AMSTON LAKE FILE

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ENVIRONMENTAL IMPACT OF ADDITIONAL RESIDENTIAL DEVELOPMENT ON AMSTON LAKE

PREPARED FOR THE
HEBRON PLANNING & ZONING COMMISSION

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Section I

Engineers — Planners — Landscape Architects

I. Introduction

With the sewering of the Hebron side of the Amston Lake watershed nearing completion, the Hebron Planning & Zoning Commission is contemplating amending the Amston Lake zoning district requirements to address the revised spatial requirements for each building lot. As part of the rezoning analysis, the Commission requested that a determination be made of possible additional environmental impacts on Amston Lake based on various sizes of building lots.

This environmental impact study concentrates on identifying the phosphorous loadings on Amston Lake and what, if any, limiting factors there may be. Phosphorous was chosen for the study vehicle because it is the most effectively controlled nutrient in a watershed with fairly advanced amounts of development. Since one half of the nitrogen loading to the lake from septic systems will be effectively removed once the sewer system on the Hebron side of Amston Lake is completed, nitrogen levels in the Amston Lake watershed were not extensively investigated as part of this report.

Phosphorous is an important measure in determining the relative health of a water body and what stage the pond or lake may be in as far as the eutrophication process is concerned. As described in the Connecticut Department of Environmental Protection's Watershed Management Guide For Connecticut Lakes, eutrophication is the process of lake aging caused by enrichment of the pond or lake with nutrients contributed from its surrounding watershed. 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.

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.

This study addresses the existing conditions of Amston Lake and what additional residential development may occur without creating an adverse environmental impact on the trophic status of the Lake.

PARE ENGINEERING CORPORATION

Section II

Engineers — Planners — Landscape Architects

II. Existing Conditions

As taken from the Environmental Review Team Report of Amston Lake completed in June, 1984, Amston Lake is 184 acres in size and is bisected by the Hebron-Lebanon town line. The drainage area of Amston Lake encompasses approximately 680 acres or 1.06 square miles and has a mean depth of approximately 6 feet. Nearly 53 percent of the land area within the watershed lies within the Town of Hebron, 36 percent of the land area lies within the Town of Lebanon and the remaining 11 percent lies in the Town of Colchester. The drainage area of Amston Lake may be defined as the geographical area from which the runoff ultimately drains into the lake. The drainage area as shown by the accompanying topographic map, tends to follow along the crests of the hills surrounding the lake (see Figure 1).

The water level of Amston Lake is controlled by an earthen dam on the western side of the lake. A concrete spillway is located in the middle of the dam. The outlet stream for Amston Lake, which is unnamed, is a tributary of the Raymond Brook.

Topography

The topography throughout the drainage area ranges from gentle to steep slopes. Steepest slopes, which are found in the northwestern portion of the drainage basin are associated with areas where bedrock is at or near the surface. Slopes also rise steeply to the east from the eastern shore of Amston Lake. The southeast portion of the drainage area is characterized by moderate slopes. This area has been extensively developed for residential use (summer as well as year round). The eastern shoreline of the lake in the Town of Lebanon has also been developed for residential use at high intensity. Gentle slopes predominate in the southern parts of the drainage area.

Maximum and minimum elevations in the drainage basin are 650 feet and 445 feet above mean sea level, respectively. Glacial till covers approximately 87 percent of the watershed while stratified drift areas make up 4 percent of the watershed. The remaining 9 percent or approximately 59 acres of the surficial watershed is made up of Inland wetland soil groups, (see figures 2 & 3, Table 1).

Hydrology

The mean annual flow from Amston Lake was determined by a methodology described in Connecticut Water Resources bulletin No. 31 and is estimated to be 1.09 million gallons per day or 1.70 cubic feet per second. The groundwater flow pattern in the watershed parallels the surface flow pattern to a great extent.

