PHYSICAL CHARACTERISTICS OF INSHORE MONITORING SITES
AN APPENDIX TO:
THE LAKE GEORGE INSHORE CHEMICAL MONITORING PROGRAM

1987 - 1991

Submitted to

The Lake George Association Fund

by

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EXECUTIVE SUMMARY

Initiated in 1986, the Lake George Inshore Chemical Monitoring Program was designed to provide information on the impacts of various types of shoreline usage on the nearshore water quality of the lake. This program's initial, and continuing purpose, is to compare terrestrial impacts on nearshore water quality from various types of land uses found within the Lake George basin. Four types of common land uses were identified and monitored in this study. These types included: marina operations, high usage commercial areas, high density residential areas, and undeveloped shorelines.

In the current effort, a detailed assessment of each site was devised to determine: 1) representativeness of the land use classification assigned, 2) watershed area of the different sites, 3) characteristics of the sub-catchments monitored, and 4) the quantity and quality of surface runoff from each site.

Among the physical aspects identified, the major findings are listed below.

- The soils described for all sites have slow to moderate water infiltration rates although a number of different soil types were identified among the sites.
- The potential for surface runoff of all soils was moderate.
- Sub-catchments ranged in area from 0.16 to 3.77 acres.
- Slopes among the sites ranged from 3 to 17%.
- The time of concentration for all sites (the time required for water to travel from the furthest point in the sub-catchment to the lake) was less than one hour. Thus, the time runoff waters were in contact with the soils was less than one hour.
- Impermeable areas negatively affect a site's ability to effectively capture and infiltrate runoff waters. The percentage of impermeable area was a reflection of that site's usage. The percentage of impermeable area for each site category is listed below.

Undeveloped	0 %
Residential	40 %
Commercial	32 %
Marina	90 %

As the percentage of impermeable area increased, so did runoff volumes, indicative of the direct relationship between impermeable area and the amount of runoff reaching the lake.

- Using loading estimates from national averages, the estimated nutrient loading rates for each Inshore site category were calculated. Considering phosphorus, the limiting nutrient for Lake George algal productivity, Undeveloped sites showed the lowest loading estimates with increasing inputs from more developed areas. A similar progression for nitrogen inputs, another major nutrient controlling productivity of Lake George, was observed.

Category	Phosphorus (lbs./year)	Nitrogen (lbs/year)
Undeveloped	0.03	0.78
Residential	0.58	4.74
Commercial	2.88	18.90
Marina	3.24	25.60

The findings of this program indicate that the sites chosen were quite similar in terms of soil type, runoff velocity, slope and potential for infiltration of runoff waters. Major differences centered on extent of impermeable area and watershed size.

The categories chosen for assessment in the Inshore Monitoring Program are accurately represented if one assumes that degree of development can be directly related to extent of impermeable area. For the above table, one sees that this assumption was true for the sites sampled. That is, as a site was more intensively used, the percent of the land area that was impermeable to rainfall and runoff increased. Whether a site is described by actual use (e.g. marina) or by percent of impermeable area, the fact exists that more intensive use yields runoff with higher concentrations of nutrients and pollutants.

INTRODUCTION

Initiated in 1986, the Lake George Inshore Chemical Monitoring Program was designed to provide information on the impacts of various types of shoreline usage on the nearshore water quality of the lake. This program's initial, and continuing purpose, is to compare terrestrial impacts on nearshore water quality from various types of land uses found within the Lake George Basin. Four types of common land uses were identified and monitored in this study. These types included: marina operations, high usage commercial areas, high density residential areas, and undeveloped shorelines. Water samples were collected in close proximity to the shoreline (shallow waters) in order to reduce the effects of dilution and to better quantify the terrestrial effects on water quality.

Since the start of this program (1986), nearshore waters have consistently shown higher concentrations of essential nutrients for algal and macrophyte growth (nitrogen and phosphorus) than found at open water sites (Eichler, Clear, and Boylen; 1990). The established sites in the Bolton Bay area have shown that the unimpacted or largely undeveloped areas have the lowest concentration of nutrients and contaminants when compared to nearshore waters of developed shorelines (Eichler, Clear and Boylen; 1989a; 1990a). Elevated nutrient concentrations associated with certain shoreline types have been attributed to resuspension of shallow sediments due to heavy recreational usage, runoff of applied yard care products such as fertilizers, and inputs from faulty or overloaded septic systems. Other possible inputs include terrestrial runoff of highway deicing materials and other pollutants associated with motor vehicles. Petroleum and corrosion products are deposited on road surfaces and become incorporated into stormwater runoff which, if not allowed to infiltrate the soil, eventually enter the lake.

In 1990, for the first time, the Inshore Program used an event-based sampling design in order to determine terrestrial inputs at times of increased runoff associated with rainfall. Although this sampling design provided information about increased short-term chemical inputs, it proved to be time and cost prohibitive. The timing and scheduling around events, and manpower restraints did not allow for the continuation of event-based sampling beyond 1990. The 1991 Program returned to a fixed-time sampling regime as used in previous years. This sampling design provides quantification of the ambient concentrations of chemical constituents over the course of the sampling period. The fixed time sampling method allows for a more comprehensive view of the changes in nearshore water chemistry as compared to the open water condition.

