Runoff is slow. The Leicester soils have a moderate available water capacity.

The Whitman soils have a seasonal high water table at or near the surface from fall through spring. The permeability of the soils is moderate or moderately rapid in the surface layer and subsoil and slow to very slow in the substratum. Runoff is slow. The Whitman soils have a moderate available water capacity.

The high water table and slow to very slow permeability are major limitations of the soils of these areas for community development. Steep slopes of excavations in these soils slump when saturated. The stones on the surface restrict landscaping, and lawns are soggy most of the year.

MyB - Merrimac sandy loam 3 to 8 percent slopes. This soil is gently sloping and somewhat excessively drained. It is on terraces and outwash plains of stream valleys. The areas are mostly irregular in shape. Slopes are smooth and convex and less than 200 feet long.

Typically, the surface layer is dark brown sandy loam 8 inches thick. The subsoil is yellowish brown sandy loam and loamy sand 16 inches thick. The substratum is yellowish brown gravelly sand and stratified sand and gravel to a depth of 60 inches or more.

Included with this soil in mapping are small areas of excessively drained Hinckley and Windsor soils; well drained

Agawam soils, and moderately well drained Sudbury soils. Included areas make up about 15 percent of the unit.

The water table of this Merrimac soil is commonly below a depth of 6 feet. The available water capacity is moderate. The soil has moderately rapid permeability in the surface layer and upper part of the subsoil, moderately rapid or rapid permeability in the lower part of the subsoil, and rapid permeability in the substratum. Runoff is slow to medium.

This soil generally is suited to community development, but the rapid permeability of the substratum causes a hazard of pollution to the ground water in areas used for septic tanks. Some slopes of excavations in this soil are unstable.

PbA, PbB - <u>Paxton and Montauk Soils, 3 to 8 percent slopes</u> - These gently sloping, well drained soils are on drumloidal, glacial till, upland landforms.

This mapping unit is about 45 percent Paxton soil, 40 percent Montauk soil, and 15 percent other soils. Areas consist of Paxton soil or Montauk soil, or both. These soils were mapped together because there are no major differences in their use and management.

Typically, the Paxton soil has a very dark grayish brown, fine sandy loam surface layer 8 inches thick. The subsoil is dark yellowish brown, yellowish brown, and light olive brown fine sandy loam 19 inches thick. The substratum is firm, very firm, and brittle, olive brown fine sandy loam to a depth of 60 inches or more.

Typically, the Montauk soil has a very dark grayish brown, fine sandy loam surface layer 7 inches thick. The subsoil is dark yellowish brown fine sandy loam and yellowish brown sandy loam 16 inches thick. The substratum is brown loamy sand and firm, very firm, and brittle, grayish brown loamy sand to a depth of 60 inches or more.

Included with these soils in mapping are small areas of well drained Broadbrook, Canton, and Charlton soils; moderately well drained Woodbridge soils; and poorly drained Ridgebury soils.

Permeability of the Paxton soil is moderate in the surface layer and subsoil and slow or very slow in the substratum. The available water capacity is moderate. Runoff is medium. The Paxton soil warms up and dries out rapidly in the spring.

Permeability of the Montauk soil is moderate or moderately rapid in the surface layer and subsoil and slow or moderately slow in the substratum. The available water capacity is moderate. Runoff is medium. The Montauk soil warms up and dries out rapidly in the spring.

The major limiting factor for community development is the very slow, slow, or moderately slow permeability in the substratum. Onsite septic systems need special design and installation to prevent effluent from seeping to the surface. Steep slopes of excavations slump when wet. Quickly establishing a plant cover and using mulch, temporary diversions, and sediment basins help to reduce erosion during construction.

PbC - Paxton and Montauk soils, 8 to 15 percent slopes. These sloping, well drained soils are on drumloidal, glacial till, upland landforms.

This mapping unit is about 45 percent Paxton soil, 40 percent Montauk soil, and 15 percent other soils. Mapped areas consist of Paxton soil or Montauk soil, or both. These soils were mapped together because there are no major differences in use and management.

Typically, the Paxton soil has a very dark grayish brown, fine sandy loam surface layer 8 inches thick. The subsoil is dark yellowish brown, yellowish brown, and light olive fine sandy loam to a depth of 60 inches or more.

Typically, the Montauk soil has a very dark grayish brown, fine sandy loam surface layer 7 inches thick. The subsoil is dark yellowish brown fine sandy loam and yellowish brown sandy loam 16 inches thick. The substratum is brown loamy sand and firm, very firm, and brittle, grayish brown loamy sand to a depth of 60 inches or more.

Included with these soils in mapping are small areas of well drained Broadbrook, Canton, and Charlton soils; moderately well drained Woodbridge soils; and poorly drained Ridgebury soils.

Permeability of the Paxton soil is moderate in the surface layer and subsoil and slow or very slow in the substratum. The available water capacity is moderate. Runoff is rapid. Paxton soil warms up and dries out rapidly in the spring.

Permeability of the Montauk soil is moderate or moderately rapid in the surface layer and subsoil and slow or moderately slow in the substratum. The available water capacity is moderate. Runoff is rapid. Montauk soil warms up and dries out rapidly in the spring.

The major limiting factor for community development is the very slow, slow, and moderately slow permeability in the substratum. Onsite septic systems need careful design and installation to prevent effluent from seeping to the surface in areas downslope from the leaching system. Quickly establishing a plant cover and using mulch and netting, temporary diversions, and sediment basins help to control erosion during construction.

PdB - <u>Paxton and Montauk soils, 3 to 8 percent slopes, very stony</u> - These gently sloping, well drained soils are on drumloidal, glacial till, upland landforms. Stones and boulders cover 1 to 8 percent of the surface.

This mapping unit is about 45 percent Paxton soil, 40 percent Montauk soil, and 15 percent other soils. Mapped areas consist of Paxton soil or Montauk soil, or both. These soils were mapped together because there are no major differences in use and management.

Typically, the Paxton soil has a very dark grayish brown, fine sandy loam surface layer 3 inches thick. The subsoil is dark yellowish brown, yellowish brown, and light olive brown fine sandy loam 24 inches thick. The substratum is firm, very firm, and brittle, olive brown fine sandy loam to a depth of 60 inches or more.

Typically, the Montauk soil has a very dark grayish brown, fine sandy loam surface layer 3 inches thick. The subsoil is dark yellowish brown fine sandy loam and yellowish brown sandy loam 20 inches thick. The substratum is brown loamy sand and firm, very firm, and brittle, grayish brown loamy sand to a depth of 60 inches or more.

Included with these soils in mapping are small areas of well drained Broadbrook, Canton, and Charlton soils; moderately well drained Woodbridge soils; and poorly drained Ridgebury soils.

Permeability of the Paxton soil is moderate in the surface layer and subsoil and slow or very slow in the substratum. The available water capacity is moderate. Runoff is medium. Paxton soil warms up and dries out rapidly in the spring.

Permeability of the Montauk soil is moderate or moderately rapid in the surface layer and subsoil and slow or moderately slow in the substratum. The available water capacity is moderate. Runoff is medium. Montauk soil warms up and dries out rapidly in the spring.

The major limiting factor for community development is very slow, slow, and moderately slow permeability in the substratum. Onsite septic systems need careful design and installation to prevent effluent from seeping to the surface in areas downslope from the leaching system. Stones and boulders need to be removed for landscaping. Quickly establishing a plant cover and using mulch, temporary diversions, and sediment basins help to control erosion during construction.

PdC - <u>Paxton and Montauk soils, 8 to 15 percent slopes, very stony</u> - These sloping, well drained soils are on drumloidal, glacial till, upland landforms. Stones and boulders cover 1 to 8 percent of the surface.

This mapping unit is about 45 percent Paxton soil, 40 percent Montauk soil, and 15 percent other soils. Mapped areas consist of Paxton soil or Montauk soil, or both. These soils were mapped together because there are no major differences in use and management.

Typically, the Paxton soil has a very dark grayish brown, fine sandy loam surface layer 3 inches thick. The subsoil is dark yellowish brown, yellowish brown, and light olive brown fine sandy loam 24 inches thick. The substratum is firm, very firm, and brittle, olive brown fine sandy loam to a depth of 60 inches or more.

Typically, the Montauk soil has a very dark grayish brown, fine sandy loam surface layer 3 inches thick. The subsoil is dark yellowish brown fine sandy loam and yellowish brown sandy loam 20 inches thick. The substratum is brown loamy sand and firm, very firm, and brittle, grayish brown loamy sand to a depth of 60 inches or more.

Included with these soils in mapping are small areas of well drained Broadbrook, Canton, and Charlton soils; moderately well drained Woodbridge soils; and poorly drained Ridgebury soils.

Permeability of the Paxton soil is moderate in the surface layer and subsoil and slow or very slow in the substratum. The available water capacity is moderate. Runoff is rapid. Paxton soils warm up and dries out rapidly in the spring.

Permeability of the Montauk soil is moderate or moderately rapid in the surface layer and subsoil and slow or moderately slow in the substratum. The available water capacity is moderate. Runoff is rapid. Montauk soil warms up and dries out rapidly in the spring.

The major limiting factors for community development are very slow, slow, and moderately slow permeability in the substratum. Onsite septic systems need special design and installation to prevent effluent from seeping to the surface in areas downslope from the leaching system. Stones and boulders need to be removed for landscaping. Quickly establishing a plant cover and using mulch and netting, temporary diversions, and sediment basins help to control erosion during construction.

PeC, 124B
124C - <u>Paxton and Montauk soils, 3 to 15 percent slopes, extremely stony</u> - These gently sloping to sloping, well drained soils are on drumloidal, glacial till, upland landforms. Stones and boulders cover 8 to 25 percent of the surface.

This mapping unit is about 45 percent Paxton soil, 40 percent Montauk soil, and 15 percent other soils. Mapped areas are composed of Paxton soil or Montauk soil, or both. These soils were mapped together because there are no major differences in use and management.

Typically, the Paxton soil has a very dark grayish brown, fine sandy loam surface layer 3 inches thick. The subsoil is dark yellowish brown, yellowish brown, and light olive brown fine sandy loam, 24 inches thick. The substratum is firm, very firm, and brittle, olive brown fine sandy loam to a depth of 60 inches or more.

Typically, the Montauk soil has a very dark grayish brown, fine sandy loam surface layer 3 inches thick. The subsoil is dark yellowish brown fine sandy loam and yellowish brown sandy loam 20 inches thick. The substratum is brown loamy sand and firm, very firm, and brittle, grayish brown loamy sand to a depth of 60 inches or more.

Included with these soils in mapping are small areas of well drained Broadbrook, Canton, and Charlton soils; moderately well drained Woodbridge soils; and poorly drained Ridgebury soils.

Permeability of the Paxton soil is moderate in the surface layer and subsoil and slow or very slow in the substratum. The available water capacity is moderate. Runoff is medium or rapid. Paxton soil warms up and dries out rapidly in the spring.

Permeability of the Montauk soil is moderate or moderately rapid in the surface layer and subsoil and slow or moderately slow in the substratum. The available water capacity is moderate. Runoff is medium to rapid. Montauk soil warms up and dries out rapidly in the spring.

The major limiting factor for community development is the very slow, slow, and moderately slow permeability in the substratum. Onsite septic systems need careful design and installation to prevent effluent from seeping to the surface in areas downslope from the leaching system. Stones and boulders need to be removed for landscaping. Quickly establishing a plant cover and using mulch and netting, temporary diversions and sediment basins help to control erosion during construction.

PeD, 124E - Paxton and Montauk soils, 15 to 35 percent slopes, extremely stony - These moderately steep to steep, well drained soils are on drumloidal, glacial till, upland landforms. Stones and boulders cover 8 to 25 percent of the surface.

This mapping unit is about 45 percent Paxton soil, 40 percent Montauk soil, and 15 percent other soils. Mapped areas consist of Paxton soil or Montauk soil, or both. These soils were mapped together because there are no major differences in use and management.

Typically, the Paxton soil has a very dark grayish brown, fine sandy loam surface layer 3 inches thick. The subsoil is dark yellowish brown, yellowish brown, and light olive brown fine sandy loam 24 inches thick. The substratum is firm, very firm, and brittle, olive brown fine sandy loam to a depth of 60 inches or more.

Typically, the Montauk soil has a very dark grayish brown, fine sandy loam surface layer 3 inches thick. The subsoil is dark yellowish brown fine sandy loam and yellowish brown sandy loam 20 inches thick. The substratum is brown loamy sand and firm, very firm, and brittle, grayish brown loamy sand to a depth of 60 inches or more.

Included with these soils in mapping are small areas of well drained Broadbrook, Canton, and Charlton soils and moderately well drained Woodbridge soils.

Permeability of the Paxton soil is moderate in the surface layer and subsoil and slow or very slow in the substratum. The available water capacity is moderate. Runoff is very rapid. Paxton soil warms up and dries out rapidly in the spring.

Permeability of the Montauk soil is moderate or moderately rapid in the surface layer and subsoil and slow or moderately slow in the substratum. The available water capacity is moderate. Runoff is very rapid. Montauk soil warms up and dries out rapidly in the spring.

The major limiting factors for community development are very slow, slow, and moderately slow permeability in the substratum and steep slopes. Onsite septic systems need special design and installation to prevent effluent from seeping to the surface in areas downslope from the leaching system. Stones and boulders need to be removed for landscaping. Quickly establishing a plant cover and using mulch and netting, temporary diversions, and sediment basins help to control erosion during construction.

Pk, 46 - <u>Carlisle muck</u> - This soil is nearly level to level and very poorly drained. It is in low depressions on outwash terraces and glacial till plains. Areas of this soil are mostly oval in shape. Slopes range from 0 to 2 percent but are mostly less than 1 percent.

Typically, this soil is black, very dark brown, and dark reddish brown muck to a depth of 60 inches or more.

Included with this soil in mapping are small areas of very poorly drained Adrian, Palms, Saco, Scarboro, and Whitman soils. A few small areas have a thin mineral layer on the surface. Included areas make up about 25 percent of the unit.

The water table of this Carlisle soil is at or near the surface during most of the year. The available water capacity is high. Permeability is moderately rapid. Runoff is very slow, and water is on the surface of some areas from autumn to spring and after heavy rains.

Most areas of this soil are wooded or are covered by marshgrasses and sedges. Most areas do not have adequate drainage outlets. Although this soil supports red maple, ash, and alder, it is poorly suited to woodland production. The organic material will not support heavy equipment, and uprooting is common during windy periods.

The high water table and the low strength of the organic material make this soil generally unsuitable for community development.

Rk - <u>Rock outcrop-Hollis complex, 3 to 45 percent slopes</u> - This gently sloping to very steep complex consists of rock outcrop and the somewhat excessively drained Hollis soil on glacial till uplands. Stones and boulders cover 1 to 8 percent of the surface. Areas are mostly irregular in shape. Slopes range from 3 to 45 percent.

Rock outcrop and Hollis soil are so intermingled on the landscape that it was not practical to separate them in mapping at the scale used. This complex is about 50 percent rock outcrop, 30 percent Hollis soil, and 20 percent other soils.

Rock outcrop is hard, unweathered, exposed bedrock. It is mainly gneiss and schist.

Typically, the Hollis soil has a very dark brown, fine sandy loam surface layer 2 inches thick. The subsoil is dark brown and dark yellowish brown fine sandy loam 15 inches thick. Hard, unweathered bedrock is at a depth of 17 inches.

Included in this complex are small areas of well drained Canton, and Charlton soils; and moderately well drained Sutton soils. Also included are many small areas that have bedrock at a depth of 20 to 40 inches.

Permeability of the Hollis soil is moderate or moderately rapid above the bedrock. The available water capacity is low. Runoff is medium through very rapid. Hollis soil warms up and dries out rapidly in the spring.