Mean Annual Flow (1.09 million gal per day

1.7 Cubic feet per sec

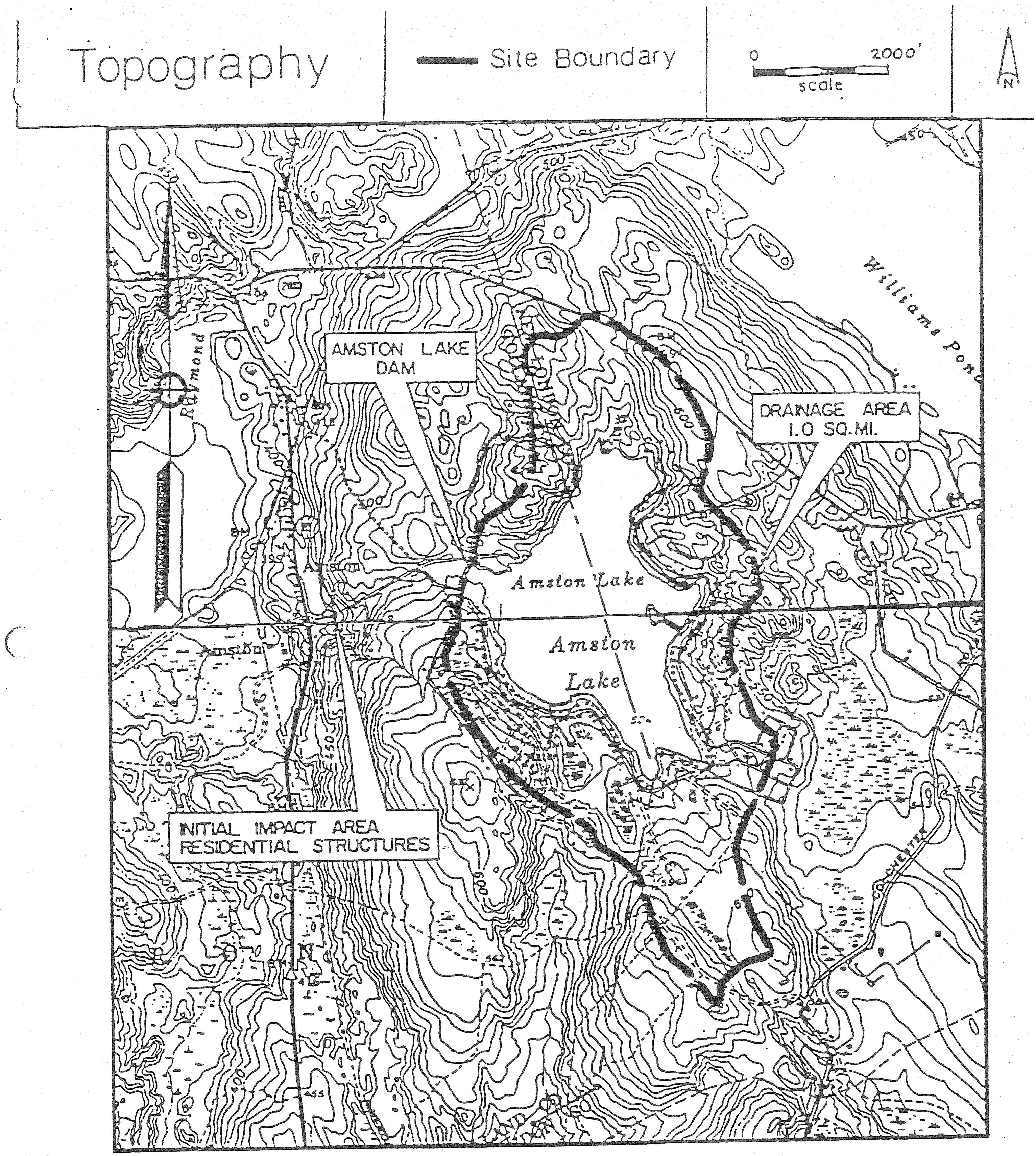

Topography
Site Boundary
0
2000'
scale
N
AMSTON LAKE
DAM
DRAINAGE AREA
1.0 SQ.MI.
INITIAL IMPACT AREA
RESIDENTIAL STRUCTURES
Amston Lake
Amston
Lake
Amston
Williams Pond
Richmond
500
600
450
400