With the completion of 5 years of data collection, the goals of this program were reviewed to assure that data collection and analysis protocols are providing the information desired from this program. Site selection/validation was identified as an area where more information was necessary. That is, were the sites selected:

1) representative of the land use classification assigned,
2) comparable in watershed area, and
3) *characteristic of the land use types defined in the Program.*

An intensive investigation of each site involved in the Inshore Program was devised to answer some, if not all, of the above questions.

Considered to be of primary importance in comparing each site and its impact on nearshore water quality are elements making up its runoff characteristics. Some of these elements include subcatchment area, soil types, slope, and types of cover (e.g. impermeable vs. permeable) among others. The five years of data collected are reviewed in light of the findings of the survey. Comparability of sites and characterization of impacts to inshore water quality were related to different land uses within each of the subcatchment types.

STUDY SITE

The extended study site encompasses the Bolton/Huddle Bay area of Lake George, New York. The shoreline types and usages within this area include a wide range of activities including: wetlands, forests, town parks, residential areas, hotels/motels, and marinas. Recreational use (boating and swimming) within this area is moderate to heavy during the peak summer (June-August), which corresponds to the sampling period for this project.

Eight specific sites were chosen according to land-use category. Sites were chosen within close proximity to each other, hence the Bolton/Huddle Bay area, in order to minimize the effect of intra-lake differences in water chemistry (Figure 1).

METHODS

In determining the specific site characteristics, a number of factors were considered and evaluated. These factors include watershed area, soil type, hydrologic soil type, slope, and cover types. Integration of these elements allows a formulation of runoff curves and discharge rates for each site.

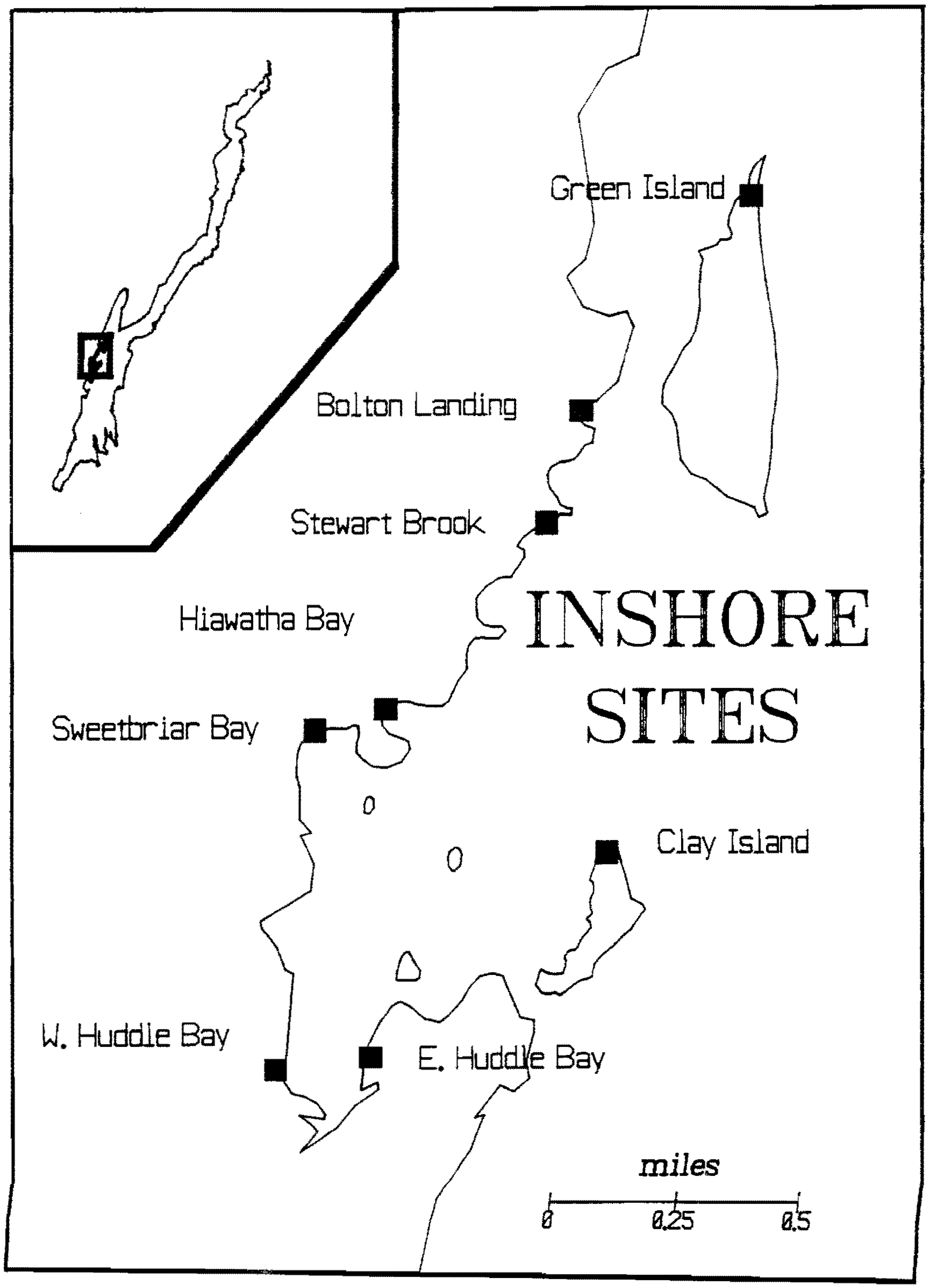
Watershed area for each site was initially identified from 7.5" U.S. Geologic Survey (USGS) topographic map. On-site inspections were then carried out in order to identify more specific conditions that may affect water movements. These more specific inspections were vital due to the relatively small watersheds being considered, where small changes in water movement patterns can have a significant effect on watershed areas. After site areas were verified, the map information was digitized and entered into the MapInfo Geographic Information System (GIS) where specific watershed areas were determined.