The major limiting factors for community development are the shallow depth to bedrock and rock outcrop. Suitable sites for onsite septic systems commonly require large lots and specially designed systems.

Excavations require blasting. Stoniness and rock outcrop severely limit landscaping. Quickly establishing a plant cover and using mulch and netting, temporary diversions, and sediment basins help to control erosion during construction.

Ru - <u>Rippowam fine sandy loam</u> - This nearly level, poorly drained soil is on flood plains of major streams, rivers, and their tributaries. Areas are dominantly long and narrow or irregular in shape.

Typically, this Rippowam soil has a black, fine sandy loam surface layer 8 inches thick. The subsoil is dark grayish brown and dark gray, mottled fine sandy loam 27 inches thick. The substratum is dark grayish brown gravelly coarse sand to a depth of 60 inches or more.

Included with this soil in mapping are small areas of moderately well drained Pootatuck soils and poorly drained Limerick soils. Included areas make up about 20 percent of this map unit.

The Rippowam soil has a seasonal high water table at a depth of about 6 inches. It is subject to frequent flooding. Permeability is moderate or moderately rapid in the surface layer and subsoil and rapid or very rapid in the substratum. The available water capacity is moderate. Runoff is slow. Rippowam soil warms up and dries out slowly in the spring.

This soil is poorly suited to community development because of flooding and the seasonal high water table. Areas used for onsite septic systems require extensive filling, and systems require special design and installation. Areas also need to be protected from flooding. Sediment deposited by flooding will damage lawns. Lawns are wet and soggy in the fall and spring.

SvB - <u>Sutton fine sandy loam, 3 to 8 percent slopes</u> - This gently sloping, moderately well drained soil is on upland glacial till plains, hills, and ridges. Areas are dominantly irregular in shape.

Typically, this Sutton soil has a very dark grayish brown, fine sandy loam surface layer 9 inches thick. The subsoil is yellowish brown, dark yellowish brown, and dark brown, mottled fine sandy loam and sandy loam 24 inches thick. The substratum is olive brown, mottled sandy loam to a depth of 60 inches or more.

Included with this soil in mapping are small areas of well drained Canton and Charlton soils; moderately well drained Woodbridge soils; and poorly drained Leicester soils. Included areas make up about 10 percent of this map unit.

The Sutton soil has a seasonal high water table at a depth of about 18 inches. Permeability is moderate or moderately rapid. The available water capacity is moderate. Runoff is medium. Sutton soil warms up and dries out slowly in the spring.

The major limiting factor for community development is the seasonal high water table. Onsite septic systems need special design and installation to prevent effluent from seeping to the surface. Foundation drains help to prevent wet basements.

Lawns are wet and soggy in the fall and spring. Quickly establishing a plant cover and using mulch, temporary diversions and sediment basins help to control erosion during construction.

SwB - Sutton fine sandy loam, 2 to 8 percent slopes, very stony - This nearly level to gently sloping moderately well drained soil is on upland glacial till plains, hills, and ridges. Stones and boulders cover 1 to 8 percent of the surface. Areas are dominantly irregular in shape.

Typically, this Sutton soil has a very dark grayish brown, fine sandy loam surface layer 4 inches thick. The subsoil is yellowish brown, dark yellowish brown, and dark brown, mottled fine sandy loam and sandy loam 29 inches thick. The substratum is olive brown, mottled sandy loam to a depth of 60 inches or more.

Included with this soil in mapping are small areas of well drained Canton and Charlton soils; moderately well drained Woodbridge soils; and poorly drained Leicester soils. Included areas make up about 10 percent of this map unit.

The Sutton soil has a seasonal high water table at a depth of about 18 inches. Permeability is moderate or moderately rapid. The available water capacity is moderate. Runoff is slow or medium. Sutton soil warms up and dries out slowly in the spring.

The major limiting factor for community development is the seasonal high water table. Onsite septic systems need special design and installation to prevent effluent from seeping to the surface. Foundation drains help to prevent wet basements. Lawns are wet and soggy in the fall and spring. Quickly establishing a plant cover and using mulch, temporary diversions, and sediment basins to help control erosion during construction.

SxA, SxB - Sutton fine sandy loam, 2 to 15 percent slopes, extremely stony - This nearly level to gently sloping, moderately well drained soil is on upland glacial till plains, hills, and ridges. Stones and boulders cover 8 to 25 percent of the surface. Areas are dominantly irregular in shape.

Typically, this Sutton soil has a very dark grayish brown, fine sandy loam surface layer 4 inches thick. The subsoil is yellowish brown, dark yellowish brown, and dark brown, mottled fine sandy loam and sandy loam 29 inches thick. The substratum is olive brown, mottled sandy loam to a depth of 60 inches or more.

Included with this soil in mapping are small areas of well drained Canton and Charlton soils; moderately well drained

Woodbridge soils; and poorly drained Leicester soils. Included areas make up about 10 percent of this map unit.

The Sutton soil has a seasonal high water table at a depth of about 18 inches. Permeability is moderate or moderately rapid. The available water capacity is moderate. Runoff is slow or medium. Sutton soil warms up and dries out slowly in the spring.

The major limiting factor for community development is the seasonal high water table. Onsite septic systems need special design and installation to prevent effluent from seeping to the surface. Foundation drains help to prevent wet basements. Stones and boulders need to be removed for landscaping. Quickly establishing a plant cover and using mulch, temporary diversions, and sediment basins help to control erosion during construction.

83B, 83C - <u>Woodbridge fine sandy loam, 3 to 15 percent slopes, extremely stony</u> - This gently sloping and sloping moderately well drained soil is on drumloidal, glacial till, upland landforms. Stones and boulders cover 8 to 25 percent of the surface. Areas are dominantly irregular in shape.

Typically, the Woodbridge soil has a very dark brown, fine sandy loam surface layer 3 inches thick. The subsoil is yellowish brown, light olive brown, and grayish brown, mottled fine sandy loam and sandy loam 26 inches thick. The substratum is very firm, brittle, olive sandy loam to a depth of 60 inches or more.

Included in this unit are small areas of well drained Paxton, Montauk, and Broadbrook soils; moderately well drained Sutton soils; and poorly drained Leicester and Ridgebury soils. Also included are many small areas of soils that have a loamy sand substratum.

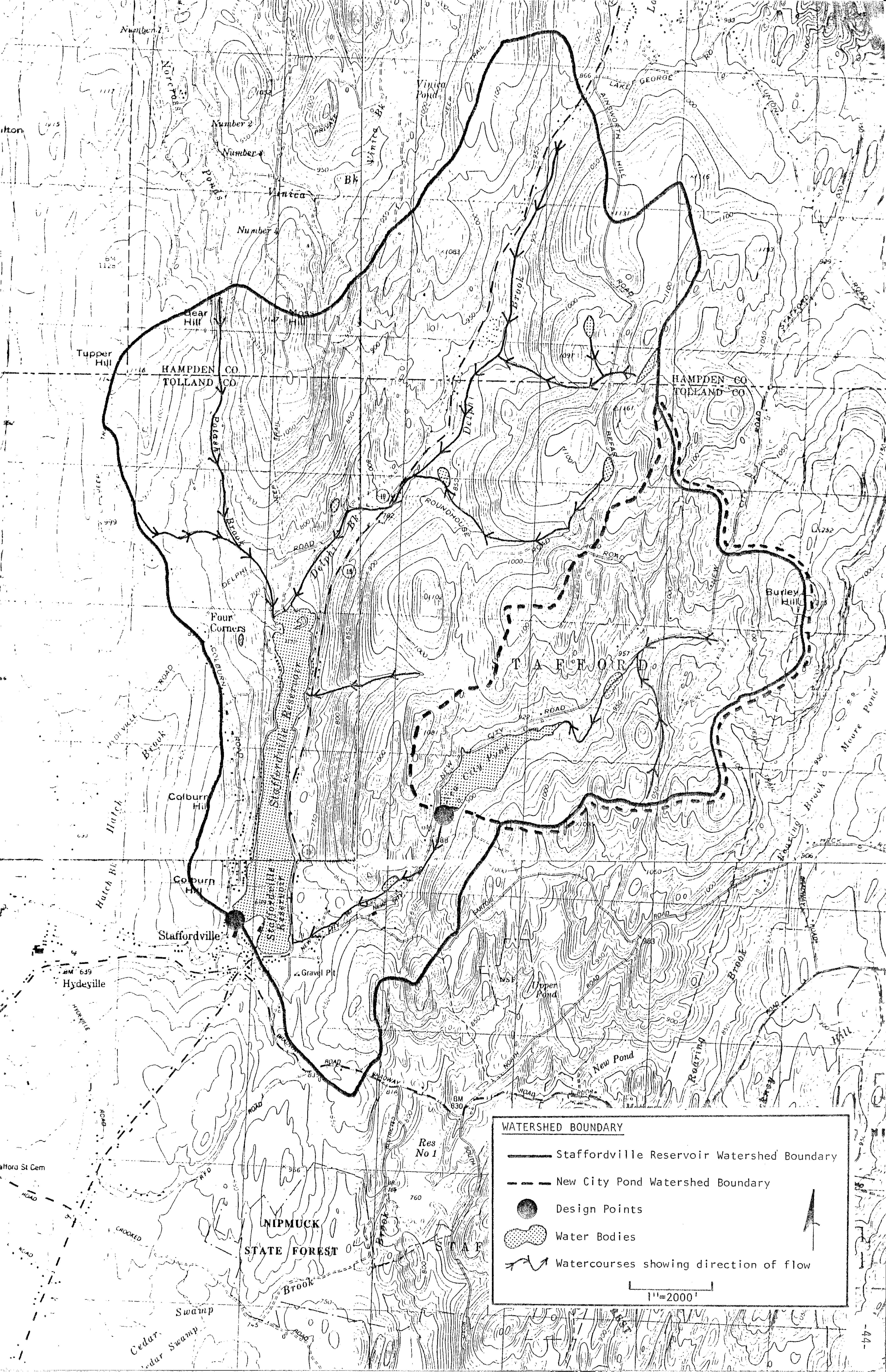
The Woodbridge soil has a seasonal high water table at a depth of about 18 inches. Permeability is moderate in the surface layer and subsoil and slow or very slow in the substratum. The available water capacity is moderate. Runoff is medium or rapid. Woodbridge soils warm up and dry out slowly in the spring.

The major limiting factors for community development are the seasonal high water table and the slow or very slow permeability in the substratum. Onsite septic systems need special design and installation to prevent effluent from seeping to the surface in areas downslope from the leaching system. Slopes of excavated areas slump when wet. Foundation drains help to prevent wet basements. Stones need to be removed for landscaping. Quickly establishing a plant cover and using mulch and netting, temporary diversions, and sediment basins help to control erosion during construction.

83E - <u>Woodbridge fine sandy loam, 15 to 25 percent slopes, extremely stony</u> - This soil is moderately steep and moderately well drained. It is on the side slopes of drumlins and hills of glacial till uplands. Stones and boulders cover 8 to 25 percent of the surface. Areas of this soil are mostly oval or long and narrow in shape.

This soil is described the same as Woodbridge fine sandy, 3 to 15 percent slopes, extremely stony except for slope gradient.

Steep slopes, seasonal high water tables, and slow permeability in the substratum are the major limiting factors for community development. Onsite septic systems need special design and installation to prevent effluent from seeping to the surface in areas downslope from the leaching system. Slopes of excavated areas slump when wet.


WATERSHED BOUNDARY
Staffordville Reservoir Watershed Boundary
New City Pond Watershed Boundary
Design Points
Water Bodies
Watercourses showing direction of flow
1"=2000'
Staffordville Reservoir
New City Pond
STAFFORD
Staffordville
Hydeville
Four Corners
Colburn Hill
Burley Hill
Bear Hill
Tupper Hill
Moss Hill
HAMPDEN CO
TOLLAND CO
Delphi Bk
Potash Brook
Vinica Bk
Vinica Pond
Roaring Brook
Hatch Bk
Upper Pond
New Pond
Res No 1
NIPMUCK
STATE FOREST
Cedar Swamp
Gravel Pit
ROUNDHOUSE ROAD
COLBURN ROAD
AINSWORTH HILL
LAKE GEORGE

6. HYDROLOGY

By definition, the watershed of Staffordville Reservoir comprises all land areas from which ground or surface water may ultimately enter the reservoir. A raindrop falling on the watershed boundary would have a 50 percent chance of passing into or out of the watershed. As shown on the topographic map, the watershed boundary tends to follow the crests of local hills and ridges. It is to be expected that the true physical boundary may deviate to some extent from the boundary as mapped. The contours shown on the map are not completely accurate and small topographic details do not appear because of the 10 foot contour interval. Nevertheless, the boundary as mapped should be substantially correct and may be used as a reliable indicator of the general area of concern. It should be recognized, however, that any variations of true boundary from mapped boundary would be particularly important where the boundary is closest to the reservoir. Any planning for these areas should allow for a reasonable buffer strip outside the mapped boundary to provide a safety margin.

Staffordville Reservoir is actually the downstream end of a drainage area that includes, at least, one other sizable water body (New City Pond) and a few smaller surface water bodies. As mentioned earlier, New City Pond has a surface area of approximately 36 acres and a total drainage area of about 1,190 acres or 1.86 square miles. According to a publication entitled Fishery Survey of the Lakes and Ponds of Connecticut (Connecticut Board of Fisheries and Games, 1959) the average depth of the pond is about 6 feet. Based on this, the maximum volume of New City Pond can be estimated to be about 69 million gallons. The surface area of Staffordville Reservoir is about 165 acres and the watershed area is about 5,258 acres (8.2 square miles). According to the Fishery Survey, the average depth of the Reservoir is 9-½ feet. Based on this information, the maximum volume of Staffordville Reservoir is estimated to be about 511 million gallons.

The reservoir was created by artificially impounding Furnace Brook, the outlet stream for the reservoir with a stone and masonry dam. According to Town officials, a few industries in Stafford Springs have surface water rights on the Reservoir. Furnace Brook ultimately flows into the Willimantic River. The reservoir is fed by three major streams; Potash Brook, Delphi Brook and the outlet stream for New City Pond, and an unnamed stream in the eastern part of the watershed.

It should be pointed out that because these surface water bodies are in a series, sources of contamination that may effect New City Pond or any of the smaller ponds in the upper reaches of the watershed, may also ultimately effect Staffordville Reservoir. As an example, many residences surrounding the reservoir especially on the west side and south end are sewered, with the sewage being pumped out of the watershed. On the other hand, land surrounding New City Pond, which is undeveloped, is not served by public sewers. If development did occur around the pond, residences would need to rely on on-site septic systems, unless the public sewer line was extended to serve the area. Septic system effluent is one of the most common pollutants of real estate lakes in Connecticut. The Team has no reason at this time to believe that development will occur around New City Pond or is presently threatened by such effluent; the point of the example is merely to show that if a pollution problem were to occur in New City Pond because of septic effluent, the problem could be transmitted to Staffordville Reservoir. Hence, sewering the Staffordville Reservoir residences is only a partial solution.

The natural water quality in a watershed can be adversely influenced by various sources of pollution such as septic systems, sedimentation and erosion and stormwater runoff from roads. These sources of pollution, either singularly or in combination, can severely impact the environmental health of the reservoir or other surface water bodies in the watershed.

If a septic system is not properly designed, installed or maintained, there is a good chance it will malfunction. A malfunctioning septic system will either result in the backflow of sewage effluent into a house or the breakout of septic effluent on the surface of the ground. Sewage effluent discharging onto the ground surface may ultimately reach Staffordville Reservoir. The sewage effluent can contribute phosphorus, nitrates and other pollutants to the reservoir's waters. A far more important consideration, however, is that a failing septic system is a public health hazard. The public health threat is a concern which demands immediate correction.