FIGURE 1

Surficial Geology

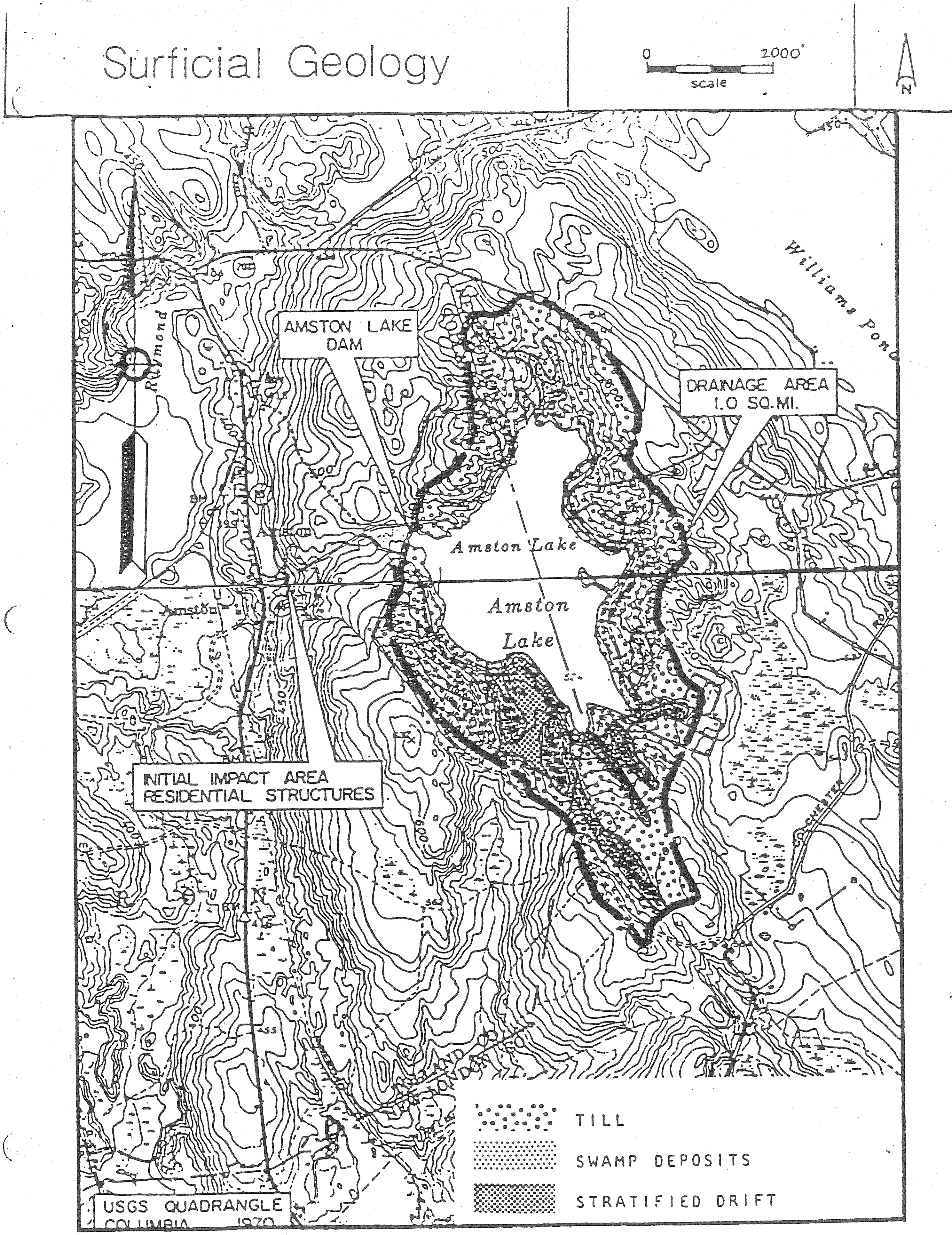


FIGURE 2
(4)