Soil types were determined from U.S. Dept. of Agriculture, Soil Conservation Service (USDA SCS) soil maps. Hydrologic soil types were also determined from the Warren County Soil Survey (USDA, 1989).

Slope for each site was calculated from elevations on USGS topographic maps, and from on-site inspection. Types of cover were categorized as either permeable or impermeable. Permeable areas included tree, shrub, or grass cover and were determined by on-site inspection to be a percentage of the total site area. Impermeable areas included covered structures and paved parking areas. Areas of all structures were verified from Town of Bolton tax maps. Paved areas along with all other cover types were determined as a percentage of site area and estimated from on-site inspection.

Runoff volumes and peak discharge rates were determined for each subcatchment by using the computerized method TR-55, (USDA, 1986) developed by the Soil Conservation Service. The computerized model, TR-55, takes into account many aspects of the subcatchments such as area, soil type, slope, length, and type of cover.

Figure 1. Map of the Bolton Bay area of Lake George, indicating the location of the Inshore sampling sites..



RESULTS AND DISCUSSION

SOIL TYPES

Of major importance to understanding how land uses adjacent to a lake impact nearshore water quality are the soils present. Soils, in part, control the rates of infiltration (percolation) of runoff waters, the volume of surface runoff, and the chemical characteristics of the runoff. Soil permeability or the ability to infiltrate runoff waters, is defined as the quality of the soil that enables water to move downward through it. Permeability ranges from very slow (less than 0.06 inches per hour) to very rapid (more than 20 inches per hour) and is measured by percolation rate or the speed at which water moves downward through a saturated (fully wetted) soil. Soils also retain water, and their storage capacity is important to terrestrial vegetation as well as its influence on runoff water quality. The longer the runoff waters are in contact with the soils, the greater the nutrient removal efficiency. Soils and their associated plant and animal communities capture nutrients and pollutants in a variety of ways including:

- direct attachment or absorption to the surface of soil particles,
- utilization by microorganisms,
- uptake by plant roots, and
- retention as pore water found between the grains of soil.

Once captured, nutrients can be recycled through microbial activity and made available to terrestrial vegetation, converted to gases that diffuse from the soils or slowly released to the groundwater and ultimately the lake system.

Below is a list of the specific sites grouped into their original land usage category. Each subcatchment's soil type is given with a brief remark about its permeability and rate of surface runoff. Soil types, hydrologic groupings and suitability for infiltration devices are summarized in Table 1.

Undeveloped Sites

Green Island: The soils of this shoreline are Belgrade (BaA) silt loam. Permeability is moderate in the surface layer and slow to moderately rapid in the substratum. Surface runoff is rated as slow. Slow surface runoff indicates that the bulk of precipitation is allowed to infiltrate into the soils. Once in the soils, microbial activity and absorption to soil particles removes a substantial portion of the dissolved nutrients and contaminants prior to entry of the waters into the lake. This soil type also has a good storage capacity, retaining a portion of the precipitation and delaying runoff. This delay allows a longer period for nutrient removal. Due to their absorptive capability, these soils are also a good substrate for the growth of vegetation, as evidenced by the extensive forest canopy at this site. Terrestrial vegetation also slows runoff by a variety of means including direct uptake, surface wetting of their large leaf areas, and through accumulation of detrital materials (leaves and twigs) on the forest floor. Slowing or infiltrating runoff reduces erosion of terrestrially derived materials by slowing the velocity of runoff waters.

Clay Island: The soils for the entire delineated watershed for this site are composed of Bice-Woodstock (BeC), a very bouldery fine sandy loam. Permeability is moderate to moderately rapid and surface runoff is rated as medium. These coarse textured soils do not retain a large volume of water, and because infiltration is rapid, runoff waters do not stay in contact with the soils for very long. This lack of residence time reduces the efficiency of the soils to filter or absorb nutrients. Lack of nutrients coupled with rapid drying of these type soils limits their ability to support vegetation, another means for slowing runoff. The forest canopy at this site is open (scattered) with limited understory vegetation. The extremely small watershed associated with this site (0.16 acres) coupled with the flat slope (less than 3%) indicate a very limited amount of runoff from this site.

Residential Sites

Stewart Brook: Udorthents (Ud, smoothed) soils make up the drainage area for this site mainly due to the amount of construction that has taken place. These type soils are frequently fill and topsoil associated with developed areas. Permeability varies greatly over this classification of soils and depends on local conditions. At this site exposed bedrock makes up the northern border of the subcatchment and coarse sandy soils are observed in the outwash areas. The depth of soils in this area is probably shallow. Shallow soils coupled with moderately steep slopes result in rapid runoff. Excessive drying and lack of residence time for runoff waters are the principal limitations for growth of vegetation on these soils. Typical vegetation at this site is maintained lawn and shrubbery with scattered trees.