According to Town officials on the review day, there may be residences on the east side of the Reservoir in the northern portion that may be discharging domestic wastes into the Reservoir. It should be pointed out that no sewage overflows were observed by Team Members on the review day. Because sources of contamination in the watershed will generally have a greater impact on surface water quality if they are relatively close to the waterbody, the town health officer should consider conducting a sanitary survey of these residences in the Reservoir which are not tied into the sewer line. If any septic systems are discharging to the Reservoir directly or malfunctioning steps should be taken to correct the problem(s).

Much of the watershed of Staffordville Reservoir is undeveloped; hence, the potential exists for major changes in the quality of surface and groundwater runoff.

In light of the preceding discussions, it seems clear that the areas of the watershed in which development would be least likely to have an adverse impact on the reservoir are the upland areas, north of Delphi Road and New City Pond. Further development of the land surrounding the Reservoir--particularly in unsewered areas, between the Reservoir and Route 19, along the east side of Route 19 and around New City Pond would be most likely to have a negative effect.

Due to the presence of moderate to steep slopes, till-based soils, which may be characterized by slow percolation rates, compact layer, elevated groundwater table, sandy/gravelly soils (rapid infiltration and limited renovative capabilities) and shallow to bedrock areas, it seems likely that some of this land would be only marginally suited for on-site sewage disposal systems and would probably require engineered septic systems. This is further complicated by the fact that most of the land surrounding the Reservoir is zoned as half acre lots. Since a public water supply is not available to the homes around the Reservoir, they need to rely on individual on-site wells. It should be pointed out that in order to assure that sufficient groundwater quality is maintained to permit water supply by individual on-site wells, residential development taking place on land where the above mentioned geologic limitation are present, generally should require a density not exceeding one unit per acre. Depending upon the severity of those geologic conditions on any particular parcel of land, it is possible that more than one acre of land area may be required or that the land may be unsuitable for development. On the other hand, if the public sewer line was extended to serve the areas mentioned earlier, a more dense development (perhaps half acre lots) might be conceivable.

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 Staffordville Reservoir watershed. These include the following: (1) conducting sanitary surveys to identify potential sources of pollution. This may include the introduction of fluorescene dye into 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 entire 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 consequence of failures, list materials which should not be disposed of in a septic system, state water conservation measures and stress the need for routing septic tank pumping. An excellent pamphlet for this purpose was developed by the Northeastern Connecticut Regional Planning Agency and the Northeast District Department of Health entitled, "Homeowner's Guid 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) consideration adopting a town ordinance which requires the installation of sewage disposal systems meeting all state health code requirements at the time of building conversion from seasonal to year round use.

In terms of transportation related activities such as road salting and sanding and automobile residue, there is a chance that road drainage, laden with salt, soil and/or sand may find its way into the Reservoir. At the present time, the team has no reason to suspect the above mentioned transportation related contaminants (i.e., de-icing compounds, oil, etc.) are a potential threat to the water quality of Staffordville Reservoir or feeder ponds.

Based on visual inspection of the Reservoir minimal accumulation of road sand is being deposited in the Reservoir. Every effort should be made by the state and/or town to control erosion and sedimentation from roadways within the watershed.

The excavation or disturbance of soils in the watershed can ultimately lead to the mobilization of finer soil particles. If proper precautions are not taken, this can result in environmental damage to surface water bodies in the watershed. On July 1, 1975, the Connecticut Soil Erosion and Sediment Control Act (.A. No. 83-388) became fully effective. This law requires that all development in the town will require an erosion sediment control plan. It should be pointed out that an erosion sediment control plan is required with any application for development where greater than one-half acre (cumulatively) will be disturbed. A single family dwelling not part of a subdivision is exempt. (See Section 9 for further erosion and sediment information on control.)

It should be pointed out that the Connecticut DEP has recently (revised 1986) 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 water body 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. (See Section 8 for further information on lake management.)

Additional residential development or other 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. Because the watershed extends into Massachusetts, town officials should work cooperatively and effectively with land use officials in that State to implement best development practices so that water quality in Staffordville Reservoir is maintained at a high standard.

7. WATER SUPPLY

The principal aquifer underlying the watershed area appears to consist of crystalline, metamorphic rock. The stratified drift deposits in the watershed area does appear to possess the hydrogeologic characteristics for a prolific aquifer. Commonly, where stratified drift deposits are coarse grained, generally thick and close to a major streamcourse, it may be possible to obtain relatively large volumes of groundwater at approximately 50 to 2,000 gallons per minute.

The schist and gneisses (metamorphic) underlying most of the watershed area are usually capable of yielding three (3) gallons per minute or more without penetrating much more than 300 feet of bedrock.

According to a survey of 134 bedrock floored wells in the Shetucket River basin, in which the study area lies, it is indicated that ninety percent yielded 3 gallons per minute or more. (Source: Connecticut Water Resource Bulletin No. 11).

The natural quality of the water supply should be good. However, bedrock underlying the watershed area mineralized with iron and/or manganese. Concentrations of these minerals are typically high, throughout Stafford and as a result, well water commonly needs to be treated with a suitable method of filtration. Water softening devices are available to surmount hardness problems, but the use of these filter systems may cause significant contamination of groundwater.

8. LAKE AND WATERSHED MANAGEMENT

All lakes and ponds undergo the aging process called eutrophication, a form of water pollution which results in a decline in recreational utility and aesthetic appeal. Eutrophication is a gradual natural process which is accelerated by man's use of the lands which surround the waterbody. Through awareness and considerable effort and commitment, the eutrophication process is controllable and manageable. Every lake and pond in Connecticut will benefit from "preservation" oriented management which slows the eutrophication process and prolongs the useful life of the waterbody. Many lakes and ponds are also in need of "restoration" oriented management to correct or reverse undersireable conditions brought about in the absence of prudent management in past years.

The DEP Water Compliance Unit has developed a watershed Management Guide for Connecticut Lakes. This handbook has been developed to assist concerned citizens in understanding the process of eutrophication and the principles of eutrophication control through the management of the lake's surrounding watershed land. The handbook is a synthesis of information assimilated by the DEP through its eutrophication abatement activities in recent years. Material in the handbook was selected to fulfill basic information needs of the general public, as determined by our experiences with a variety of lake projects and our contact with numerous individuals and lake organizations. The handbook is intended to assist the layman in working more effectively with technical experts in government agencies and private industry to protect and restore Connecticut's lakes.

The handbook addresses such topics as septic systems, agricultural land, wetlands, residential land and erosion and sedimentation. A copy of this publication is included in the Appendix of this report.

Although Staffordville Reservoir does not experience nuisance algae and weed growth at the present time, at some future point the implementation of vegetative control program may become necessary. The DEP Water Compliance Unit's Management Guide for Connecticut Lakes (June 1986) is a primer on the control of algae and aquatic weeds. This publication is also in the Appendix.

9. EROSION AND SEDIMENT CONTROL

The Staffordville Lake watershed was inspected for major sediment sources. The four main inlets to the lake were viewed and it appears that the inputs of water borne sediments are small and are not a major threat to the water quality of the lake.

Several potential sources were noted:

1. Wales Brookside Village in Wales Massachusetts is constructing new homes on the east side of Delphi Brook. This area should be monitored with the assistance of the Town of Wales. No sediment and erosion controls were evident on the site.

2. Gravel operations on Route 19 and on Petz Road are within the watershed. Both of these operations are contained (no discharge points for runoff) but could become sediment sources if improperly managed. If these pits are not active, plans should be developed and implemented to address closing the pits, regrading slopes, and permanently stabilizing the areas with vegetative cover. The Planning and Zoning Commission should review the permits issued to operators and enforce the conditions listed or require that permits be obtained for these areas.

3. Approximately 1000 feet of streambank along the outlet of New City Pond immediately downstream of the New City Road crossing appears to be unstable and has been undercut in several locations. High runoff events could continue to weaken this bank and cause large volumes of material to be deposited into the brook. It is recommended that this area be inspected and monitored if necessary.

4. The proposed residential development on the east side of Staffordville Lake could contribute sediment to the lake if controls are not planned and implemented properly. The erosion and sediment control provisions of the Planning and Zoning Regulations of the Town of Stafford should be strictly adhered to. Principles and standards found in the Guidelines for Soil Erosion and Sediment Control, Connecticut (1985) should be used to develop this plan.

5. Poor timber harvesting practices within the watershed could result in accelerated erosion and subsequent sedimentation of feeder streams. A review of forest management plans and inspection of work in progress could minimize this potential threat. The Town may want to consider adopting timber harvesting regulations which include soil erosion and sediment control provisions.

WATER QUALITY

Much of the turbidity in the lake may be the result of heavy motorboat activity that stirs up lake bottom sediments. The Town in cooperation with the Staffordville Lake Association may want to consider an ordinance which regulates boating activities on the lake. Either a horsepower limitation or maximum speed limit may be effective.

GENERAL RECOMMENDATIONS

1. Identify, establish and protect steambelt zones and adjacent wetlands within the lake watershed.

2. Require on-site delineation of inland wetlands by applicants who make permit requests to the Inland Wetland Commission and on-site verification of the wetlands by the Commission or its agent. Set up a policy for protection of wetlands within the watershed and revise or adopt new wetlands regulations to cover these requirements. Require strict adherence to permit conditions and regulations.

3. Require strict adherance to soil erosion and sediment control regulations.

10. VEGETATION

INTRODUCTION

The 5248 acre (8.2 square miles) watershed of the Staffordville Reservoir is located in the northeastern section of the town of Stafford. The predominant timber types are northern hardwoods and mixed hardwoods. Generally these types remain separate and distinct. Northern hardwoods are located on lower slopes with deeper soils and more moisture. Mixed hardwoods are found on middle and upper slopes in somewhat drier moisture regimes. Where these two types blend the forest is called transition hardwood type. When these forest types grade into one another mapping is difficult so for the purpose of this report the acreage of these and other types are only approximate. Other vegetative types include agricultural fields, hardwood swamps, natural and planted conifer stands and residential areas. The composition and potential of the major vegetative types is discussed below.

VEGETATION DESCRIPTIONS

a. Transition hardwoods, mixed hardwood, northern hardwood: The overstory of the mixed hardwood areas are composed of black oak, white oak, red oak, scarlet oak, black birch, red maple, pignut and shagbark hickory and beech. On drier sites white pine is common as a component. The northern hardwood type is composed of sugar maple, yellow birch and American beech with occurrences of white ash, basswood, hemlock, white pine. The transition hardwoods are a combination of these two forest types. Understory vegetation is dominated by thick Mountain Laurel (especially on drier, poorer growing sites), viburnum, blueberry, witch hazel, dogwood, ironwood, spice bush and sweet pepper bush. Ground cover is composed of ferns, some graces and club moss. These forest types compose approximately 70% of the total acreage of the watershed. Many of the tree species present in the stands have high commercial value as sawtimber. The health and vigor of these trees is variable depending on past land use, site conditions (slope, aspect, moisture, soils) and on past vegetation management. Areas on lower slopes with less steep, less rocky terrain, deeper soils and adequate moisture have good forest product productivity potentioal through proper forest management. Trees on good growing sites will respond well to periodic thinnings aimed at removing poorer quality trees and leaving the tall, straight, well-formed trees to grow. Healthier trees produce high quality wood for lumber, are able to maintain better wildlife populations and are more resistant to insect and disease outbreak, namely gypsy moth caterpillar.

b. Hardwood Swamp: Forested wetlands appear to make up about 5% of the watershed acreage. Red maple is the primary tree species with American elm, yellow birch and white ash. The understory vegetation is blueberry, spice bush, sweet pepper bush, skunk cabbage, poison ivy and club moss. Generally tree growth potential is limited by high water table and subject to windthrow due to shallow rooting in these areas. Wet soil conditions also limit operability and access so the possibility for timber management practices is usually eliminated completely.

c. Agricultural Fields/Open Fields: These highly productive areas are currently growing a human food crop, hay, or silage corn for the most part. Some areas are orchard or abandoned fields reverting to forest. This non-forested land occupies about 10% of the watershed.

d. Residential: Approximately 10% of the watershed, mainly adjacent to the reservoir, is homes.

e. Conifer Plantations/Natural Softwood: This forest type is composed of either planted white pine, red pine, and some spruce or naturally seeded white pine or hemlock. The softwoods generally occur naturally on drier, sandy soils where the pine and hemlock can better utilize the available, limited moisture. Conifer species are of lower value as timber than hardwoods, but worth managing for species diversity in a predominantly hardwood forest and valuable in a watershed to slow snow melt. Although this type occupies only about 5% of the watershed the encouragement of conifers can provide for more diverse wildlife habitat, interrupts the oak monoculture and food supply of gypsy moth caterpillars and other insects and diseases for which oaks and other hardwoods are hosts, and acts to improve the aesthetic aspect of the forest, expecially in winter.

MANAGEMENT CONSIDERATIONS

The Forestry Bureau of the Department of Environmental Protection encourages all woodland owners to manage their forest lands. When properly prescribed and executed, forest management practices will increase the production of forest products, improve wildlife habitat and enhance the overall condition of the woodland ecosystem with minimum negative environmental impact.

Areas which present limitations to forest management fall into two major categories. Areas with poor access due to extremely steep slopes and rockiness as well as poorly drained and saturated soils will limit management activity. Tree growth, health, and quality is often limited by the steep slopes and associated shallow to bedrock soils or saturated wetland soils found in these areas. When the limiting conditions become severe enough the trees will usually have little or no value commercially.

To reach a healthy and productive state, individual forest stands should be periodically evaluated to determine present and future management needs. A public forester from the Department of Environmental Protection can be contacted at 684-3430 to provide preliminary advice and assistance in woodland management. These services are provided at no charge for up to two days per land ownership per year. Services of a more intensive nature are available from private consulting foresters.

FOREST MANAGEMENT AND WATER QUALITY

Healthy woodlands provide a protective influence on water quality by stabilizing soils, reducing impact of precipitation and runoff, and moderating the effects of adverse weather conditions. Woodlands therefore help to reduce erosion, sedimentation, siltation and flooding. Research has shown that soil protected by the cover of litter and humus found in woodland areas contributes little or no sediment to streams.

In areas where soil is unprotected, such as gravel pits that are closed or steep slopes with shallow soil, tree planting is recommended. Usually white pine and larch planted in combination is recommended to reclaim bare soil. Trees will further protect the soil from wind erosion, especially in combination with planted grass.

Improper cultivation and harvesting of timber may lower water quality in several ways: (1) erosion, siltation and sedimentation caused by improperly located and constructed access roads, skid trails, yarding areas and stream crossings; (2) by allowing harvesting in seasonally wet soils during the wrong time of year; (3) siltation and sedimentation caused by logging debris left in stream, interfering with natural flows; (4) increase in stream temperature as a result of the complete removal of stream bank vegetation, eliminating shade (this can be especially detrimental to aquatic life); (5) influx of nutrients caused by application of fertilizer, soil conditioners and wetting agents (used especially in forest fire control); (6) chemical pollution caused by improper application of herbicides and insecticides (although the wide spread use of chemicals is not prevalent in forest management in Connecticut, chemicals are used on farms and by homeowners which could contribute to lower water quality if improperly disposed of or used near streams and ponds). A pamphlet entitled: "Logging and Water Quality in Connecticut" is available from the Department of Environmental Protection. A series of Best Management Practices (BMP's), recommendations to minimize negative impacts of silvicultural practices on water quality are presented in the pamphlet which is available upon request from 684-3430 or 295-9523.

Tree harvesting is a necessary tool to maintain a healthy and productive forest. Research has determined that nutrients loss from good silvicultural practices (i.e. the practices of cultivating and harvesting timber) does not, for the most part, result in significant deterioration of water quality. Healthy forests also provide oxygen to the atmosphere, visual and audio barriers and have a cleansing effect on the atmosphere as a pollution collector (dust, pollen, particulates). Adverse impacts on water quality can be minimized through good planning, professional consultation and responsible implementation as a productive forest is a vital part of an overall healthy environment.