Soils

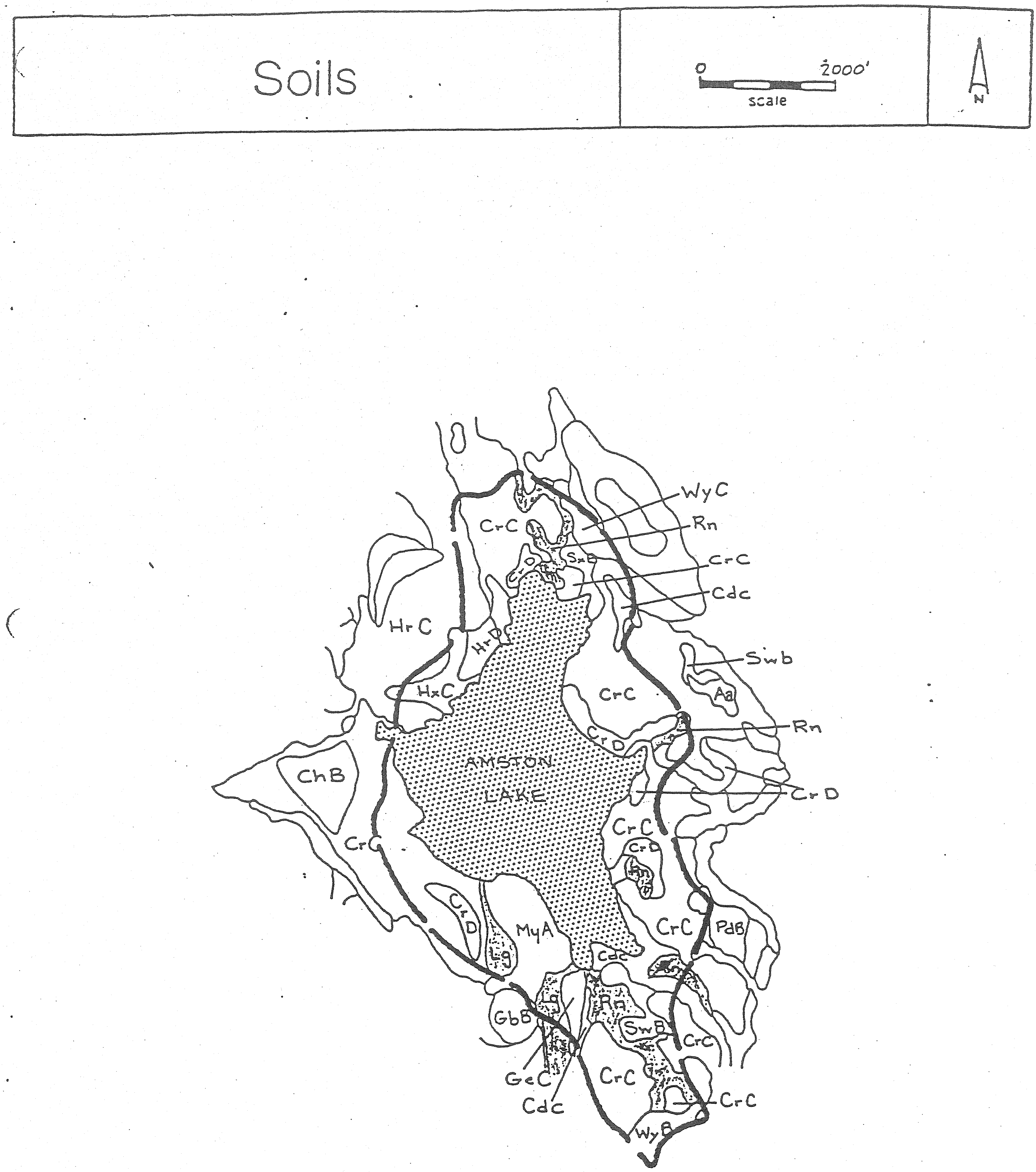


FIGURE 3

(5)

TOLLAND COUNTY

Map Symbol	Mapping Unit Names	Hydrologic Group
ChB	Canton and Charlton fsl, 3 to 8% slopes, very stony	B
ChC	Canton and Charlton fsl, 8 to 15% slopes, very stony	B
ChD	Canton and Charlton fsl, 15 to 35% slopes, very stony	B
CrC, CeC	Canton and Charlton fsl, 3 to 15% slopes, extremely stony	B
CrD	Canton and Charlton fsl, 15 to 35% slopes, extremely stony	B
GbB	Gloucester gravelly sl, 3 to 8% slopes, very stony	A
HrC	Charlton-Hollis complex, 3 to 15% slopes, very rocky	B
HrE	Charlton-Hollis complex, 15 to 45% slopes, very rocky	B
HxC	Hollis-Charlton-Rock outcrop complex, 3 to 15% slopes	C
Lg	Ridgebury, Leicester and Whitman fsl, extremely stony	C
MyA	Merrimac sl, 0 to 3% slopes	A
Pk	Carlisle muck	D
Pm	Adrian and Palms	D
SxA, SxB	Sutton fsl, 2 to 15% slopes, extremely stony	B

NEW LONDON COUNTY

Map Symbol	Mapping Unit Names	Hydrologic Group
Aa	Adrian and Palms mucks	D
CbB	Canton and Charlton fsl, 3 to 8% slopes	B
CcC	Canton and Charlton fsl, 8 to 15% slopes	B
CdD	Canton and Charlton fsl, 15 to 35% slopes	B
CrC	Charlton-Hollis fsl, 3 to 15% slopes, very rocky	B
CrD	Charlton-Hollis fsl, 15 to 45% slopes, very rocky	B
HrC	Hollis-Charlton-Rock outcrop complex, 3 to 15% slopes	C
HrD	Hollis-Charlton-Rock outcrop complex, 15 to 45% slopes	C
PbD	Paxton and Montauk fsl, 15 to 25% slopes	C
PdB	Paxton and Montauk fsl, 3 to 8% slopes, very stony	C
Rn	Ridgebury, Leicester, and Whitman fsl, extremely stony	C
SwB	Sutton fsl, 0 to 8% slopes, very stony	B
SxB	Sutton fsl, 0 to 8% slopes, extremely stony	B
WxA	Woodbridge fsl, 0 to 3% slopes	C
WxB	Woodbridge fsl, 3 to 8% slopes	C
WyB	Woodbridge fsl, 0 to 8% slopes, very stony	C

The soils around this lake are mostly of glacial till origin. A few glacial outwash soils are along the southern end of the lake.