East Huddle Bay: Bice (BcB), a fine sandy loam, makes up the watershed soil at this site. Permeability is moderate to moderately rapid and surface runoff is medium. These soils retain a moderate volume of water, and allow runoff waters to remain in contact with the soils. Residence time allows a certain amount of nutrient capture and thus these soils support a moderate amount of terrestrial vegetation. Vegetation currently found at this site is maintained lawn, shrubbery and scattered trees. These soils are prone to erosion if vegetation cover is not maintained.

Commercial Sites

Hiawatha Bay: Bice-Woodstock (BeC) make up the soil type for this site, which consist of very bouldery fine sandy loams. Permeability is moderate to moderately rapid and surface runoff is medium. These coarse textured soils do not retain a large volume of water, and because infiltration is rapid, runoff waters do not stay in contact with the soils for very long. This lack of residence time reduces the efficiency of the soils to filter or absorb nutrients. Lack of nutrient retention coupled with rapid drying of these type soils limits their ability to support vegetation, another means for slowing runoff. Typical vegetation at this site includes maintained lawns and scattered trees with limited understory vegetation.

West Huddle Bay: The entire drainage area for this site is composed of Udorthents (Ud) soils which very greatly in permeability, depending on local conditions. These type soils are frequently fill and topsoil associated with developed areas. Permeability varies greatly over this classification of soils and depends on local conditions. At this site, exposed bedrock occurs at the lakeward border of the subcatchment and coarse sandy soils are observed in the outwash areas. The depth of soils in this area is probably shallow. Shallow soils coupled with moderately steep slopes result in rapid runoff. Excessive drying and lack of residence time for runoff waters are the principal limitations for growth of vegetation on these soils. Typical vegetation at this site is maintained lawn and shrubbery with scattered trees.

Marina Sites

Bolton Landing: Woodstock (WoC) soils typify the soil classification at this site. These soils are a fine sandy loam containing areas of rock outcrops. Permeability is moderately rapid and surface runoff is medium on soils and rapid on rock outcrops. Rock outcrops form the northern border of this site and serve to divide it from residential usage. These coarse textured soils do not retain a large volume of water, and because infiltration is rapid, runoff waters do not stay in contact with the soils for very long. Coupled with the rapid infiltration, the shallow depth of soil over bedrock further limits the ability of these soils to slow velocity or retain runoff waters. This lack of residence time reduces the efficiency of the soils to filter or absorb nutrients. Lack of nutrients coupled with rapid drying of these type soils limits their ability to support vegetation, another means for slowing runoff. Typical vegetation at this site is limited to a small area of maintained lawn in the central portion of the subcatchment and scrub vegetation on the northern margin.

Sweetbriar Bay: Bice-Woodstock (BeC) deposits make up the soil type for this site, which consist of very bouldery fine sandy loams. Soil permeability is moderate to moderately rapid and surface runoff is medium. These coarse textured soils do not retain a large volume of water, and because infiltration is rapid, runoff waters do not stay in contact with the soils for very long. This lack of residence time reduces the efficiency of the soils to filter or absorb nutrients. Lack of nutrients coupled with rapid drying of these type soils limits their ability to support vegetation, another means for slowing runoff. Typical vegetation at this site is limited to a small area of maintained lawn.

The table below (Table 1) gives each site, its predominant watershed soil type, hydrologic grouping, and its suitability rating for septic tank absorption fields. Three sites, but only one of the developed sites (East Huddle Bay, a residential site), are not on the town sewer. Information for infiltration devices such as septic tanks and their associated leach fields can be extrapolated to infiltration devices such as dry wells and detention ponds necessary for management of stormwater runoff. The footnotes within the table explain some of the definitions used.

With the exception of the undeveloped site at Green Island, the soil types present at the inshore sites are similar in their ability to percolate and retain runoff waters. All are in the moderate to moderately rapid range for soil permeability and their potential for surface runoff is medium. At Green Island, while runoff and percolation rates are slow to moderate, the shallow depth of the seasonal ground water table yields very limited contact time for runoff waters and severely limits the ability of these soils to capture and mediate surface runoff.

Table 1. Hydrologic soil classifications of Inshore sites.

Site	Soil Type	Hydrologic Group [1]	Septic Tank Suitability [2]
Green Island	BaA	B	severe; wetness, percs slowly
Clay Island	BeC	B	moderate; slope, percs slowly
Stewart Brook	Ud	C	severe; depth to rock
East Huddle Bay	BcB	B	moderate; percs slowly
Hiawatha Bay	BeC	B	moderate; slope, percs slowly
West Huddle Bay	Ud	B	moderate; slope, percs slowly
Bolton Landing	WoC	C	severe; depth to rock
Sweetbriar Bay	BeC	B	moderate; slope, percs slowly

[1] **Hydrologic Group**

Group B: moderate infiltration rate when thoroughly wet and a moderate rate of water transmission.

Group C: slow infiltration rate when thoroughly wet and a slow rate of water transmission.

[2] **Septic Tank Suitability:**

moderate: soil properties or site features are not favorable for indicated use and special planning, design, or maintenance needed to overcome or minimize the limitations.

severe: features so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possible increase in maintenance required.

HYDROLOGIC SOIL GROUPS

Hydrologic soil groupings are used to estimate runoff from precipitation. The classes were devised by the Soil Conservation Service in order to predict runoff, and are based on information from numerous studies throughout the United States. Soils not protected by vegetation are assigned to one of four groups coded A through D. They are grouped according to the intake of water when soils are thoroughly wet and receive precipitation from long duration storms. The four groups are:

A. Soils with high infiltration rate (low runoff potential) when thoroughly wet. These are mainly deep, well drained sands.