DEVELOPMENT AND FOREST MANAGEMENT

Trees grown in a forested environment are used to each other for support. When side support is removed from individual trees by clearing they are subject to windthrow and crown breakage. The area around the base of a tree is especially sensitive to proper soil aeration and oxygen-carbon dioxide exchange. Even slight disturbances caused by excavation or filling can upset the delicate balance. In any development only the straightest, full crowned trees should be retained. During the building process injury to the main stem, branches and roots by heavy machinery should be avoided. Trees to be retained in a development should not be in close proximity to any houses and should be flagged so that no excavation occur under the leaf surface area of the tree or within 50 feet of the base of the tree. Trees which have had their roots cut or filled over by machinery are more subject to insect and disease attack and/or mortality in 4-6 years. Once dead, these trees pose a serious safety hazard to a home and people.

CONCLUSION

Following best management practices, professional forest advice and using common sense will help to avoid water quality degradation from silvicultural operations and high liability trees in developments. The implementation of the recommended BMP's should be of a voluntary nature, aided through an accelerated educational program and perhaps an incentive program, rather than through regulation. At this time the State Forestry Bureau supports uniform state wide harvesting guidelines rather than non-uniform local regulation. Educational and incentive programs may be reinforced through landowner groups, adult education field tours of D.E.P. lands for citizens, the use of thorough timber sale contracts and reasonable performance deposits. A public or private forester can assist a landowner in developing a good timber sale contract. Periodic on-site inspections are also essential to ensure that the terms of harvesting inspections are also essential to ensure that the terms of harvesting contracts are met. Most important however is the use of a competent professional forester in cooperation with the education of landowners and loggers as the key to the successful use of BMP's in forest management. Further quidelines to maintain water quality on managed woodlands can be found in the pamphlet "Timber Harvesting Guidelines" by the Wood Producers Association of Connecticut (WOODPAC). The guidelines in this publication are aimed at protecting the forest ecosystem from thoughless timber harvesting practices that can lower environmental quality in the long and short run. Copies of the pamphlet are available from WOODPAC or the Department of Environmental Protection --295-9523.

11. FISH RESOURCES

IMPOUNDMENTS

Staffordville Reservoir and New City Pond were surveyed in the fall of 1984 and 1985 by DEP Fisheries personnel. Data concerning relative abundance of fish populations and water chemistry data was collected. A beach seine, vertical gill nets, and horizontal gill nets were used to sample the fish populations. Dissolved oxygen, conductivity and pH levels were measured.

Staffordville Reservoir is a typical Connecticut warm-water pond and is surrounded by many cottages. It has a surface area of 165.2 acres, a maximum depth of 16 feet and an average depth of 9.5 feet. Currently fishing pressure is light because shore access is limited and no public boat access exists.

Several warm-water fish species inhabit the reservoir. Bluegill sunfish, yellow perch and chain pickerel are relatively abundant. Largemouth bass, golden shiner, black crappie and pumpkinseed sunfish are common while brown bullhead, white catfish and white suckers were scarce.

The waters of the reservoir are completely mixed and thermal stratification does not occur. This body of water is relatively infertile with a pH of 6.5 and conductivity of 38mhos.

Recommendations: The results of recent surveys suggest that the lake is best suited to warm-water fish such as those found to be common in this survey. No supplemental stocking is recommended. Establishment of a public boat launch would allow more people to make use of the fish resources.

New City Pond is located to the east of Staffordville Reservoir and acts as a settling basin for water that will ultimately flow into the reservoir. This small shallow impoundment is surrounded by pasture and woodland. This pond has a surface area of 36.6 acres, a maximum depth of 10 feet and an average depth of 5.7 feet.

The 1985 survey found several warm-water fish species present in New City Pond. Yellow perch, chain pickeral and golden shiner were found to be abundant while bluegill sunfish were common. Largemouth bass are reported to exist, though none were captured during the recent survey.

The waters of the pond are completely mixed and thermal stratification does not occur. This pond has a pH of 6.4 and the conductivity of 28mhos.

Recommendations: Special care should be taken to prevent soil erosion into the pond by maintaining present vegetative cover. Protect the vegetation surrounding the pond from grazing livestock.

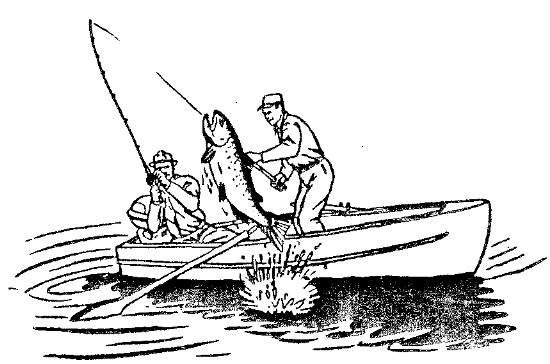
STREAMS

The Staffordville Reservoir is fed by three named small streams; Potash Brook, Furnace Brook (New City Brook) and Delphi Brook.

Stream bottoms consist mainly of gravel and rock substrates. The streams have a moderate to steep gradient and they are about four to eight feet wide. Stream belts are vegetated, providing shade and cover for fish. Their root systems help prevent soil erosion and stablize stream banks, proving benificial to the fish populations.

These streams support wild brook trout and, although not observed, dace. Delphi Brook is superior to the other brooks and is stocked each spring by the State with brook trout. The rock and gravel bottom of all the streams is ideal for the insects that the trout depend on for food. The three major insect groups observed were the caddisfly, stonefly and mayfly.

Recommendations: It is very important to maintain a vegetative buffer zone (where no development or timber harvest takes place) about 25 feet on each side of all three brooks. The vegetation keeps the water cool and prevents erosion. An increase in water temperature or soil erosion would have a detrimental effect on the fish populations. Brook trout populations and the insects they feed on are drastically reduced when there is an increase in sediment load due to erosion. Preservation of buffer strips along streams will protect the fish populations and reduce sedimentation into Staffordville Reservoir.



12. WILDLIFE RESOURCES

DESCRIPTION OF AREA

The lake is long and narrow and is oriented north to south. There are a number of homes, cabins and cottages built on the east and west shores of the lake. Lakeshore Boulevard runs closely along most of the western shore and Route 19 runs closely along the eastern edge.

Because of these physical features the amount of shoreline habitat is very small. Wildlife habitat is confined to a narrow strip except at the northern end of the reservoir which is not developed.

Submergent and emergent vegetation is very scarce. The body of water as reported in the Connecticut Fishery Survey is quite infertile. Because of this there would be less food production at the lower levels of the food chain such as algae, phytoplankton and insects. In turn, higher levels of the food chain such as frogs, snakes, ducks, birds and mammals would also be reduced, and many species would possibly not be present.

The vegetation on the shoreline is composed of red and sugar maple (Acer rubrum, sacharinum), white birch (Betula papyrifera), black cherry (Prunus serotina), red and black oak (Quercus rabra, velutina) and white ash (Faxinum americana). Shrubs inc lude common elder (Sambucus canadensis), sweet pepperbush (Clethra alnifolia) along with herbaceous vegetation such as meadowsweet (Spirea latifolia) and grape (Vitis aestivalis). There are several species of non-native shrubs found there also. These native species are important to wildlife, but because the habitat available is limited along the shoreline, they do not offer much food and cover.

WILDLIFE CONSIDERATIONS

The area immediately surrounding the lake provides poor to fair wildlife habitat for two reasons. First, the edge is very small and there is just not a sizeable portion of habitat available because of roads and development. Secondly, the shoreline habitat that is there provides minimal food and cover because of the lack of emergent vegetation. There is no marshy swampy area associated with the lake. The area is not attractive to "dabbler" ducks such as mallards and wood ducks, shorebirds and aquatic mammals. Migrant diving ducks such as canvasbacks might use the area because of the small fish produced there that they would utilize as a food source.

Canada geese may make limited use of the area but food and cover would also be limited for them. They are more likely to be present than other waterfowl species because they are highly adaptable to man. They can make use of lawns for grazing and can become a nuisance in some cases.

The surrounding upland forest does provide good to excellent habitat for species such as squirrels, deer, and other species. It offers excellent habitat to species of birds commonly associated with the Northwest Highlands and Uplands regions. Some characteristic breeding birds of this region include the Golden crowned Kinglet (Regulus satrapa), Black-throated Blue Warbler (Dendroica caerulenscens) and Red-breasted Nuthatch (Sitta canadensis). The Audubon Breeding Bird Atlas reports that this area is one of only two places where the Brewsters Warbler (Vermirora leucobronchlalis) nests.

RECOMMENDATIONS

Recommendations are necessarily limited because of the various private ownerships comprising the area. Because the value of the shoreline habitat is marginal and because it is privately owned, there is little that realistically could be done to improve conditions.

Recommendations on the remaining area of the watershed are also limited because the area is under many different private ownerships. In order to continue to provide good conditions for the upland birds mentioned earlier, any logging should be limited to selective cuttings if possible.

The habitat associated with the lake provides only poor to fair conditions for most species of wildlife currently, and until advanced eutrophication occurs it will continue to do so. The surrounding watershed area provides good to excellent habitat for some species, especially the birds mentioned earlier. Limitations to development and selective logging would benefit some of these avian species.

13. PLANNING CONSIDERATIONS

RECOMMENDATIONS OF EXISTING PLANS

There are two plans which consider the Staffordville Reservoir area, the State Plan of Conservation and Development and the Town Plan of Development. The Plan of Conservation and Development sets State policy for where particular types of land use should be located, and is binding only if State funds are used in a project. The 1986 proposed revision to the Plan continues previous designations of the reservoir and New City Pond as Preservation areas and the surrounding area as Rural. This means that no state-funded project would be allowed which threatened the quality of the water bodies or the rural character of the area.

Stafford's Plan of Development, which was adopted in 1972, proposed a low density residential density for the reservoir and the surrounding area. This low density was variable, however, in that the area immediately around the reservoir was proposed for densities not exceeding 1.5 families per acre while the surrounding area was not to exceed 1 family per acre. This placed the highest "low" density around the reservoir, where there was more potential for environmental harm. This recommendation was implemented in the Town's zoning regulations.

STAFFORD ZONING REGULATIONS

The Town zoning regulations place a belt of AA General Residential use around the reservoir and make the rest of the watershed, including New City Pond, AAA Rural & Single Family Residential. Lots in the AA zone must have 40,000 square feet of area, while AAA lots must be of 44,000 square feet. There are also differences in minimum lot frontage, yard requirements, livable floor area and site coverage, with the AAA zone having the stricter requirements. Homes in both areas must have two off-road parking spaces, and the AA zone allows two-family homes if site and floor area requirements, among others, can be met.

Old lots of record around the reservoir tend to have small frontages, so more than one would be required to satisfy requirements for new construction or conversion of a seasonal home to year around use. A portion of the western side of the reservoir has been sewered, which solves the sewage disposal problems. The difficulties posed by the steep slopes, however, are easily seen in the placement of the homes, garages and parking spaces, and in the need for pumping to make the sewer system work.

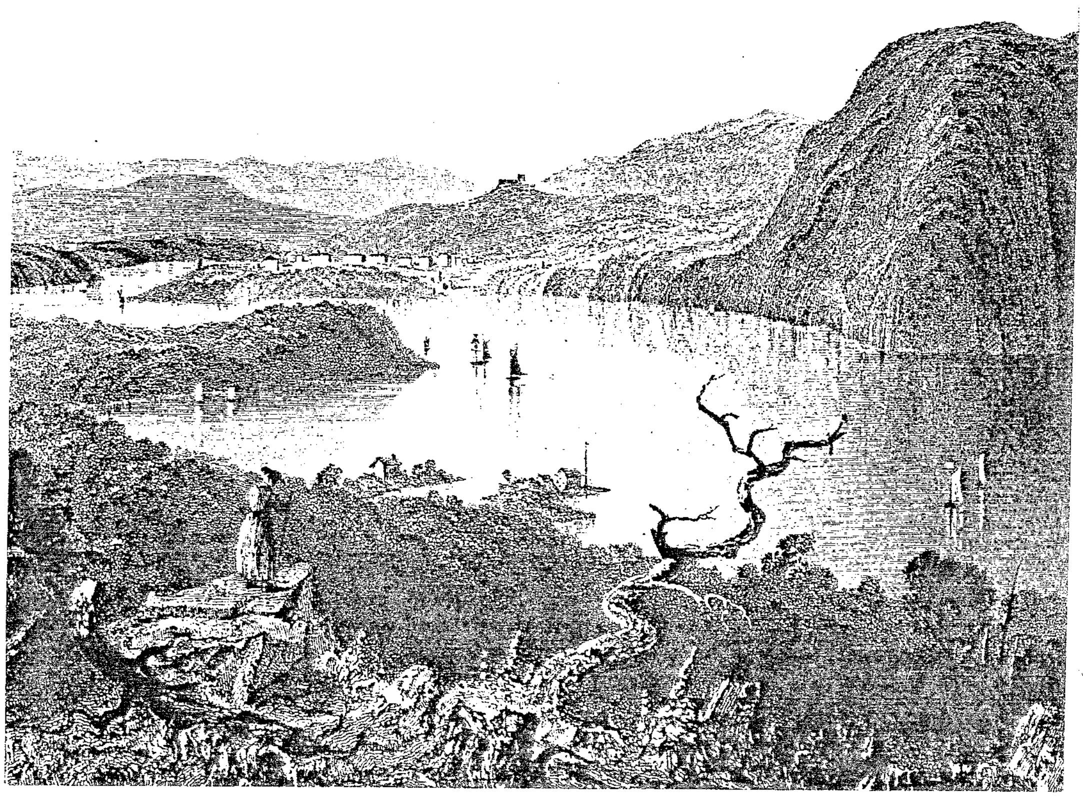
RECOMMENDATIONS

The present road system and the desirability of on-the-water locations will tend to channel development around the reservoir and pond and along streams feeding into them. Stafford has indicated a desire to protect the reservoir and its watershed, but the present zoning does not provide this protection. It is likely that less than expected development pressures, steep slopes and failure of land to come on the market have probably had more effect than zoning on limiting harmful development. The minimum lot size should be increased to at least two acres, and no two family units should be allowed in AA portions of the watershed. A larger lot size could be required where site conditions are especially difficult.

The Town should strictly enforce related regulations, such as inland wetland regulations, and should require detailed site review when subdivisions or other types of development are proposed in sensitive locations. Unsewered lots along the reservoir should have engineered septic systems, and non-residential uses, if allowed, should be strictly regulated. Strict enforcement will be especially critical if land around New City Pond is developed.

A lake is the landscape's most beautiful and expressive feature. It is the earth's eye; looking into which the beholder measures the depth of his own nature.

from **Walden**
by Henry David Thoreau



Appendix

A WATERSHED MANAGEMENT GUIDE FOR CONNECTICUT LAKES

CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER COMPLIANCE UNIT

REVISED 1986

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EUTROPHICATION

The Process of Eutrophication

Eutrophication is the process of lake aging, caused by enrichment of the lake with plant nutrients from its surrounding watershed land. During the aging process many lake characteristics undergo dramatic changes. To lake users, changes observed include algae blooms increasing in frequency, intensity, and duration; beds of aquatic plants becoming dense and more extensive in coverage of the lake bottom; sediment deposits accumulating, shoal areas developing, and the lake becoming shallower; and the oxygen content of bottom waters declining. As these conditions become pronounced, recreation opportunities become seriously impaired. During the latter stages of the eutrophication process, the lake evolves to a wetland - a swamp, marsh, or bog - and no longer can support its former recreation uses.

The Rate of Eutrophication

The rate at which eutrophication advances is determined by the rate at which the lake is fertilized by its watershed. Under natural conditions, nutrient inputs from a forested watershed are minimal and it may take many centuries for a lake to change in appearance. However, man's development and use of watershed land inevitably results in greater nutrient export from the watershed, and an acceleration in the rate of eutrophication. If man's watershed activities are not controlled, severe lake eutrophication can be brought about in a matter of decades.