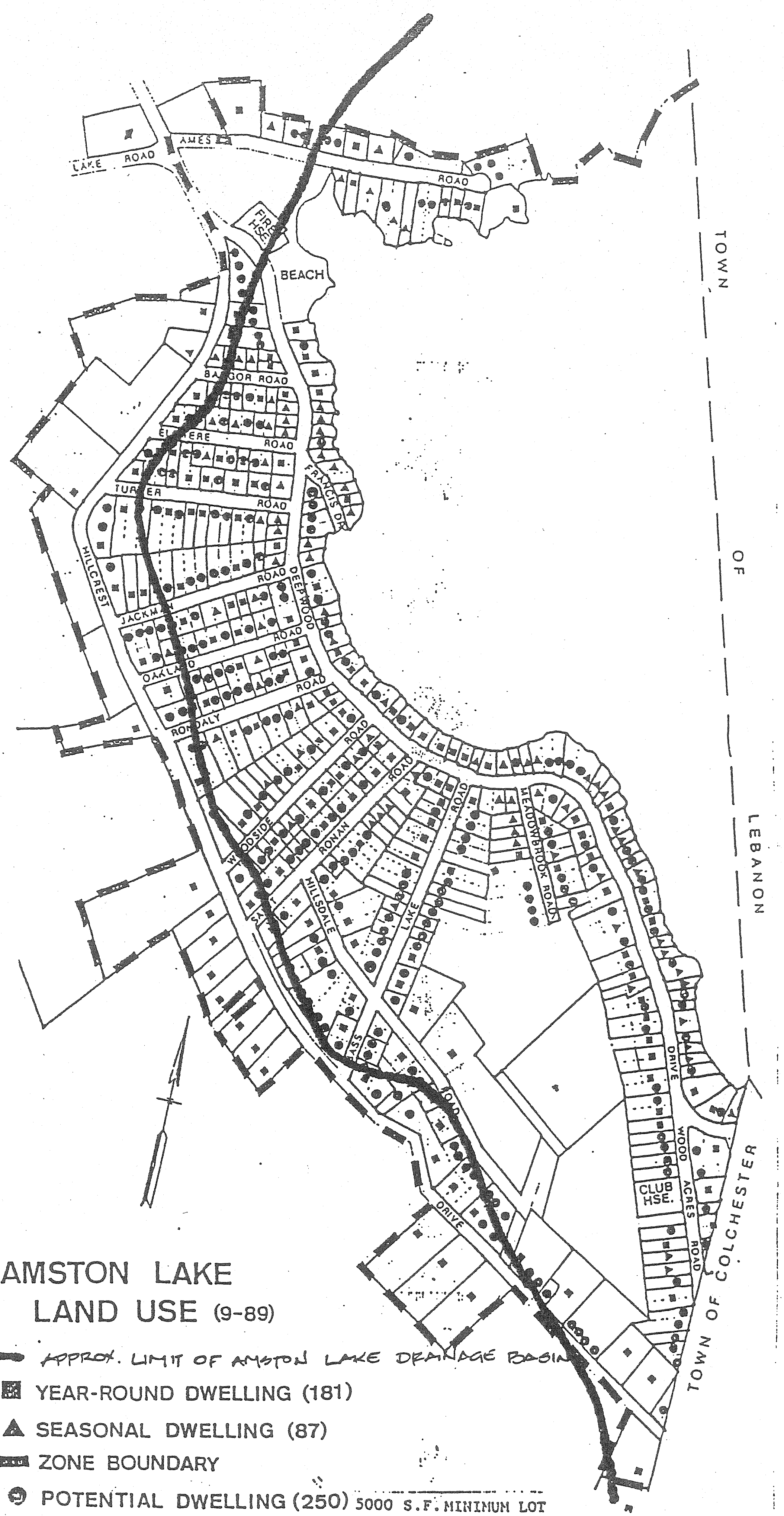
Slope, and shallow depths to bedrock and hardpans are the most limiting factors of these soils. They range from excessively drained to poorly drained. The poorly drained soils are mostly along stream channels.

The land use around the lake is mostly residential. The use of on-site septic systems in areas of steep slopes, hardpans and shallow depths to bedrock may eventually have an impact upon the lake if they are not properly designed.

TABLE 1

Residential Development

Currently 83 seasonal and 140 year 'round residences are located within the watershed in Hebron (see Figure 4) while 155 seasonal and 78 year 'round residences are located within the watershed in Lebanon. In Colchester, 11 residences are located within the Amston Lake watershed. The majority of these dwellings are located along the eastern, southern and western shores of the lake. The northern shores are presently relatively free of development pressures.



AMSTON LAKE
LAND USE (9-89)

- APPROX. LIMIT OF AMSTON LAKE DRAINAGE BASIN
- YEAR-ROUND DWELLING (181)
- SEASONAL DWELLING (87)
- ZONE BOUNDARY
- POTENTIAL DWELLING (250) 5000 S.F. MINIMUM LOT

PARE ENGINEERING CORPORATION

Section III

Engineers — Planners — Landscape Architects

III. Environmental Analysis

The Environmental Analysis of the Amston Lake Drainage Basin is based on an allowable loading of nutrients to the lake. The National Academy of Sciences (NAS) has defined lake phosphorous concentrations for each marginal trophic state. These spring overturn concentrations have also been adopted by the Connecticut Department of Environmental Protection and are shown below.

Trophic State	Total Phosphorous (ppb)
Oligotrophic	<15
Mesotrophic	15 - 25
Meso-eutrophic	25 - 30
Eutrophic	>30

These spring overturn concentrations determine the amount of summer algae and aquatic plant growth. The total phosphorous values shown above are independent of the size of the lake or drainage basin. However each lake is different. This analysis addresses the hydrologic characteristics of the Amston Lake Drainage Basin to determine the nutrient tolerance or allowable nutrient supply of the lake at each trophic state.