B. Soils with moderate infiltration rate when thoroughly wet. These are mainly moderately deep, well drained soils.

C. Soils with slow infiltration rate when thoroughly wet. These are mainly moderately fine soils with a slow rate of water transmission.

D. Soils with very slow infiltration rate (high runoff potential) when thoroughly wet. These are mainly clay soils with a very slow rate of water transmission.

Hydrologic soil groupings are one of the elements used in the TR-55 model to predict runoff volumes. Soil groupings for the inshore sites were assigned mainly B codes (see Table above) with only the Bolton Landing and Stewart Brook sites coded as C. These two sites have exposed bedrock outcrops and shallow soils which accelerate runoff and limit percolation. The B grouping indicates moderate rates of percolation and infiltration for runoff of stormwaters.

DRAINAGE BASINS

The drainage basin area for each of the sampling sites was determined from topographic maps and on-site inspections (Table 2). The sites displayed a range in basin sizes from Clay Island at 0.16 acres to Bolton Landing at 3.77 acres. Drainage area is determined by topographic characteristics of the sites, i.e. slope and orientation, coupled with any man-made diversions of runoff, and is not necessarily representative of groundwater movement. Groundwater movement is determined by underlying bedrock formations and seasonal water tables which are frequently unknown. The small size of the watersheds and their proximity to the lake however, strongly suggests that all water flow will be relatively shallow and ultimately enter the lake in a short period of time. Drainage basins for each of the sample sites are also separated from upstream parcels of land by roadways. These roadways all have water diversion systems (ditches & culverts) which direct upstream and adjacent runoff from the sample sites. Care was taken in initial site selection, to avoid sources of concentrated runoff such as streams or culverts, which might unduly bias results for the sample sites.

Based on slope, watershed size, soil characteristics, vegetation types and extent of impermeable area, the TR-55 model produces a time of concentration which is the time that is required for waters to travel from the furthest point in the watershed to the receiving body (the lake). Concentration times for all watersheds were under one hour, with a range of from 0.01 hours to 0.77 hours (Table 2). The small size of all the watersheds makes for very short transport times for all sites.

SLOPE CHARACTERISTICS

Watershed slope is an important factor controlling the velocity of runoff and the time allowed for infiltration. Slopes within the inshore watersheds were variable (Table 2), however, only small portions of any of the watersheds were considered as having steep slopes (>15%). Average slope ranged from 3 to 17% for the eight watersheds. The East Huddle Bay residential site produced the steepest slope. This site has a very small watershed and a steep bank at the waters edge, resulting in the steep slope value.

Table 2. Area, slope and time of concentration data for the inshore sub-catchments

Site	Sub-catchment (acres)	Time of Concentration (hours)	Slope (percent)
Green Island	0.47	0.77	3
Clay Island	0.16	0.29	8
Stewart Brook	0.94	0.26	10
East Huddle Bay	0.21	0.08	17
Hiawatha Bay	2.77	0.49	4
West Huddle Bay	2.04	0.32	12
Bolton Landing	3.77	0.35	5
Sweetbriar Bay	0.55	0.01	5

PERMEABILITY

On-site development alters the characteristics of the land, particularly its potential for runoff of stormwaters. While soil characteristics can determine the potential of a site for capture and infiltration of runoff waters, the influence is limited by the amount of structure built over them. Structures limit the exposure of the soils, and thus their ability to capture runoff waters. Structures determine the amount of permeable surfaces and ultimately determine overall site permeability. In Table 3, the percentage of permeable and impermeable surface for each site is listed. The area of structures for each site was determined from tax map data and visual inspections were conducted for verification.

Table 3. Watershed areas and percent of watershed with impermeable surface.