Stages of Eutrophication

There are three basic stages of eutrophication which are used to describe the age of a lake. These stages are termed "oligotrophic", "mesotrophic" and "eutrophic". Oligotrophic refers to lakes in the early stages of the eutrophication process, while eutrophic refers to lakes in the late stages. Mesotrophic refers to middle-age lakes in transition between oligotrophic and eutrophic states. These stages are also referred to as trophic states or trophic classifications.

Each stage of eutrophication is characterized by a distinct set of lake conditions. Oligotrophic lakes are deep lakes with clear, infertile waters. They are low in biological productivity, having sparse amounts of algae and aquatic plants. They have minor accumulations of bottom sediments, and have well oxygenated bottom waters. Oligotrophic lakes are prime recreation lakes. Eutrophic lakes are relatively shallow lakes with fertile, turbid waters. They are high in biological productivity, having dense blooms of algae and dense beds of vascular aquatic plants. Eutrophic lakes have substantial accumulations of bottom sediments and have poorly oxygenated bottom waters. Eutrophic lakes have limited recreational utility. Mesotrophic lakes exhibit a mid-range of fertility, productivity, depth, and sedimentation.

INTRODUCTION

Connecticut's lakes and ponds are valuable natural resources which are used intensively for swimming, fishing, sailing, waterskiing, and many other forms of water based recreation. Lakes and ponds add diversity and aesthetic interest to the landscape and contribute immeasurably to the enjoyment of daily life in lakeside communities. They are important economic entities as well, with money spent in the pursuit of recreation contributing to local and regional economies. Lakes and ponds also enhance local property values, thereby augmenting the tax revenues of local communities.

Unfortunately, all lakes and ponds undergo the aging process called eutrophication, a form of water pollution which results in a decline in recreational utility and aesthetic appeal. Eutrophication is a gradual natural process which is accelerated by man's use of the lands which surround the waterbody. Through awareness and considerable effort and commitment, the eutrophication process is controllable and manageable. Every lake and pond in Connecticut will benefit from "preservation" oriented management which slows the eutrophication process and prolongs the useful life of the waterbody. Many lakes and ponds are also in need of "restoration" oriented management to correct or reverse undesirable conditions brought about in the absence of prudent management in past years.

This handbook has been developed to assist concerned citizens in understanding the process of eutrophication and the principles of eutrophication control through the management of the lake's surrounding watershed land. The handbook is a synthesis of information assimilated by the DEP through its eutrophication abatement activities in recent years. Material in the handbook was selected to fulfill basic information needs of the general public,as determined by our experiences with a variety of lake projects and our contact with numerous individuals and lake organizations. The handbook is intended to assist the layman in working more effectively with technical experts in government agencies and private industry to protect and restore Connecticut's lakes.

Studies of the trophic conditions of Connecticut lakes have resulted in the development of a formal classification system which defines trophic states on the basis of scientific measurements of water quality. A "highly eutrophic" stage was included in the eutrophic lakes. The mesotrophic state was subdivided into "early mesotrophic", "mid mesotrophic", and "late mesotrophic" conditions in order to further differentiate among lakes in this relatively broad category. A list of Connecticut lakes which have been formally classified is presented on pages 26 and 27 of this handbook.

These classification categories are useful tools for comparing the water quality of different lakes, for establishing benchmarks for short and long term trend comparisons, and for estimating the probable level of management required to meet lake use objectives. Trophic classifications are not rigid, and a lake may be eutrophic in some respects and mesotrophic in others. Also, the designation of a lake as eutrophic does not indicate that it is unsuitable or undesirable for all types of recreation, nor should it discourage efforts to manage the lake resource. Similarly, the classification of a lake as oligotrophic should not engender complacency towards management. In both instances, water quality can be maintained and improved through a management program.

<u>Eutrophication of Artificial Lakes and Ponds</u> - When initiating a lake study, it is important to recognize that many lakes and ponds in Connecticut were formed by the construction of a dam across a stream or across the outlet of a wetland. These artificial waterbodies often exhibit an advanced stage of eutrophication. They are relatively shallow waterbodies which are enriched by the nutrients accumulated by the predecessor wetland or terrestrial ecosystem. However, these water quality conditions do not evolve from the oligotrophic state - these lakes experience an advanced state of eutrophication from the time they are formed. Improvement of conditions in these lakes is exceptionally difficult because restoration does not involve the return to previous water quality conditions, but rather involves the creation of conditions which had never existed previously. Examples of this type of lake are Silver Lake in Berlin/Meriden, North Farms Reservoir in Wallingford, Mamanasco Lake in Ridgefield, Lake Winnemaug in Watertown, and Winchester Lake in Winchester.

<u>Eutrophication as Water Pollution</u> - Eutrophication is widely recognized as a form of water pollution which seriously impacts the recreational value of lakes and ponds. Programs to address eutrophication problems are mandated by both state and federal legislation.

Section 25a-338 of the Connecticut General Statutes requires the DEP to conduct a study of the growth and cause of algae and other plant life in the inland waters of the State, and to undertake programs of algae abatement and weed control in cooperation with other public and private agencies.

Section 314 of the Federal Clean Water Act (P.L. 95-217) requires that each State submit to the Environmental Protection Agency an identification of publicly owned freshwater lakes and a classification of those lakes according to trophic condition. The statute further requires states to submit to the EPA procedures, processes, and methods to control sources of pollution to lakes, and methods and procedures to restore the quality of lakes.

The Limiting Nutrient, The Key to Controlling Eutrophication

In order for any form of life to grow and multiply, the basic building blocks of life must be available in the environment. Those essential substances are commonly referred to as nutrients. In a lake, algae depend on nutrients in the water column to satisfy their growth. The larger rooted aquatic plants also depend on nutrients in the water column, although to a lesser extent since many species can also extract nutrients from lake sediments.

The term "limiting nutrient" refers to that particular nutrient which is in shortest supply relative to the growth needs of an organism grows. When the limiting nutrient becomes depleted, growth stops even though other nutrients are still available in surplus. Any increase in the supply of the limiting nutrient will result in a corresponding increase in growth. Conversely, any decrease in the supply of the limiting nutrient will result in a corresponding decrease in growth. The key to controlling the growth of algae and vascular plants in a lake - the key to controlling eutrophication - is to reduce the supply of the growth limiting nutrient.

Carbon, nitrogen, and phosphorus are the three basic plant nutrients which could hypothetically be limiting to the growth of algae and aquatic plants in a lake. Surface waters have an abundant supply of carbon because carbon dioxide gas (CO_2) readily dissolves in lake waters from the atmosphere. Similarly, nitrogen gas (N_2) readily dissolves in lake waters from the atmosphere and is present in abundance. There are many forms of common nuisance blue-green algae which are physiologically capable of "fixing" N_2 and utilizing this form of nitrogen for growth. These algae thrive even when dissolved mineral nitrogen forms (ammonia, nitrate) are scarce. Thus, carbon and nitrogen are not generally limiting to the eutrophication process.

Phosphorus, the third basic plant nutrient, has been found to be the growth limiting nutrient in the eutrophication process of most lakes and ponds. Phosphorus is not readily available as a gas from the atmosphere, and it is usually present in relatively scarce quantities in lake waters. Lake water quality studies have found that most lakes have a scarce supply of phosphorus relative to other nutrients and are phosphorus limited. Some highly eutrophic lakes have been found to be nitrogen limited, although this is not due to a low nitrogen supply but rather to an excessive phosphorus supply. In these lakes, restoration strategies focus on phosphorus control to reduce the supply to a level where it becomes limiting.

The key to controlling the eutrophication process, therefore is controlling phosphorus enrichment.

WATERSHED MANAGEMENT OVERVIEW

Objectives

The watershed of a lake is that land area which drains to the lake. The watershed is therefore the source of water for the lake. Water quality of a lake, to a large extent, is determined by qualities imparted to water by watershed land as the water drains to the lake.

Watershed management is aimed at identifying and controlling existing and potential watershed characteristics which ultimately influence a lake's trophic condition. Since phosphorus is the nutrient which governs the productivity of algae and aquatic plants, watershed management is first and foremost concerned with reducing phosphorus enrichment. An important secondary consideration is the reduction of sediment inputs which contribute to physical lake filling and the development of shallow shoal areas where tributaries and storm waters enter the lake.

Watershed management is imperative for each and every lake, regardless of the lake's trophic condition. If a lake is oligotrophic, watershed management will serve to preserve its superior quality and prolong its useful life for recreation. If a lake is eutrophic, watershed management will serve to temper the eutrophication process and enhance the effectiveness of restoration measures within the lake. Watershed management must be the foundation for all lake preservation and lake restoration programs.

Point Sources and Non-point Sources

Sources of phosphorus and sediment are divided into two broad categories, point sources and non-point sources. Point sources are concentrated, localized discharges such as outfalls from sewage treatment plants. Non-point sources are diffuse and are not easily identified because they do not enter a watercourse at a single point. Rainstorm runoff from a residential area and drainage from a cornfield are examples of non-point sources.

In Connecticut, State policy has prohibited point source discharges to a natural lakes and ponds and many artificial impoundments (including their tributary watercourses). In a relatively few cases, artificial river impoundments are significantly enriched with point sources of phosphorus. State and federal point source control programs are responsible for implementing advanced waste treatment to control eutrophication in these lakes. Thus, the primary concern for management of eutrophication in lakes and ponds in Connecticut is the identification and control of non-point sources.

Connecticut 208 Program - Connecticut's program for controlling non-point sources was developed through the Connecticut Areawide Waste Treatment Management Planning Program (Connecticut 208 Program). This program, established and funded under Section 208 of the 1972 Federal

Water Pollution Act Amendments, was instrumental in developing information on the nature and characteristics of non-point sources, non-point source control measures, and institutional arrangements for implementing controls. Lake watershed management principles draw substantially from information provided by the Connecticut 208 Program efforts.

WATERSHED RESOURCE MAPS

The first step in developing a lake management program is to obtain information about the lake watershed which is pertinent to existing and potential non-point sources of phosphorus and sediment. Several recent statewide natural resource and land use inventories have produced valuable baseline information which is portrayed on maps at 1/24,000 scale (USGS topographical guadrangle scale). This baseline information can be used to construct various lake watershed maps which show features related to eutrophication.

Lake Watershed Boundary Map

The Natural Resources Center of DEP has delineated watershed boundaries on mylar overlays which are on file at the State Office Building in Hartford. A boundary map for a lake watershed can be traced from the mylar onto USGS topographical maps. This serves as a base map on which various watershed characteristics can be portrayed.

Land Use Map

The Connecticut 208 Program developed maps of predominant land use in 5.7 acre grids. Fifteen land use categories were considered - low density residential, moderate density residential, high density residential, institutional, commercial, industrial, open land, cropland, orchard land, dairy production, forest production, resource extraction, wetland, water, and woodland. This information is on file at Regional Planning Agency offices on mylar overlays. A watershed land use map can be constructed by tracing this information onto a lake watershed boundary map.

Wetlands Map

The Connecticut 208 Program developed "water quality sensitive areas" maps which portray legally defined wetlands as well as flood prone areas of environmental or historic interest. This information is on file at Regional Planning Agency offices on mylar overlays. A map of wetlands and other sensitive areas in a lake watershed can be constructed by tracing this information onto a watershed boundary map.

Erosion and Sediment Source Map

The Connecticut 208 Program conducted a statewide inventory of active erosion and sediment sources in 1977 and 1978. The inventory considered cultivated cropland sites greater than two acres, construction sites greater than two acres, surface mines, stream banks, road banks, gravel roads, and unpaved driveways. Active sites were mapped on mylar overlays which are on file at Regional Planning Agency offices and at Soil and Water Conservation District offices. An erosion and sediment source map for the lake watershed can be developed by tracing sites onto a watershed boundary map. This map can serve as a baseline for developing an updated erosion and sediment source maps based on field observations. It is possible that some sites identified in the 1977-78 inventory have stabilized and no longer are active sources. It is also possible that new sites developed in the lake watershed since the 1977-78 inventory.

Areas of High Erosion Potential Map

The Connecticut 208 Program conducted a statewide inventory of high erosion potential areas based on slope of the land and soil type. This information is portrayed on mylar overlays on file at Regional Planning Agency offices. A map of high erosion potential areas for the lake watershed can be constructed by tracing this information onto a watershed boundary map.

Detailed Soils Group Map

The U. S. Department of Agriculture Soil Conservation Service has developed a statewide mapping of detailed soils groups in cooperation with the Natural Resources Center of DEP. This information is on file at the Natural Resource Center in Hartford as mylar overlays. A map of soils groups for a lake watershed can be constructed by transferring this information onto a watershed boundary map. This information can be used to evaluate the suitability of watershed land for on-site sewage disposal (septic systems), and to evaluate erosion potential of watershed land. Technical assistance may be needed to properly interpret the soils information.

Accessory Land Use Maps

The Connecticut 208 Program conducted two additional statewide inventories which can be used to construct useful lake watershed maps. The "Open Space and Dedicated Lands" inventory portrays land in public ownership, quasi-public ownership, and non-profit organization ownership. These lands include water utility property, land trust property, golf courses, recreation areas, nature preserves, and institutional property. This information is portrayed on mylar overlays at Regional Planning Agency offices. A map of open space and dedicated lands in the lake watershed can be constructed by tracing this information onto a watershed boundary map.

A statewide inventory of "lands Unavailable for Development" portrays flood hazard areas, wetlands, watercourses, waterbodies, urban areas, and dedicated lands. This information is available on mylar overlays at Regional Planning Agency offices. A map of property in the lake watershed which is unavailable for development can be constructed by tracing this information onto a watershed boundary map.

NON-POINT SOURCES AND CONTROLS

Erosion and Sedimentation

Erosion is a natural process whereby soil is worn away from the land by running water. Sedimentation is the deposition of eroded material in a watercourse. The severity of erosion and sedimentation is influenced by soil type, slope of the land, type of vegetative cover, intensity and duration of precipitation, and proximity to a watercourse. Some erosion and sedimentation from a lake watershed is inevitable, since this occurs as a natural process. Erosion and sedimentation can be greatly increased by activities of man which disturb the land, remove vegetation, and expose soil to the direct forces of rainfall and surface runoff.

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 is 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 shoals which are conducive to the growth of aquatic plants. In addition, organic matter associated with soil particles is decomposed by micro organisms, contributing to the depletion of oxygen in waters overlying the lake sediments.

Serious natural erosion can occur on land with steep slopes, along streambanks, and along lake shorelines. Common man-made sites of erosion are cultivated fields, roadway embankments, roadway drainage ditches, timber harvesting, and construction sites. Erosion associated with specific land features or specific land uses can be controlled by utilizing the "best management practices" which are addressed in subsequent sections of this report. Erosion associated with construction activities is a serious source of erosion which is not restricted to any particular land use of land feature, but rather can occur anywhere in the lake watershed. Special consideration of this erosion source follows:

Construction Site Erosion - Research has shown that soil erosion from construction sites may be 10 to 100 times greater than erosion from agricultural land of the same size, slope, and soil type. The demand to develop lake watershed land, especially land near the lake, is exceptionally strong Construction site erosion must therefore be regarded as a major causative factor in the lake eutrophication process.

Methods for controlling construction site erosion and sedimentation are described in Guidelines for Soil Erosion and Sediment Control, CT Council on Soil Water Conservation, January 1985. This document can be obtained from the DEP Natural Resources Center. This publication is a technical handbook which was developed to assist government officials, developed, engineers, contractors, and others to minimize erosion and sedimentation from sites undergoing development. Among the erosion control topics which are discussed in detail are site planning;

vegetative controls such as seeding, sodding, and tree planting; non-structural controls such as hay bale checks, mulching, land grading, and traffic control; and structural controls such as diversions, rip rap, and sediment basins. This handbook should be used as the basic guidance manual for controlling construction site erosion in lake watersheds.