Nutrient budgets or tolerance limits may be used as guidelines for watershed management to determine the amounts and types of future development which are acceptable. If the calculated annual phosphorous loading rate is greater than the estimated budget (allowable supply), control measures may be instituted in the problem areas. Control measures may be desirable in any case to allow future development to occur without advancing the eutrophication of the lake.

This analysis utilizes the Dillon-Rigler Model to determine the existing and future phosphorous loading rates to Amston Lake.

The Dillon-Rigler Model is designed to calculate the Unit Phosphorous Loading in grams of Phosphorous per square meter of lake surface area per year (A). The Model may be slightly changed to calculate the Allowable Phosphorous supply per year (B).

(A) $L = \frac{[P] \cdot \bar{z} \cdot e}{(1-R)}$ (B) $P = \frac{[P] \cdot Q}{(1-R)}$

Where;

L = the annual phosphorous input from all exterior sources in grams of total phosphorous per square meter of lake surface area.

[P] = the mean in-lake concentration of total phosphorous in milligrams per liter (mg/l) at spring overturn.

$\bar{z}$ = the mean depth of the lake in meters.

e = the flushing rate in times per year.

R = The retention coefficient, the proportion of phosphorous input that does not pass through the outflow.

Q = the volume of water passing through the lake in cubic meters per year.

P = the annual phosphorous input in grams/year. Easily converted to kilograms per year.

This methodology has been used by the Windham Regional Planning Agency for Columbia Lake in the Town of Columbia; Lake Wangumbang in the Town of Coventry; and Lake Chaffee in the Town of Ashford as well as other lakes in Connecticut.

The annual phosphorous input from the Amston Lake watershed, which is so important in the Dillon-Rigler Model comes from a number of different sources. For this watershed, phosphorous contributions from soil erosion, motor vehicles, septic systems and direct atmospheric fallout were addressed. Sources not deemed to be significant contributors of phosphorous include, abandoned private residential landfills, livestock and waterfowl.

The analytic models used for the soil erosion, vehicular, septic system and direct atmospheric fallout are as follows:

Phosphorous from Erosion-Related Sources

The following three formulae are used to calculate the phosphorous from these sources.

(1) E = b x A x R x K x LS x C x Pr

(2) S = Sd x E

(3) PE = m x Cx(PT) x Rp x S

Where;

E = the estimated erosion in metric tons/yr., as calculated by formula (1).

b = a dimensional constant = 224.2. One ton/acre/yr = 224.2 metric tons/km/yr.

A = the area in square kilometers.

R = a rainfall factor = 150. Determined by the U.S. Soil Conservation Service (SCS), it represents the erosive potential of a normal year of precipitation in the Berkshires.

K = a soil erodibility factor. It is estimated by SCS for every type of soil in Connecticut.

LS = a factor expressing the combined effect of length and degree of slope. It too is estimated by SCS. Of its two components, the slope is by far the most consequential. See Figure 1.

C = a cover factor expressing the erosion protection provided by various types of ground cover. It generally ranges from 0.005 for forests in this area to 0.30 for highly developed industrial and commercial lands. Well documented in essentially every study of urban runoff, there are many reasons erosion increases with the intensity of development: (1) loss of canopy to check the erosion splash effect of driving raindrops; (2) loss of capacity of the ground surface to absorb short duration rains and to absorb much of the erosive energy of overland flow; (3) increased bareness of the surface during construction, maintenance and use; and (4) greatly increased production of more erodible material such as dust, mud and the discarded residues of civilization.

Pr = an erosion control practice factor determined by SCS. It is typically about 0.8 for cropland in this area and 1.0 for other lands.

S = annual sediment in metric tons/yr, as calculated by formula (2).

Sd = the sediment delivery ratio. It expresses the proportion of erosion that enters water courses to become sediment. It varies inversely between 0.22 for a small 0.1 km drainage area to 0.02 for a 750 km area (see Table 4).

PE = the quantity of erosion-related phosphorous entering the lake in kg P/yr, as calculated by formula (3).

m = a dimensional constant, 10 (1000 kg/metric ton 100 percent).

CS (PT) = the percentage of total phosphorous typically found in the surface soils in the study area, 0.065.

Rp = the phosphorous enrichment ratio. It reflects the physical-chemical fact that phosphorous is more likely to adhere to the finer soil particles, which are also more erodible. An average figure is 2.35, but a lower figure, 2.0, is used to recognize the fact that the soil particles generally in Connecticut (as observed in our study of the K-factors described above) are significantly coarser than average.