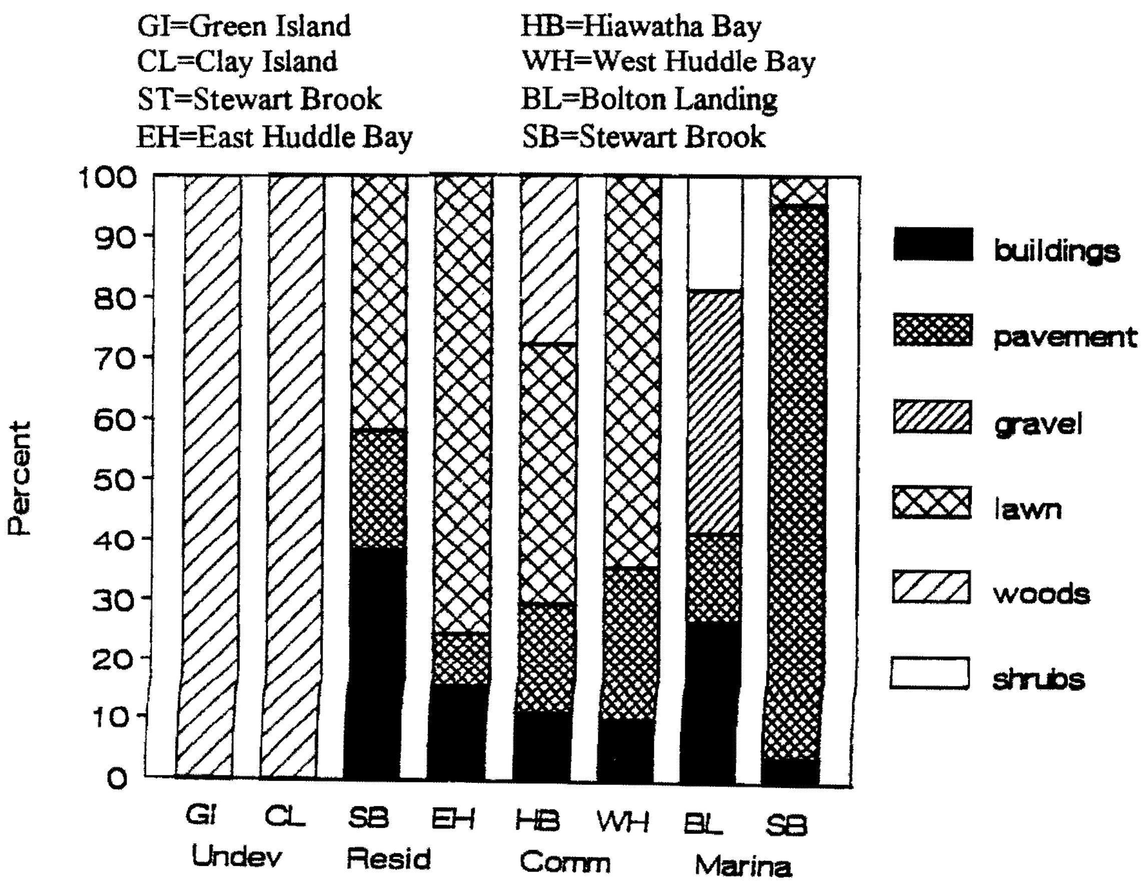
Site	Impermeable Area (percent)	Permeable Area (percent)
Green Island	0	100
Clay Island	0	100
Stewart Brook	58	42
E. Huddle Bay	23	77
Hiawatha Bay	28	72
W. Bolton Bay	35	65
Bolton Landing	81	19
Sweetbriar Bay	99	1

The area of impermeable surface at sites with some form of development, ranged from a low of 23% at East Huddle Bay to a high of 99% at Sweetbriar Bay. Figure 2 shows the extent of permeable and impermeable surfaces present at each site. The average level of impermeable surfaces for the four land use categories were:

Undeveloped	0%
Residential	40%
Commercial	32%
Marina	90%

The level of impermeable surfaces at each site ascend in order of degree of land usage with the exception of the residential site at Stewart Brook, where 58% of its area is impermeable compared to a range of 23 - 35% for the other sites in the residential/commercial group. At this site, a high level of build-up, encompassing roof areas, driveways, and roads contributed to the elevated level of impermeable surfaces for residential sites. By the above averages, the sites appear to fall into 3 groups rather than the four land use categories, with residential and commercial uses producing comparable levels of impermeable surfaces. The lack of permeable surfaces is one the primary factors influencing runoff water quality. In addition to eliminating percolation into the soils, impermeable surfaces such as parking areas add their own list of contaminants and nutrients from automobile fuels, lubricants, deicing materials and corrosion products.

Figure 2. Graph showing the composition of the cover for each site's sub-catchment.