Erosion and Sediment Control Regulations - Excessive sedimentation from construction activities can be reduced when erosion and sedimentation (E & S) control needs are recognized and BMP's are employed. In Connecticut, E & S control management roles are well defined and E & S control management is a shared responsibility. Municipal government through its Inland Wetlands Agency, Zoning Commission, or General Site Plan Review procedures, are required by State Statues to evaluate E & S control needs. The Connecticut Council on Soil and Water Conservation, the Soil and Water Conservation Districts, and Regional Planning Agencies routinely promote the need for thorough municipal E & S control programs and are available to provide technical assistance.

Similarly, DEP's role is to encourage the development of municipal programs. Furthermore, DEP - Water Resources Unit is the E & S control plan reviewer and regulator for State sponsored projects requiring Inlands Wetlands Permits and manager of local Inland Wetland Permit Programs where municipalities have not assumed such authority.

In 1983, major E & S control legislation was passed (P. A. 83-388) to strengthen this program in Connecticut. Key provisions of this statute require:

- development of E & S control guidelines and model regulations for municipalities by the Connecticut Council on Soil and Water Conservation (completed in 1985); and

- mandatory adoption of municipal E & S control programs by July 1, 1985.

This law was amended in 1985 to defer mandatory municipal adoption to June 30, 1986.

Residential Land

An acre of residential land will contribute much more phosphorus to a spell than an acre of woodland in the same location. Residential land adjacent to the lake will contribute more to eutrophication than residential land in distant areas of the watershed. The importance of residential land in the eutrophication of a lake is readily appreciated when on observes the amount of land adjacent to any particular lake which is occupied by seasonal or permanent residences.

Sources of phosphorus associated with residential land include construction site erosion, failing septic systems, properly functioning septic systems, fertilization of lawns and gardens, disposal of vegetation from yard upkeep, and stormwater runoff. Construction site erosion has been discussed in the preceding section, and stormwater runoff will be addressed in a later section. The remaining sources and their controls will be discussed below.

Failing Septic Systems - Sewage disposal in residential areas not serviced by sanitary sewers is accomplished with on-lot subsurface disposal systems commonly referred to as septic systems. When functioning properly, septic systems provide for the sanitary breakdown of wastewaters into simple chemical substances including soluble phosphorus compounds. The basic components of the system include a house sewer, septic tank, distribution system, and leaching field. Sewage is delivered to the septic tank via the house sewer. In the septic tank, solids are physically separated from liquids (primary treatment) by the sedimentation of heavy solids to form a sludge blanket, and the flotation of light solids to form a scum layer. The distribution system delivers the liquids to the leaching field. The liquid effluent is decomposed biologically (secondary treatment) in the leaching system.

A septic system can fail if it is not properly designed, installed, or maintained. A failing system will wither 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 the lake eutrophication issue.

The correction of individual or scattered failing septic systems in a residential area is the responsibility of town health official. The correction of widespread failures within a residential community is initiated by facility planning as provided by state and federal water pollution control statutes. A community sewage disposal system is a likely outcome in these cases.

Prevention of Failing Septic Systems - The first safeguard against septic system failure is the proper design and installation of the system. The DEP has published a document entitled Septic System Manual to guide local land use officials on the legal and technical aspects of the design and installation of on-site subsurface sewage disposal systems. The manual provides a brief explanation of the actual process of sewage treatment that takes place in a septic tank, leachfield and surrounding soil. It is intended to enhance the knowledge of local officials and provide for a more informed review of development proposals. This manual should be consulted by local commissions when reviewing applications for planning, zoning, and wetlands permits which involve the installation of new septic systems in the lake watershed.

Proper operation and maintenance practices will serve to prevent the premature failure of existing septic systems in the lake watershed. The septic system should not be used for the disposal of garbage, solvents, paints, household chemicals, and medicines because these materials can cause clogging or can interfere with biological treatment processes. Water conservation should be practiced in the household since heavy water use can hydraulically overload a septic system and cause failure. A poster detailing water conservation practices is available from the DEP:

Water Compliance Unit. For maintenance, a septic tank should be pumped routinely every 3-5 years to remove accumulated scum and sludge which would otherwise move into the distribution system and leaching system, causing clogging and eventual failure.

The Connecticut 208 Program has de eloped three reports which can guide a lake organization in the development of a community wide septic system management program. Theses are "A Proposed Septic System Inspection and Maintenance Program for Killingworth, Connecticut" by the Connecticut River Estuary Regional Planning Agency; "Voluntary Septic System Management Program for the Towns of Canterbury, Killingly, and Woodstock" by the Northeastern Connecticut Regional Planning Agency; and "Voluntary Septic System Management Program For Quaddick Lake, Thompson" by the Northeastern Connecticut Regional Planning Agency.

A simple and effective means of educating lakeside residents about the proper operation and maintenance of septic systems is an information pamphlet distributed by a lake organization to property owners. The pamphlet should advise homeowners about the consequences of failures, list materials which should not be disposed of in a septic system, explain 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 "Homeowners Guide to Septic System Maintenance - Or How To Save Thousands of Dollars."

<u>Non-failing Septic Systems as Phosphorus Sources</u> - The liquid effluent which flows from the leaching field of a septic system passes into the surrounding soil and enters the ground water system. This leachate has a high concentration of soluble phosphorus. The ground water flow is generally in the direction of the lake, where it enters the lake as springs. Whether phosphorus travels with the ground water to the lake depends on interactions between soil particles and phosphorus. Many factors are involved, including the proximity of the septic system to the lake, the age of the septic system, the soil type and its capacity to attenuate phosphorus, the path of travel of leachate, the time of travel of leachate, the time of travel of leachate, and the elevation of the ground water table.

At present, the incomplete scientific understanding of the interactions between soil particles and ground water phosphorus makes it difficult to predict if or when a septic system will become a source of phosphorus to lake waters. Some soil studies in Connecticut have suggested that soils have an enormous capacity to adsorb and retain phosphorus. More recent Connecticut studies have suggested that leachate may travel in preferential channels through the soil, limiting the exposure of phosphorus to soil adsorption sites. The studies also found that soils will release phosphorus to the ground water when the water table is high and the soils are flooded for several weeks.

In view of this information, it is apparent that the likelihood of a septic system contributing phosphorus to lake waters is enhanced if the septic system is located in thin soils on ledgerock, or if the septic system is located in an area which experiences a seasonally high water table which saturates soils with water. If many lakeside septic systems fall into these categories, it is probable that septic systems are an important factor in the eutrophication of the lake.

In homes with laundry facilities, the phosphorus passing through the septic system can be reduced 30-40 percent by the use of nonphosphate laundry detergents. Concerned lakeside residents should adopt a "better safe than sorry" attitude towards phosphate detergents. The use of nonphosphate laundry detergents by lakeside residents would constitute a sincere personal commitment to taking every available step to abate eutrophication of the lake.

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Section 25-54oo of the Connecticut General Statutes enables the DEP to an the use of phosphate detergents in a lake watershed to protect lake water quality. Originally, this authority was developed to enable the DEP to control eutrophication in cases where community-wide septic system failures had been identified but the construction of community sewers was not imminent. The exercise of this authority to control phosphorus from non-failing septic systems is a new concept which warrants consideration as lake diagnostic studies develop detailed information about septic systems and soils in lake watersheds.

Cottage Conversions - In many lakeside communities, seasonal cottages have been winterized and converted to permanent homes. If a septic system is not expanded and upgraded when a conversion occurs, it may not conform to minimum requirements of the Public Health Code. Local health officials must evaluate the adequacy of septic systems serving converted cottages, and oversee the timely correction of inadequate systems. Cottage conversions are usually subject to local building permits and zoning approval.

Lawn and Garden Fertilizers - Lawns and gardens are generally very efficient at utilizing soil nutrients and preventing their loss through runoff and leaching. However, runoff and leaching of nutrients can occur if fertilizer applications exceed nutrient requirements, or if fertilizers are applied prior to storm events which cause runoff. These situations can be avoided if fertilizers are matched to soil requirements, and if applications are timed to avoid periods of runoff. Soil test kits can be purchased at a nominal charge from the University of Connecticut Cooperative Extension Service county offices. The samples are analyzed at the Extension Service Laboratory, and the results identify soil nutrient deficiencies.

Yard and Garden Vegetation Disposal - Leaves, grass clippings, and other vegetative material from yard and garden maintenance should not be deposited in a location where the material may be washed into the lake.

Vegetative material will add to the sediment in the lake and will provide plant nutrients upon decomposition. Each property owner should select a suitable site away from the lake and its watercourses for the composting of vegetative material.

Agricultural Land

An acre of agricultural land will contribute less phosphorus to a lake than an acre of residential land in the same location, but more phosphorus than an acre of woodland in the same location. Agricultural sources of phosphorus and sediment are associated with cropland, with pasture land and feed lots, and with manure storage and handling.

The Connecticut 208 Program, through the Connecticut Council on Soil and Water Conservation, 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, and soil and water conservation.

A basis goal of the statewide program is to promote accelerated implementation of BMP's in watersheds designated "high priority" by the 208 Program agricultural study. Several lakes will benefit from this strategy. The watersheds of Roseland Lake and Wappaquassett Lake are designated "Highest Priority" by the 208 study. The impact of agricultural activity on the water quality of Roseland Lake was estimated to be highly significant. The impact on Wappaquassett Lake was estimated to be moderately significant. The Watersheds of Lake Wononpakook, Mudge Pond, Beardsley Pond, and Fitchville Pond were designated as "High Priority" by the 208 study. The impact of agricultural activity on water quality was estimated to be highly significant for Mudge Pond and moderately significant for Wononpakook, Beardsley, and Fitchville.

The agricultural BMP Program also includes the implementation of several statewide objectives over the next 15-20 years. These consist of the implementation of erosion controls on sites with high calculated soil loss; the implementation of BMP's for retention of soils on critical sites near watercourses; the establishment of vegetated buffer strips between cultivated fields and watercourses, and between barnyards and watercourses; the establishment of winter cover crops on cultivated fields; and the development of farm waste management systems with routine review and follow-up inspections.

A lake organization should consult with the local Soil and Water Conservation District to obtain information on the status of agricultural activities in its particular lake watershed. The lake organization should establish cooperative, working relationships with District personnel, Soil Conservation Service personnel, and local farmers in order to develop a strategy for the timely implementation of agricultural BMP's needed to protect lake water quality.

Woodland and Timber Harvesting

An acre of properly managed woodland in a lake watershed contributes much less phosphorus to the lake than an acre of residential land in the same location. However, harvesting of timber for firewood or lumber is aland disturbance activity which has the potential to cause serious erosion and sedimentation. Under the Connecticut 208 Program, a Forestry Advisory Committee undertook a statewide study of the impacts of timber harvesting on water quality. A field study and analysis of 80 logging sites was conducted by the committee in 1979. In general, it was found that harvesting practices in Connecticut are limited in scope and intensity, and rarely involve types of timber, slopes, harvesting equipment, or management practices which lead to severe water quality degradation. The committee concluded that harvesting operations did not affect nutrient export levels, but could cause site specific problems with sedimentation.

The Forestry Advisory Committee has adopted a policy of advocating voluntary compliance with best management practices to control erosion and sedimentation by timber harvesting. Appropriate practices are described in the Committees' handbook entitled "Logging and Water Quality in Connecticut - A Practical Guide for Protecting Water Quality While Harvesting Forest Products". This document is available from the Connecticut 208 Program or the Connecticut Forest and Park Association, Inc. The handbook describes effective and practical erosion and sedimentation controls related to haul roads, skid trails, stream crossings, harvesting practices, and job termination practices. A lake organization should develop cooperative working relationships with landowners, loggers, and foresters to ensure that these best management practices are employed in the lake watershed.

Wetlands

Scientific research has demonstrated that wetlands in a lake watershed play a vital role in regulating the timing of transport of phosphorus to the lake. During the spring and summer biological growth period, wetlands remove significant amounts of phosphorus from overlying waters and effectively withhold that phosphorus from transport downstream. Mechanisms by which wetlands retain phosphorus include physical entrapment of particulate phosphorus, chemical sorption by organic matter and soil particles, uptake by aquatic plants and attached algae, and utilization by bacteria and other microorganisms. During the fall and winter, wetlands release phosphorus as decomposition of wetland vegetation takes place. Consequently, transport of this phosphorus to downstream waters and to the lake occurs at a time of the year when the phosphorus is least likely to contribute to nuisance algae blooms and weed growth.

Thus, although little phosphorus is permanently withheld by wetlands on an annual basis, the "spring and summer storage; fall and winter release" pattern of phosphorus flux through a wetland serves to minimize summer algae blooms and weed problems in a downstream lake. Wetlands in a lake watershed should be appreciated for this valuable service provided to lake water quality.

The perpetuation of a wetland's phosphorus regulatory function involves, quite simply, maintaining the wetland in a natural state. Alteration or elimination of the wetland reduces or eliminates the effectiveness of this regulatory role and contributes to the degradation of the trophic condition of a downstream lake.

Another important function of wetlands relevant to lake water quality is the control of flooding and associated erosion. Wetlands retain water during periods of high runoff and gradually release water at moderate rates of flow. This flow regulation reduces flooding and erosion which could contribute sediment and phosphorus to a lake. The importance of this function for a particular wetland depends on the topography of the surrounding land, the location within the lake drainage basin, and the size of wetland area relative to the size of its drainage area. Alteration or elimination of wetlands would impair the regulation of runoff, and sediment and phosphorus loads to a downstream lake would increase.

It is recommended that the appropriate wetlands regulatory agency utilize the authorities of Connecticut's Inland Wetlands and Watercourses Act (Sections 22a-36 through 22a-45 Connecticut General Statutes) to maintain the wetlands in a lake watershed in their natural states. This is particularly important for wetlands which are contiguous with the lake or its tributary watercourses. Maintaining wetlands in their natural states will protect lake water quality by providing for continued regulation of seasonal phosphorus loads, and continued control of flooding which could cause erosion.

Specifically, a wetlands agency should give due consideration to wetlands functions which enhance lake water quality when acting on permit application for regulated activities in legally defined wetlands. This consideration is appropriate since the review of application must, by statute, weigh environmental impacts of proposed actions, and weigh irreversible and irretrievable commitments of resources associated with proposed actions. In order to facilitate the implementation of this recommendation, a wetlands agency should make special recognition of lake watershed wetlands on working maps used by agency members.

Stormwater Runoff

Stormwater runoff is the overland flow of water associated with precipitation events of periods of snowmelt. Runoff from residential areas and roadways in a lake results in the transport of sediments, phosphorus, and other pollutants to lake waters. A watershed management program should include measures for minimizing the impacts of stormwater runoff. The following measures should be considered:

Preservation of Wetlands - Wetlands provide for the temporary storage and gradual release of stormwater runoff, and provide for the retention of phosphorus, sediments, and other pollutants. Preservation of wetlands in accordance with Sections 22a-36 through 22a-45 of the Connecticut General Statutes is an important way to control stormwater runoff.

Existing Residential Areas - Stormwater transport of sediment from residential areas to a lake can be controlled by the installation of storm sewers with sediment traps at catch basins and points of discharge. Sediment traps must be cleaned of sand, leaves, and other debris on a regular basis to maintain their effectiveness. Routine street sweeping in the early spring should be conducted in lakeside residential areas to minimize the amount of sand and debris susceptible to stormwater transport. The rate of stormwater runoff can be reduced by employing artificial stormwater detention ponds and by minimizing the amount of impervious and semipervious pavements and surfaces.