Figure #5

Slope-Effect Chart (Topographic, LS) Source: SCS

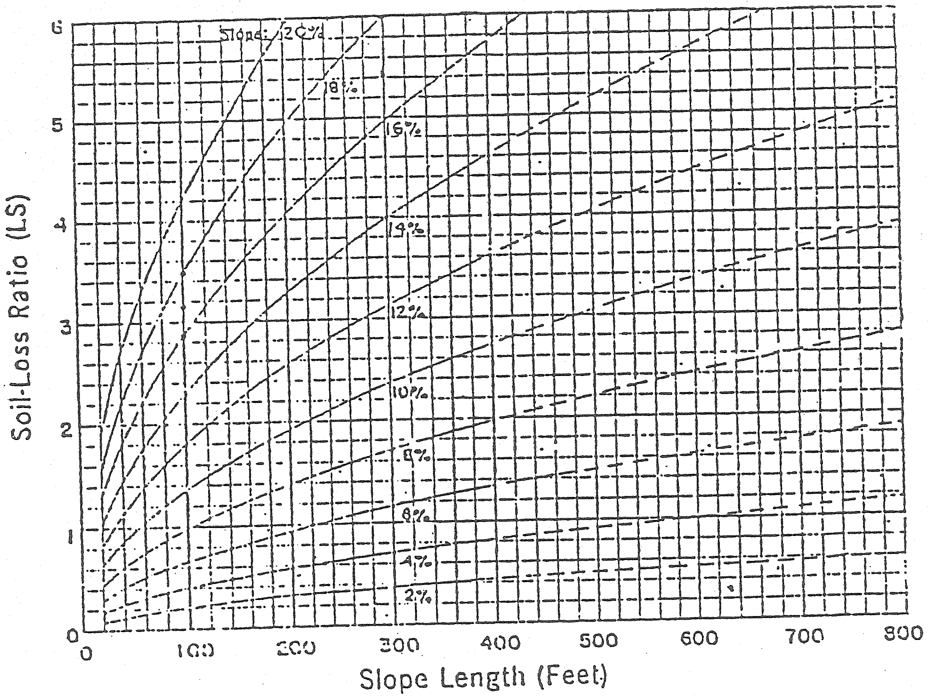


Table #2

Sediment Delivery Ratios

Drainage Area (km^2)	Sediment Delivery Ratio (S_d)*
0.1	.22
0.2	.19
0.3	.17
0.4	.16
0.5	.15
0.6	.15
0.7	
1.0	.14
1.5	.13
	.13
2.0	.12
2.5	.12
3.0	.11
	.11
4.0	.11
5.0	.10
7.0	.10
8.0	.09
9.0	.08
10.0	.08
15.0	.07
20.0	.06
30.0	.06
40.0	.05
75.0	.05
100.0	.04
150.0	.04
200.0	.03
300.0	.03
500.0	.02
750.0	.02
1000.0	
1181.0**	

*The ratios of the total annual erosion estimated by the universal soil loss equation to the measured annualized quantity of sediment downstream.
**Size of the Housatonic River watershed above the water quality sampling Station HS-26.

Figure # 5

Slope-Effect Chart (Topographic, LS) Source: SCS

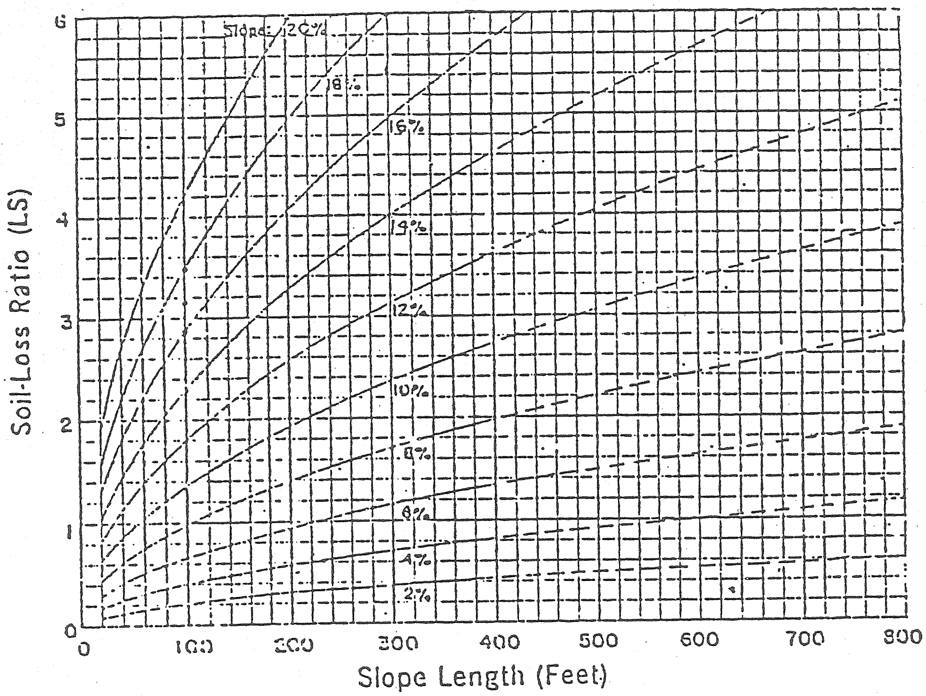


Table # 2

Sediment Delivery Ratios

Drainage Area (km^2)	Sediment Delivery Ratio (S_d)*
0.1	.22
0.2	.19
0.3	.17
0.4	.16
0.5	.15
0.6	.15
0.7	
1.0	.14
1.5	.13
	.13
2.0	.12
2.5	.12
3.0	.11
	.11
4.0	.11
5.0	.10
7.0	.10
8.0	.09
9.0	.08
10.0	.08
15.0	.07
20.0	.06
30.0	.06
40.0	.05
75.0	.05
100.0	.04
150.0	.04
200.0	.03
300.0	.03
500.0	.02
750.0	.02
1000.0	
1181.0**	