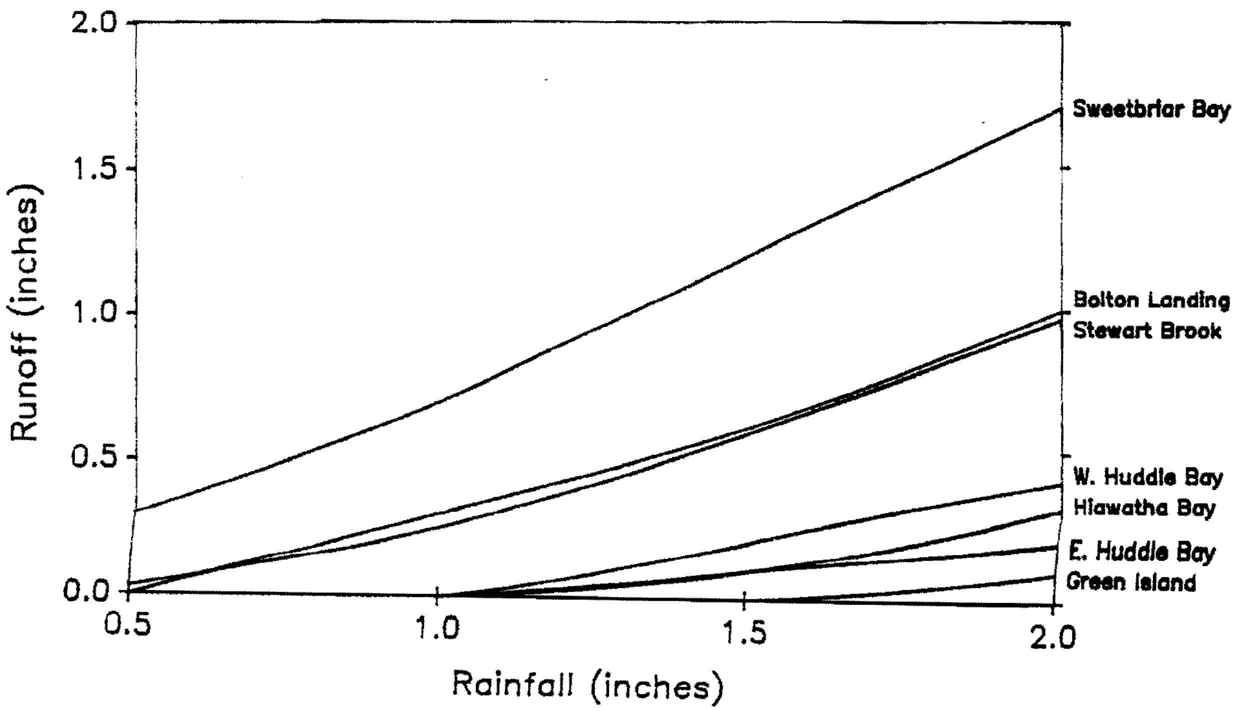


The type of vegetation (e.g. grass, trees or shrubs) also affects the rate of runoff and/or infiltration of stormwaters. The extent and type of each of the surfaces listed (see Figure 2) is used by the TR-55 model to predict runoff volumes. Sites with more impermeable surfaces and only low growing vegetation capture the least amount of runoff waters. Heavily forested sites capture and retain the greatest amount of runoff waters, thus producing the greatest nutrient removal prior to entry of waters to the lake.

RUNOFF VOLUMES

Curves of runoff volumes were generated for each site via the runoff modeling program TR-55 developed by the Soil Conservation Service of the US Department of Agriculture and described in the Methods section. Runoff curves for all sites are presented in Figure 3. For the eight sites considered, as the amount of impermeable area increased, the relative amount of runoff produced increased. This demonstrates the importance of the amount of impervious area in each watershed on runoff amounts. Another important aspect related to impervious surfaces is the question of whether it extends directly to the water's edge. This situation would allow direct runoff of stormwaters into the lake. With some amount of shoreline permeable material a portion of the runoff waters are allowed to infiltrate. Only the marina sites have impermeable surfaces to the waters edge, a common makeup of marinas having boat-launching areas. The Stewart Brook residential site had a minimal amount of pervious area along the waters edge. This site was selected as being representative of a densely developed residential area, however the level of impermeable surfaces and runoff curves are more typical of commercial sites. The commercial and undeveloped sites and the residential site at East Huddle Bay all have continuous permeable areas along the shoreline.

Figure 3. Runoff curves determined for each site. (Clay Island site did not record any measurable runoff for rainfalls up to two inches).



NUTRIENT LOADING

Loading rates or the export of contaminants from a watershed via runoff have been determined for various types of land uses and degree of impermeable area. A summary of selected compounds is presented in Table 4. These loading rates can be applied to the watersheds used in the current study to predict the amount of nutrients entering the lake from these sites (Table 5). As percent of impermeable surface increases, watershed area plays a larger role in loading rates.

Table 4. Loading estimates for sites with varying levels of impermeable area. Loading rates are in lbs/acre/year (NYSDEC, 1992).

Land Use	Percent Impervious	BOD	Total Phosphorus	Total Nitrogen
Undeveloped Forest	1	6	0.1	2.4
Single Family Lot	18	17	0.7	6.7
Townhouse /	35	26	1.2	9.9
Garden Apts.	40	32	1.5	10.8
Commercial	80	145	1.4	12.2

Table 5. Loading rates for the inshore sampling sites based on national estimates.

Site Name	Phosphorus (lbs/year)	Nitrogen (lbs/year)
Green Island	0.047	1.20
Clay Island	0.016	0.36
Stewart Brook	0.94	7.80
East Huddle Bay	0.21	1.68
Hiawatha Bay	3.30	21.5
W. Huddle Bay	2.45	16.3
Sweetbriar Bay	0.77	9.2
Bolton Landing	5.70	42.0

SITE SUITABILITY

Although the inshore sampling sites were selected to be characteristic of typical land use types within the Lake George basin, the single characteristic that most typifies each type of land use is the percent of impermeable surfaces present. Using extent of impermeable surface rather than specific land use is a better grouping variable than land use, however each type of land use has some specific character of its own. For example, marinas generally have impermeable surfaces to the waters edge (launch ramps) while commercial properties are vegetated with maintained lawns and shrubbery. Residential properties are generally a mix of grass and forest cover and undeveloped parcels are dominated by mature forest canopies. Extent of impermeable surface is also typically the defining variable for non-point source runoff calculations.