New Residential Areas - Stormwater runoff from planned residential areas can be controlled by including stormwater management as part of the overall site development plan. Stormwater control measures should be incorporated into the site plan so that the runoff rate from the developed site is the same as it had been prior to development. Methods of stormwater control which can be considered include preservation of wetlands, installation of artificial stormwater detention ponds, temporary storage in open spaces, temporary storage in underground tanks, and the use of permeable pavements.

An effective means of implementing stormwater management is through town planning and zoning regulations which require Stormwater Runoff Control Plans for the detention and controlled release of stormwater runoff from new developments. Generally, plans should be required for sites where impervious surfaces exceed 60 percent of the total area. The Guidelines for Soil Erosion and Sediment Control can be used as a guide for local regulations.

Roadway Runoff - State highways, town streets, and unpaved roads can be significant sources of sediments in lake watersheds. Under the Connecticut 208 Program, the Northwestern Connecticut Regional Planning Agency developed a report entitled "Best Road Maintenance Practices for Critical Watersheds" which should be used as a guide to minimizing erosion and sedimentation from roadways in lake watersheds. The report presents detailed information on the design of roadway drainage systems; the management of paved roadways, including sanding operations and early spring street cleaning; the stabilization of road banks with vegetation and proper grading; and the grading and surfacing of unpaved roads. A lake organization should establish cooperative working relationships with appropriate town and/or state maintenance officials in order to implement a sound management program for lake watershed roads.

Waterfowl

Ducks and geese are generally considered attractive wildlife assets which enhance the aesthetic appeal of a lake. However, large numbers of migratory waterfowl which spend considerable periods of time on a lake can contribute appreciable loadings of phosphorus and nitrogen to lake waters. In a study of one Connecticut Lake, it was estimated that the phosphorus in the excrement of four geese in one month was equivalent to the total annual loading of phosphorus from 2.5 acres of watershed land. In order to quantify the impact of waterfowl on a lake, it is necessary to develop accurate information on waterfowl population numbers, feeding habits, resting areas, and periods of occupancy. In the absence of detailed information, it should be recognized that large flocks of migratory waterfowl which stop at a lake for many weeks can be an important factor in the eutrophication process.

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, balloons, 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 in controlling nuisance waterfowl whenever possible. 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.

Streambanks and Shorelines

Streambanks and shorelines are sites where erosion can cause serious cause sedimentation which immediately impacts a lake. Activities which disturb the land surface should be avoided in these areas, and maintenance of a zone of natural vegetation, or a greenbelt, should be encouraged. Construction activities in these areas should employ erosion and sediment controls as described in Guidelines for Soil Erosion and Sediment Control.

General guidance for stabilizing streambanks and protecting streambanks and protecting streambanks against scour and erosion is presented in the Guidelines for Soil Erosion and Sediment Control. Measures to be considered for critical streambank sites include bank sloping, riprap, vegetation, jetties, fencing, and removal of obstructions. Each streambank site is unique, and implementation of controls should be done under the guidance of the federal Soil Conservation Service and/or the county State Soil and Water Conservation District.

It is a common practice for lakeside property owners to construct masonry retaining walls along shorelines which are vulnerable to erosion. Retaining walls absorb the shock of waves, and prevent soil from moving off the land and into the lake. General guidance on the construction of retaining walls is provided in the Guidelines for Soil Erosion and Sediment Control. Additional guidance should be obtained from professional builders.

Erosion and sediment control measures undertaken along streambanks and shorelines may require approval of the Inland Wetland Agency and/or the U. S. Army Corps of Engineers.

Atmosphere

Recent eutrophication studies have shown that measurable amounts of phosphorus may enter a lake through precipitation and dry atmospheric fallout. Precipitation data at one Connecticut lake suggested that atmospheric phosphorus was associated with pollen dispersion. Other research has suggested that atmospheric phosphorus emanates from local and distant sources of air pollution. Although atmospheric phosphorus is a factor in lake eutrophication, control of atmospheric loadings is not within the scope of a local lake management program.

Lake Sediments

Under certain conditions, sediments on the lake bottom can release phosphorus and nitrogen to overlying waters. Depending on lake mixing characteristics and algae bloom sequences, these recycled nutrients may contribute to nuisance algae blooms. The identification of internal enrichment can only be made through detailed lake water quality monitoring. Control of this source involves in-lake technology which is outside the scope of this handbook. However, it is important to recognize that for some Connecticut lakes, lake sediments are a significant source of enrichment of lake waters.

Resource Agencies

State and Federal

Department of Environmental Protection
Natural Resources, Water Compliance, Water Resources, Wildlife & Forestry Units
165 Capitol Avenue
Hartford, Connecticut 06106

Connecticut 208 Program
c/o Connecticut DEP Water Compliance Unit
165 Capitol Avenue
Hartford, Connecticut 06106

Connecticut Council on Soil & Water Conservation
State Office Building
165 Capitol Avenue
Hartford, Connecticut 06106

USDA Soil Conservation Service
Mansfield Professional Park
Storrs, Connecticut 06268

Connecticut Agricultural Experiment Station
123 Huntington Street
New Haven, Connecticut 06054

U. S. Geological Survey
450 Main Street
Hartford, Connecticut 06103

U. S. Fish and Wildlife Service
4 Whalley Street
Hadley, Massachusetts 01035

Connecticut Forest and Park Association, Inc.
1010 Main Street
P. O. Box 389
East Hartford, Connecticut 06108

U. S. Army Corps of Engineers
Regulatory Branch
424 Trapelo Road
Waltham, Massachusetts 02254

Regional Planning Agencies

South Central RPA
96 Grove Street
New Haven, Connecticut 06510

Housatonic Valley CEO
256 Main Street
Danbury, Connecticut 06810

Greater Bridgeport RPA
525 Water Street
Bridgeport, Connecticut 06604

CT River Estuary RPA
Hitchcock Corners
Essex, Connecticut 06426

Central CT RPA
1019 Farmington Avenue
Bristol, Connecticut 06010

Northeastern CT RPA
Sackett Hill Road
Warren, Connecticut 06754

Windham RPA
Main Street
Willimantic, Connecticut 06226

Capitol Region COG
214 Main Street
Hartford, Connecticut 06106

Southeastern CT RPA
139 Boswell Avenue
Norwich, Connecticut 06360

Northeastern CT RPA
P. O. Box 198
Brooklyn, Connecticut 06234

Central Naugatuck Valley RPA
20 East Main Street
Waterbury, Connecticut 06702

Midstate RPA
100 DeKoven Drive
Middletown, Connecticut 06457

Valley RPA
Derby Train Station
Main Street
Derby, Connecticut 06418

Southwestern CT RPA
213 Liberty Square
E. Norwalk, Connecticut 06855

County Offices

USDA Soil Conservation Service District Conservationist (SCS)
Soil and Water Conservation Districts (S&WCD's)
UConn Cooperative Extension Service Extension Agents (UCONN)

Fairfield County SCS, S&WCD
UConn Agricultural Center
Route 6 Stony Hill
Bethel, Connecticut 06801

Hartford County, SCS, S&WCD
Agricultural Center
340 Broad Street
Windsor, Connecticut 06095

Hartford County UCONN
Extension Service
Carriage House
Hartford, Connecticut 06105

Litchfield County SCS, S&WCD
UConn Agricultural Center
Litchfield, Connecticut 06759

Middlesex County SCS, S&WCD
UConn Extension Center
Route 9-A
Haddam, Connecticut 06438

New Haven County SCS, S&WCD
UConn Extension Service
322 North Main Street
Wallingford, Connecticut 06492

New London County SCS, S&WCD
UConn Extension Service
562 New London Turnpike

Tolland County SCS, S&WCD
UConn Agricultural Center
24 Hyde Avenue
Vernon, Connecticut 06066

Windham County SCS, S&WCD
UConn Extension Center
P. O. Box 112
Wolf Den Road
Brooklyn, Connecticut 06234

Resource Maps

Title	Prepared by*	Scale
Watershed Boundary (Drainage Basins)	RPA's, DEP NRC	1:24,000
Land Use	RPA's	1:24,000
Water Quality Sensitive Areas	RPA's	1:24,000
Erosion & Sediment Source Inventory	RPA's, S&WCD's	1:24,000
Areas of High Erosion Potential	RPA's	1:24,000
Open Space & Dedicated Lands	RPA's	1:24,000
Detailed Soils Groups	SCS DEP NRC	1:24,000

* RPA - Regional Planning Agency
S&WCD's - Soil & Water Conservation Districts
SCS - Soil Conservation Service
DEP NRC - Department of Environmental Protection Natural Resources Center

Resource Publications

Title	Source
"Erosion & Sediment Source Inventory"	CCSWC, RPA's, S&WCD's
"Guidelines for Soil Erosion and Sediment Control"	CCSWC
"Septic System Manual"	DEP Water Compliance Unit
"A Proposed Septic System Inspection & Maintenance Program for Killingworth, Ct."	CRERPA
" Voluntary Septic System Management Program for Canterbury, Killingly, and Woodstock"	NERPA
"A Voluntary Septic System Management Program for Quaddick Lake, Thompson"	NERPA
"A Homeowners Guide to Septic System Maintenance"	NERPA, NDDH
"Logging & Water Quality In Connecticut - A Practical Guide for Harvesting Forest Products & Protecting Water Quality"	Ct. 208 Forestry Advisory Committee
"Best Road Maintenance Practices for Critical Watersheds	NWRPA
"Connecticut AG 208 Project"	CCSWC
"Inventory of the Trophic Classifications of Seventy Connecticut Lakes"	DEP Natural Resources Center
"Lake Management Handbook - A Guide To Quantifying Phosphorus Inputs to Lakes"	DEP Water Compliance Unit, Windham RPA
"Lake Waramaug Watershed Management Plan"	DEP Water Compliance Unit, Northwestern CT RPA

Connecticut Lake Trophic Conditions

Trophic Condition	Lake	Town(s)	Surface Area (Acres)
Oligotrophic	Alexander	Killingly	190.4
	Bashan	East Haddam	276.3
	Beach	Voluntown	394.3
	Billings	North Stonington	105.1
	Highland	Winchester	444
	Mashapaug	Union	297.1
	Uncas	Lyme	69
	West Hill	New Hartford	263
Early Mesotrophic	Bigelow	Union	18.5
	Candlewood	New Fairfield Sherman New Milford Danbury Brookfield	5,542.0
	Columbia	Columbia	277.2
	Crystal	Ellington, Stafford	200.9
	Dodge	East Lyme	33
	Long	Ledyard, North Stonington	98.6
	Mount Tom	Litchfield, Morris Goshen	61.5
	Norwich	Lyme	27.5
	Rogers	Lyme, Old Lyme	264.9
	Quassapaug	Middlebury	271
	Waumgumbaug	Coventry	378
	West Side	Goshen	42.4
	Wyassup	No. Stonington	92.4
Mesotrophic	Amos	Preston	105.1
	Black	Woodstock	73.4
	Burr	Torrington	85
	Cedar	Chester	68
	Cream Hill	Cornwall	72
	East Twin	Salisbury	562.2
	Gardner	Salem, Montville Bozrah	486.8
	Glasgo	Griswold	184.2
	Gorton	East Lyme	53
	Hayward	East Haddam	198.9
	Little School house	Thompson	68.4

(continued)

Trophic Condition	Lake	Town(s)	Surface Area (Acres)
Mesotrophic	Lower Bolton	Bolton, Vernon	178.4
	Pachaug	Griswold	830.9
	Pattagansett	East Lyme	123
	Pocotopaug	East Hampton	511.6
	Powers	East Lyme	152.6
	Quaddick	Thompson	466.8
	Quonnipaug	Guilford	111.6
	Shenipist	Vernon, Ellington Tolland	52.8
	Squantz	New Fairfield Sherman	288
	Terramuggus	Marlborough	83
	Tyler	Goshen	182
Late Mesotrophic	Ball	New Fairfield	89.9
	Black	Meriden Middlefield	75.6
	Hitchcock	Wolcott	118.4
	Middle Bolton	Vernon	114.9
	Moodus	East Haddam	451
	Mudge	Sharon	201
	Taunton	Newtown	126
	Waramaug	Warren, Washington Kent	680.2
Eutrophic	Bantam	Litchfield, Morris	916
	Batterson Park	Farmington New Britain	162.7
	Beseck	Middlefield	119.6
	Eagleville	Mansfield	80
	Housatonic	Shelton	382.2
	Kenosia	Danbury	56
	Linsley	No. Branford Branford	23.3
	Long Meadow	Ledyard, No. Stonington	11.7
	Mamanasco	Ridgefield	95
	Roseland	Woodstock	88
	Wononpakook	Salisbury	164
	Wononscopomuc	Salisbury	352.6

(continued)

Trophic Condition	Lake	Town(s)	Surface Area (Acres)
Highly Eutrophic	Cedar	North Branford	21.8
	1860 Reservoir	Wethersfield	35
	Lillinonah	Southbury Bridgewater Brookfield, Newton	1900
	North Farms	Wallingford	62.5
	Silver	Berlin, Meriden	151
	Winnemaug	Watertown	120
	Zoar	Newtown, Monroe Oxford, Southbury	975

A MANAGEMENT GUIDE FOR CONNECTICUT LAKES

A Primer on the Control of Algae and Aquatic Weeds

STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER COMPLIANCE UNIT

JUNE 1986

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A MANAGEMENT GUIDE FOR CONNECTICUT LAKES

INTRODUCTION

Connecticut's lakes and ponds are valuable natural resources which are used intensively for swimming, fishing and boating. Our lakes are also important economic entities, adding to local property values and augmenting the tax revenues of local communities. Connecticut's lakes are resources deserving of our protection and, in many cases, our commitment to restoration.

CONNECTICUT'S LAKES PROGRAM

The Lake's Management section of the DEP Water Compliance Unit is the agency which oversees lake water quality and related issues. Our staff of biologists and engineers are available for assistance on the following:

- in-lake algae and weed control techniques
- watershed management guidelines
- general information on algae and weeds
- general water quality data on a large number of Connecticut lakes
- technical assistance and review of proposed plans for lake projects
- Environmental Review Team Projects
- information on financial assistance programs for algae and weed control activities.

EUTROPHICATION

Unfortunately all of our lakes and ponds undergo a natural aging process called eutrophication. Eutrophication is a form of water pollution which results in the decline of a lake's recreational utility and aesthetic appeal. The process generally advances over many, many years, however it can be accelerated by human activities in the lake's watershed. Through awareness and commitment the process is controllable and manageable. "A Watershed Management Guide for Connecticut Lakes" (1986) presents the principles of eutrophication control through prudent management of the land surrounding the lake. This publication is available at no charge from the Department of Environmental Protection (DEP) Water Compliance Unit at (203) 566-2588. The effectiveness of the lake management techniques described in this handout will be greatly enhanced by the implementation of a sound watershed management plan.

It is generally accepted that there are 3 stages of eutrophication. These stages are termed oligotrophic, mesotrophic and eutrophic. Oligotrophic lakes are in the earliest stages of the process. These are deep lakes with clear, infertile waters and little or no algae and aquatic weed growth. There are only minor accumulations of sediments on the bottom and even the deepest waters are well oxygenated. Eutrophic lakes are in the latter stages of the process, with water quality characteristics exactly opposite those found in oligotrophic lakes. These lakes have limited recreational utility. Mesotrophic lakes fall somewhere between these two extremes.

The preceding description of the eutrophication process applies to natural lakes. There are many man-made lakes and ponds in Connecticut, formed by damming a stream or excavating a wet area. These artificial waterbodies often exhibit an advanced stage of eutrophication from the time they are created. Improvement of water quality conditions in man-made lakes is extremely difficult because restoration does not involve the return to previous conditions, but rather involves the creation of conditions which never existed previously.

MEASURES OF WATER QUALITY

Every lake is a complex system of interactions between chemical, physical and biological components. In order to better understand the lake system, it is essential to have a basic understanding of many of these elements. Selection of the most appropriate management option depends on a sound knowledge of the lake system. The following is a brief description of the most common parameters used to assess lake water quality.