*The ratios of the total annual erosion estimated by the universal soil loss equation to the measured annualized quantity of sediment downstream.

**Size of the Housatonic River watershed above the water quality sampling Station HS-26.

Phosphorous from Motor Vehicles

(1) Measure the length of each road within each subbasin (in inches) on a USGS topographic map. Small town roads may be considered together. Convert the road lengths to kilometers at map scale.

(2) Obtain average daily traffic counts from the Department of Transportation for state roads and the regional planning agency for large highly used town roads. Convert daily counts to yearly counts.

(3) Calculate the vehicle kilometers traveled by multiplying the length by the vehicles per year.

(4) Calculate the annual phosphorous by the following equation for each road within each subbasin: Yi = CI x Ax x VKT(2,6).

where:

Yi = supply of total phosphorous in kilograms per year (kg/yr.)

Ci = phosphorous deposition rate: 4.03 x 10 ke/axle-km

Ax = average number of axles per vehicles: 2.1

VKT = vehicles kilometers traveled

(5) Calculate the total phosphorous supply for each subbasin by summing the phosphorous supplies of all roads calculating the total phosphorous for the entire basin.

Phosphorous from Direct Atmospheric Fallout

Phosphorous falling directly on the lake surface through wet and dry precipitation has been estimated by Wetzel, 1975 (9) and utilized for Columbia Lake by Rich and Pallotti, 1977 (10). This unit value is estimated at 100 $mg/m^2/yr.$ recognizing that southern New England is located in a high pollution corridor downwind of the large industrial complex of New York-New Jersey (10). Expanding this unit value proportionately to 100 kg/km^2 and multiplying by the lake surface area (in Km^2) will yield the direct atmospheric fallout of phosphorous in kilograms per year.

Phosphorous from Septic Systems

Because of great inadequacies and deficiencies in the quantification of phosphorous from septic systems, the Center for the Environment and Man, Inc., has developed its own methodology. The methodology is a five-step process. To the knowledge of the WRPA, the CEM methodology is the best available at this time (1980). The five-step process is as follows:

(Step 1) Estimate the phosphorous which enters a typical septic system from home appliances and human waste (for both seasonal and year-round dwelling use)

(Step 2) Estimate the housing use within 300' of the lake and its tributary surface waters.

(Step 3) Estimate the housing use by soil type and distance from the lake utilizing the data from Step 2.

(Step 4) Estimate the effective life of septic systems (leaching fields) for attenuating phosphorous. (See next section: Estimating the effective life of converted septic systems for attenuating phosphorous.

(Step 5) Extract from Step 4 all systems that are currently contributing and those that will by a future date (say year 2015) and calculate the total load utilizing the data from Step 1.

Table ~~5~~ 3

Phosphorus Contributions per Dwelling at Webster Lake

Contributor	Effluent from Septic System kg P/Capita/Yr[1]	Percent of Dwellings with Contributor[2]		Occupancy Rate per Capita Years/Yr		Effluent from Septic System kg P/Yr[4]	
		Year-Round	Seasonal	Year-Round	Seasonal	Year-Round	Seasonal
Urine	0.69	100	100	3.5	1.1	2.42	0.76
Feces	0.08	100	100	3.5	1.1	0.28	0.09
Bathroom Sink	0.05	100	100	3.5	1.1	0.18	0.06
Kitchen Sink without Garbage Grinder	0.02	100	100	3.5	1.1	0.07	0.02
Clotheswasher	0.57	80	10	3.5	1.1	1.60	0.06
Dishwasher	0.17	35	5	3.5	1.1	0.21	0.01
Garbage Grinder	0.11	5	--	3.5	1.1	0.02	--
Total	1.69					4.78	1.00

[1] Estimated from Lask (12), except for dishwasher and garbage grinder which are estimated by CEM.

[2] Last three entries in each column estimated by averaging CEM interview data obtained from knowledgeable local residents. For year 2000 conditions, change these three entries to 95, 60 and 40 percent for year-round and to 30, 15 and 10 percent for seasonal.

[3] Equals 4 people at 100 days a year.

[4] For year 2000 conditions, change the last three entries and the total to 1.90, 0.36, 0.15 and 5.36 for year-round and 0.19, 0.03, 0.01 and 1.16 for seasonal.