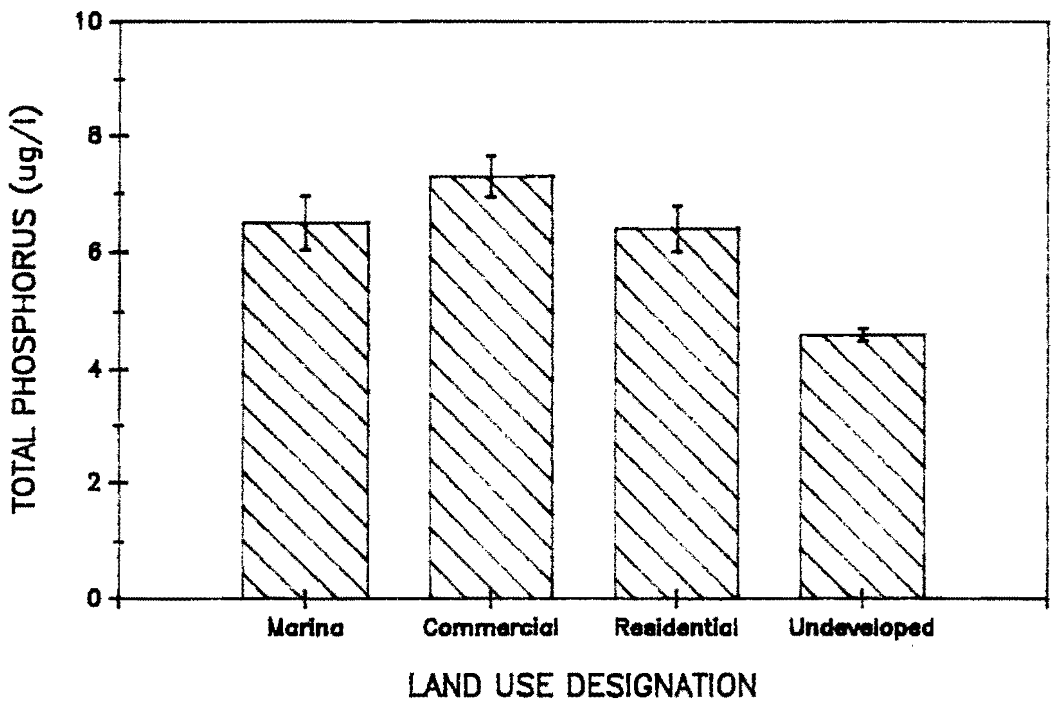
For the purpose of comparison, the sites chosen do offer a reasonable reflection of the intended site characteristics with a few exceptions. The first deals with the differences of percent impervious areas among the residential sites. East Huddle Bay and Stewart Brook contain 58% and 23% impervious surfaces respectively - a difference that becomes very apparent when viewing the Runoff Curves (Figure 3) for each site. Although the Stewart Brook site is used exclusively for residential purposes, the East Huddle Bay site may be more representative of residential uses on Lake George due to its runoff from a single unit per shoreline lot rather than runoff from multiple units over the same amount of shoreline; the former being a more common characteristic of development within the Lake George basin. Another exception includes the disparity in watershed areas between the marina sites. Sweetbriar Bay (0.7 acres) and Bolton Landing (3.7 acres) show a considerable difference in nutrient loading projections (Table 5) due to these differences.

For the ideal comparison of a small watershed's effect compared to that of another watershed with a varying land use, a small list of important considerations can be compiled. Firstly, watersheds should be of similar acreage so the amount of potential runoff as well nutrient loading can be comparable. Secondly, soil types should be similar, as these have a large impact on the quality, time of concentration and speed with which runoff waters reach the lake. Thirdly, boundaries of the watersheds should be clearly discernible so no confusion develops over actual watershed area and the soil types that are included. Finally, the slopes of the sites should be similar in order to have comparable rates for the movement of runoff waters, as contact time with the soil can have a considerable impact on their quality.

CHEMICAL COMPARISONS

Chemical data collected for this program from 1987 through 1989 and 1991 now allows a chemical water quality comparison of each site with a background of thorough understanding of the adjacent land areas. Over the course of chemical monitoring of this program, the most significant difference between land use types and their associated chemical water quality was found to be concentrations of total phosphorus (TP) as seen in Figure 4. While the developed areas (Marina, Commercial, Residential designations) showed consistent TP concentrations greater than 6.0 ug P/l, the Undeveloped areas showed an average level of 4.6 ug P/l, this shows a substantial difference in TP levels between developed and undeveloped areas. These data correspond to projected phosphorus inputs for similar land use types (Tables 4 & 5) where TP inputs from undeveloped parcels are at least one order of magnitude less than TP inputs from developed areas. Although these projections show actual inputs and this monitoring program measures only ambient water quality, the results of these inputs can be seen after dilution with lake water. This observed difference is no doubt due to a combination of all the above mentioned factors separating the undeveloped areas from those with some level of development, namely the results of the runoff curve calculations and site uses. Ultimately it is the runoff from these sites that affects their adjacent water quality, that is, greater inputs from runoff result in higher concentrations in the ambient water.

Figure 4. Average Total Phosphorus for each land use designation from the years 1987-1989, and 1991. Error bars = standard error of the mean (n=30).



From the parameters measured in past years, only the TP concentrations show continual and consistent differences in the ambient water quality between land use types, but since Lake George is considered to be a phosphorus limited system, contributions of phosphorus are perhaps the most critical. It is the input of phosphorus that can most rapidly decrease water quality in Lake George by diminishing clarity due to larger phytoplankton populations. Apparently the inputs of other nutrients and chemical parameters are not of a scale to effectively change the measurable water quality adjacent to these various land uses. Although the loading rates from these sites are believed to behave differently according to various parameters measured(e.g. runoff rates, soil types, watershed size, etc.), the measurement of the ambient water quality, as prescribed by this program, does not necessarily reflect these inputs. Constituents of runoff are diluted rapidly within the massive volume of lake water thus showing no incremental change in water quality among many analytes.

All shorelines, developed or undeveloped, will have an effect on a lake system as a result of stormwater runoff of nutrients and other chemical parameters, but it is the rate at which these inputs occur that controls the speed at which a lake's water quality may deteriorate. With the work to date, the Inshore Chemical Monitoring Program has shown how the waters associated with more developed shorelines show higher concentrations of phosphorus, the nutrient which is considered to be the limiting agent controlling the growth of phytoplankton in Lake George. This report demonstrates how even the slightest disturbances of shoreline can potentially increase the rate of phosphorus loading into the lake system. It is this rate of nutrient loading that must be slowed to a minimum if the still excellent water quality of Lake George is to persist.

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