Nutrients: Algae and aquatic weeds, not unlike their terrestrial counterparts require nutrients to grow. The most common of these plant nutrients are phosphorus and nitrogen. Enrichment of a lake with these nutrients is the fundamental cause of eutrophication. The nutrient most often in the shortest supply in the lake system is phosphorus, therefore, controlling phosphorus inputs to lake waters is the key to controlling eutrophication.

Water Temperature/Dissolved Oxygen: Water temperature and dissolved oxygen levels play extremely important roles in the lake ecosystem. The two parameters are very closely linked. Water temperature determines the lake's mixing characteristics, dissolved oxygen levels and the type and extent of the fishery. Dissolved oxygen (D.O.) is essential to the metabolism of nearly all aquatic organisms.

Summer Stratification: Deep lakes thermally stratify into distinct "thermal zones" during the summer months. These zones are depicted in Figure 1. Each zone is physically separated from the other by temperature/density differences between the layers.

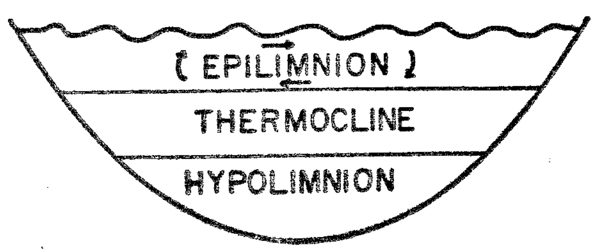

Figure I.

TYPICAL SUMMER STRATIFICATION OF A DEEP LAKE

Typical Summer Stratification of a Deep Lake: The epilimnion, or top layer, is fairly uniform in temperature and well mixed. Aquatic weeds and most summer algae blooms occur in this zone. Oxygen levels are generally high due to atmospheric diffusion and photosynthetic activity. The thermocline or metalimnion is a transition zone in which the water temperature drops approximately 1°C with each meter increase in depth. The hypolimnion or bottom layer contains the lake's coldest waters.

The distribution of D.O. is within a lake is dependent upon water temperature and biological activity. The colder water is, the more oxygen it can "hold." During the summer months the cold bottom waters of unproductive, oligotrophic lakes are generally well oxygenated. In a highly productive, eutrophic lake, biological processes like as the decay of organic material such as dead aquatic weeds, "robs" oxygen from the overlying waters of the hypolimnion. During stratification when the bottom zone is separated from the upper layers, the oxygen supply cannot be replenished by the well oxygenated epilimnion and the oxygen supply can become depleted. If this occurs, only those organisms which can live in the absence of oxygen can survive. Lack of oxygen or anaerobic conditions results in the loss of fish habitat and sets up conditions which allow for the release of nutrients like phosphorus and ammonia nitrogen into the overlying waters. Lakes in which anaerobic conditions exist for a long period of time may have significant quantities of nutrients recycled from the sediments into lake waters.

Fall Overturn: In the fall the epilimnion cools off, becomes more dense and consequently sinks and mixes with the underlying waters. This is referred to as fall overturn. Eventually the entire lake mixes surface to bottom and temperature and nutrient levels are uniform throughout the water column. Dissolved oxygen concentrations are replenished to all depths.

Winter Stratification: Winter stratification differs from summer stratification in that the coldest waters are found at the lake's surface. When the lake or pond freezes over, D.O. levels can once more become low or depleted. The formation of the ice cover eliminates the atmospheric oxygen contribution. If there is snow on the ice, light penetration is greatly reduced and consequently so is photosynthetic activity, of which oxygen is a product. In shallow, eutrophic lakes winter fish kills can result when oxygen levels become insufficient.

Spring Turnover: In the spring, when the ice melts. the lake turns over a second time. The spring turnover is accomplished primarily by wind action. At this time the water column is again uniform in it's physical and chemical characteristics. The lake will remain mixed until the surface waters warm, bringing about the onset of summer stratification and the stratification cycle begins again.

Stratification of Shallow Lakes and Impoundments: There are some exceptions to the typical stratification pattern. These exceptions include artificial impoundments with short residence times and shallow lakes and ponds. In these cases, there may be a temperature gradient where surface waters may be only slightly warmer than bottom waters or the temperature and chemical characteristics may be nearly uniform throughout the water column. In many shallow ponds, such as man-made ponds, D.O. depletion of the bottom waters by decay processes and subsequent nutrient release into overlying waters may be a significant source of nitrogen and phosphorus. In lakes that don't stratify, these nutrients are readily available to algae and weeds in the surface waters.

Algae and Aquatic Weeds: Perhaps the most familiar characteristic of a eutrophic lake is the presence of nuisance populations of algae and aquatic weeds.

Algae: There are three basic types of algae: planktonic, filamentous and macrophytic. Planktonic algae are microscopic single cells or filaments and are suspended in the water column. These include the diatoms, green and blue green algae. Filamentous algae are the long green thread-like algae that many times form floating mats but also may grow on the lake bottom. Most often these mats are composed of members of the blue green algae. Macrophytic algae resemble rooted plants but are actually advanced forms of algae. The two most common types are *Chara* and *Nitella*, the stoneworts, which grow on the lake bottom.

Aquatic Macrophytes: There are four types of aquatic macrophytes: free floating, emergent, rooted with floating leaves and submergent. The free-floating aquatic plants are commonly referred to as duckweed and watermeal. These plants are non-rooted forms that appear like small clovers. Frequently their growth is so dense that a dense mat may form over the entire water surface. Emergent forms of weeds are rooted in the lake bottom but extend through the water on into the air. Examples of emergent weeds are cattails, pickerelweed, and arrowhead. Waterlilies and the smaller-leaved watershield are types of rooted plants with leaves that float on the water's surface. Submergent macrophytes are rooted in the sediments and the entire plant grows under the water. Many of these plants grow right to the water surface, and some have floral bracts which may extend out of the water. Most forms which are considered the greatest nuisance are found in this group: the pondweeds (*Potamogetons*), coontail (*Ceratophyllum*), and the water milfoil (*Myriophyllum*).

The mere presence of algae and/or aquatic weeds does not indicate that a water quality problem exists. Algae and aquatic weeds provide fish and other aquatic organisms with food, habitat, spawning areas, as well as supply oxygen through the process of photosynthesis.

When algae or weed growth becomes so extensive that it interferes with the desired uses of the lake or pond, then some sort of balance between intended uses and nature must be achieved, and some measure of control or management technique must be employed.

The following is a brief discussion of the most common methods of algae and weed control. As stated earlier in the handout, it is extremely important to understand that the effective life of each of these methods will greatly enhanced if a prudent management plan is instituted for the watershed. It is also important to realize that a basic understanding of the lake system is necessary to enable the proper choice of method.

ALGAE CONTROL METHODS

Aeration/Destratification: Aeration is the process of artificially mixing the waterbody with compressed air or mechanical aerators (fountins). The purpose of aeration is actually two-fold. First by maintaining elevated levels of oxygen in the water column the nutrient contribution from the sediments is sealed off and secondly, the turbulence created by the system selects for growth of certain algal types which are less likely to become a nuisance.

Chemical Treatments: The use of any algicide or herbicide within Connecticut's lakes and ponds is regulated by state statute (section 430 of Public Act 872) and permits are required from the pesticides control section of the DEP. Prior to its approval, the permit application is reviewed by the DEP Pesticides Control staff, DEP Fisheries Bureau personnel and if the lake if located in a public water supply watershed, it is also reviewed by the State Department of Health Services.

The Pesticides Control Section offers a publication "Control of Water Weeds and Algae" available at no charge from (203) 566-5148. This booklet explains the types of chemicals available and the algae and weed types on which they are most effective. Chemical treatments are only cosmetic, providing immediate short term relief. Repeated applications may be necessary during the growing season.

Lakewide herbicide treatments may actually be detrimental to water quality. When all of the weeds die off at once, they are all decomposing on the lake bottom at the same time. This creates a tremendous drain on the oxygen supply of the bottom waters, setting up the proper condition for sediment recycle of nutrients as explained earlier. In a shallow, unstratified lake these nutrients are readily available for uptake by algae and blooms may result. Reduced competition for the nutrients by the weeds may also induce increased algae growth.

Hypolimnetic Withdrawal: This technique is a new experimental method which is currently in use at two Connecticut lakes. Prior to consideration of this technique, a diagnostic study must be completed to investigate the lake's nutrient cycling patterns.

AQUATIC WEED CONTROL METHODS

Aquashade: Aquashade is an inert blue coloring agent or dye which filters out the wavelengths of light which are required by aquatic plants to grow. Lakes which are candidates for aquashade treatments should have a relatively small volume of water and a long retention time (time it takes lake to flush). Aquashade however, is non-selective in the weeds it controls and also may not control some of the more vigorous weed growth. Aquashade does not control weeds growing in water less than 3 feet deep, nor does it prevent surface blooms of planktonic algae. The application of Aquashade requires a permit from the DEP Pesticides control section. Permit applications and additional information on Aquashade may be obtained by calling (203) 566-5148.

Benthic Weed Barriers: Benthic weed barriers consist of various grades of fiberglass mesh screening or perforated black nylon screening which is laid down upon the sediments to prevent weeds from growing by "mulching" them. Bottom barriers are useful at beach areas, docks and to create boating lanes.

Chemical Treatments: (see discussion in the algae control section above).

Drawdown and Excavation: If the spillway has the capacity to effectively lower the water level, lakes and ponds may be drawn down to expose the sediments in order to dry them out. In other cases when there is no water level control structure, the lake may be pumped or siphoned out. The water level is generally lowered following the recreation season.

Drawdown and excavation is sometimes employed to remove the substrate utilized by the plants for growth. The process increases water depth to levels where plants growing on the bottom will not receive enough light to survive. The effects of this method are generally long-termed. Selective excavation allows some areas to remain untouched as aquatic habitat. The DEP Fisheries Bureau should be consulted on the impact on the fishery.

The drawdown and excavation process requires the use of heavy equipment and it must be determined through engineering studies whether the pond bottom can support this weight.

This method has a relatively high capital outlay; however, the restorative effects are long termed. It is relatively quick and inexpensive compared to hydraulic dredging. State and/or local inland wetlands permits are required.

If this method is given further consideration, a feasibility study should be conducted to "map" lake sediments according to depth, composition, and underlying substances. Final disposal of excavated sediments should also be explored during the feasibility study. Hydraulic dredging (see discussion below) accomplishes the same goal as drawdown and excavation, but is far more costly due to increased specialization and complexity.

Hydraulic Dredging: Hydraulic dredging is the process of removing lake sediments without draining the water from the lake. Specialized dredges are employed which remove the sediments by suction as a slurry. The slurry is approximately 90% water and 10% sediments. This sediment must be "dewatered" prior to disposing of it, and the remaining water usually must be treated before it can be discharged. The development and construction of dewatering,containment basins is a major and expensive undertaking. State discharge and state and/or local inland wetlands permits are required.

A great deal of feasibility work must be completed by a qualified engineering/environmental firm prior to undertaking project of this scale. Capital outlay is extremely high, however the benefits of this method are generally long-termed.

<u>Weed Harvesting</u>: Weed harvesting entails the mechanical cutting of the weeds. After the weeds are cut they are drawn up into the harvester by a conveyer belt. When the harvester is full it is unloaded at a shoreline location. The weeds must then be disposed of at a site far removed from the lake so as not to become a source of nutrient enrichment. One benefit of harvesting is the actual removal of nutrients from the lake system. Another is that selected areas may be left untouched while others are harvested thus creating fishery habitat while increasing recreational utility. Although harvesting provides immediate relief it too may have to be repeated at periodic intervals and is a moderately expensive measure.

There are a few lakes in Connecticut whose lake associations have purchased their own weed harvesters for use on their particular lake. Many other lake associations contract out to weed control specialists for this service.

No state or local permits are required for weed harvesting activities.

<u>Hydroraking</u>: Hydroraking is a specialized type of weed harvesting which involves the mechanical removal of aquatic plants and their root systems. Hydroraking is more effective on certain weed types than on others. Adequate control over water lilies has been achieved with the hydrorake in some cases. As with weed harvesting there is the benefit of removing both weeds, and nutrients from the system.

<u>Weed Eating Fish</u>: Although this technique is used to varying extents in other states, the introduction of weed eating fish species is prohibited by law in the State of Connecticut. The effects of such introductions on the complex biology of lakes, ponds and rivers has not yet been adequately quantified. Contrary to what has been published in much of the popular literature, there is substantial evidence that the weed eating white amur, also called grass carp (members of the minnow/carp family), does effect the food chain in lakes and ponds. Some of the negative impacts observed during scientific studies are: (1) a reduction in crayfish production, (2) an increase in the populations of some plant species due to preferential feeding on others, (3) the inducement of algal blooms due to the concurrent elimination of macrophytes and influx of nutrients via grass carp feces, (4) interference with the reproduction of game fishes requiring vegetation for spawning, (5) reduced production of fishes requiring weed beds for refuge, and (6) the creation of unbalance ecosystems where species diversity was reduced and fish populations become unstable. these negative effects do not occur in all cases. However, we do not yet have the knowledge to predict what will happen in a specific pond or lake and therefore, cannot allow grass cap introductions to be made. The danger that introduced fish may be caught and subsequently transported to other bodies of water must also be considered.

<u>Winter Drawdown:</u> If the spillway has the capacity to effectively lower the water level, lakes and ponds may be drawn down to expose the sediments. In some cases lakes may be siphoned or pumped out. Over the winter, the bottom freezes and destroys roots, vegetative parts and susceptible seeds. Winter drawdown does not kill algae. Several Connecticut Lakes have gained control over weed problems using this method.

There are several advantages to overwinter drawdown including: no loss of summer recreational utility during project, virtually no-cost, and by concentrating fish populations there may be an increase in the growth rates of predator fish because of a reduction in the energy used for foraging for prey species. While the water level is down it is possible to selectively excavate sediments from areas that are particularly shallow or weed infested. These nutrient rich sediments should be deposited at a site removed from the lake so as not to become a source of sedimentation or nutrients to lake waters. Excavation activities may require state or local inland wetlands permits.

There are some disadvantages to overwinter drawdown including: lowering the water table significantly may dry up shallow wells around the lake, there may be possible downstream flooding during the drawdown, some species of weeds are not controlled by this method, and the method is non-selective and may result in the loss of fish and aquatic organism habitat. All of these considerations should be thoroughly examined prior to lowering the lake level.

About The Team

The Eastern Connecticut Environmental Review Team (ERT) is a group of professionals in environmental fields drawn together from a variety of federal, state, and regional agencies. Specialists on the Team include geologists, biologists, foresters, climatologists, soil scientists, landscape architects, archeologists, recreation specialists, engineers and planners. The ERT operates with state funding under the supervision of the Eastern Connecticut Resource Conservation and Development (RC&D) Area--an 86 town area.

The Team is available as a public service at no cost to Connecticut towns.

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 reviewing a wide range of projects including subdivisions, sanitary landfills, commercial and industrial developments, sand and gravel operations, elderly housing, recreation/open space projects, watershed studies and resource inventories.

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 officials of a municipality or the chairman of town commissions such as planning and zoning, conservation, inland wetlands, parks and recreation or economic development. Requests should be directed to the Chairman of your local Soil and Water Conservation District. This request letter should include a summary of the proposed project, a location map of the project site, written permission from the landowner allowing the Team to enter the property for purposes of review, a statement identifying the specific areas of concern the Team should address, and the time available for completion of the ERT study. When this request is approved by the local Soil and Water Conservation District and the Eastern Connecticut RC&D Executive Council, the Team will undertake the review on a priority basis.

For additional information regarding the Environmental Review Team, please contact Elaine A. Sych (774-1253), Environmental Review Team Coordinator, Eastern Connecticut RC&D Area, P.O. Box 198, Brooklyn, Connecticut 06234.