

FINAL REPORT ON THE PROJECT  
to  
EVALUATE WATER QUALITY IMPACTS RELATED TO THE OPERATION  
OF BOLTON LANDING MARINA, BOLTON LANDING, NEW YORK

Submitted to

AMERICAN MARINAS, INC.

by

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&

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### APPENDIX I. - Analytic Methodologies

## INTRODUCTION

Widespread public concern for water quality has provided an impetus for a number of limnological investigations on Lake George during the last 20 years. Distinct differences in water quality indicators have been reported, with the southern, more developed portion of the lake exhibiting lower transparencies (Ferris and Clesceri, 1977; Wood and Fuhs, 1979; Eichler and Boylen, 1985; 1986a; 1987a), lower hypolimnetic dissolved oxygen concentration (Siegfried, 1982; Eichler and Boylen, 1985; 1986a; 1987a), higher phosphorus concentrations (Ferris and Clesceri, 1977; Sutherland et al., 1983; Eichler and Boylen, 1985; 1986a; 1987a), and higher chlorophyll a concentrations (Sutherland et al., 1983; Eichler and Boylen, (1985; 1986a; 1987a). The differences in these water quality indicators have been related to greater human activity in the southern portion of the basin (Sutherland et al., 1983). Elevated levels of coliform bacteria, indicators of possible contamination from failing septic systems, are also routinely reported from a drainage systems, culverts and stormdrains, in the more populated areas of the basin (Eichler et al. Fresh Water Institute, 1986b,c; 1987b). As predicted, continued development in the basin is expected to accentuate these between-basin differences (Dillon, 1983; Shapiro, 1983).

Several investigators have constructed nutrient budgets for Lake George (Aulenbach and Clesceri, 1972; Gibble, 1974; Wood and Fuhs, 1979; Sutherland et al., 1983). Although estimates vary, all agree that atmospheric deposition and surface runoff are the major sources of nitrogen and phosphorus inputs to the lake. In a recent study (Eichler and Boylen, 1988), shorelines with predominantly impermeable surfaces adjacent to the shoreline were found to have higher concentrations of nitrogen and phosphorus in nearshore waters than adjacent shorelines with less development. In addition, nearshore shallow waters experiencing

high levels of recreational usage have been reported to show elevated levels of nitrogen and phosphorus compounds, generally attributed to resuspension of nutrients from sediments disturbed by boat traffic (Yousef et al., 1980).

The study reported here has been designed to document loadings of plant nutrients, principally nitrogen and phosphorus compounds, and bacterial indicators of fecal contamination to the nearshore waters of Lake George via surface runoff and sedimentary resuspension at the Bolton Landing Marina site. Stormwater retention systems included in the redevelopment of this location also will be evaluated for their effectiveness. Results of the program will be used to improve stormwater management at this location and to modify existing practices to minimize their impacts on Lake George water quality.

Sampling and analysis protocols were designed to address the water quality concerns stated in the Final Environmental Impact Statement for the Bolton Landing Marina. Data generated by this program will be provided to the Planning Board of the Town of Bolton as the regulatory agency reviewing compliance with the conditions set forth in the Final Environmental Impact Statement for this project.

## METHODS

### Sample Collection and Analysis

Samples for chemical and bacterial analysis were collected by the grab method due to the well mixed nature of the waters in the proposed sampling locations. A grab sample was collected by immersing a suitable sample container, open side down, below the water surface. The container was then inverted and filled in a way to avoid taking surface film. The collectors hands were kept as far from the mouth of the container as possible. A description of the analytical methods employed by the Rensselaer Fresh Water Institute laboratory is included as Appendix 1. Samples were stored on ice during transport to the laboratory. In the laboratory, samples for dissolved constituents were filtered through 0.4 um polycarbonate filters, and stored at 4°C prior to analysis. Samples for total metals determinations were acidified to a pH of less than 2 prior to analysis. Digestions were conducted using standard laboratory protocols.

Each sample collected was analysed for total and available nutrients. Assays included total phosphorus, soluble reactive phosphorus (SRP) , nitrate and ammonia. These nutrients are the primary limiting factors to algal productivity and, as such, strongly influence water quality. A measure of algal productivity, chlorophyll a, was also included in the analytical protocols for nearshore samples, but not analysed for stormwater samples. The presence of terrestrially derived plant material and the enclosed nature of the stormwater collection system make testing of stormwaters for chlorophyll a unsuitable.

Samples analysed for total coliform and fecal coliform bacteria were collected in sterile containers. Separate samples for these analyses were taken and stored on ice during transport

to the laboratory. All samples were processed within 6 hours of the time of collection.

In order to evaluate metal concentrations in samples from this site, a number of metal concentrations were determined including cadmium, copper, lead, manganese and zinc.

### Sampling Sites

Four sampling sites were established on July 12, 1989 to conform to locations described in the proposed sampling protocols. These sites included:

Marina Site - 1.0 meter depth - Located adjacent to the first dock south of the quick launch slipway, approximately 10 meters out from shore. A dock post at the sampling site was marked to assure reproducible sampling locations.

Marina Site - 2.0 meter depth - Adjacent to the same dock used for the 1.0 meter site. Approximately 20 meters from shore. A dock post at this location was also marked for purposes of reproducibility of sampling.

Reference Site - 1.0 meter depth - Located at the northern edge of the Bolton Landing Marina property. Two metal posts projecting at right angles from the water surface serve as the site marker. Samples are collected 3 meters from the shore which is composed of rip-rap and concrete seawalls in this area.

Stormwater Well - Located approximately 3 meters from the lake shore on the north side of the dock serving the launch ramp. Samples were collected from the outflow of the cistern.

Although site selection was generally satisfactory, the stormwater well site was not wholly appropriate. This well received the drainage of a substantial quantity of groundwater, flowing continuously throughout the period of sampling. In the

future, a different portion of the stormwater collection system should be used such that undiluted runoff waters are collected.

### Sampling Dates

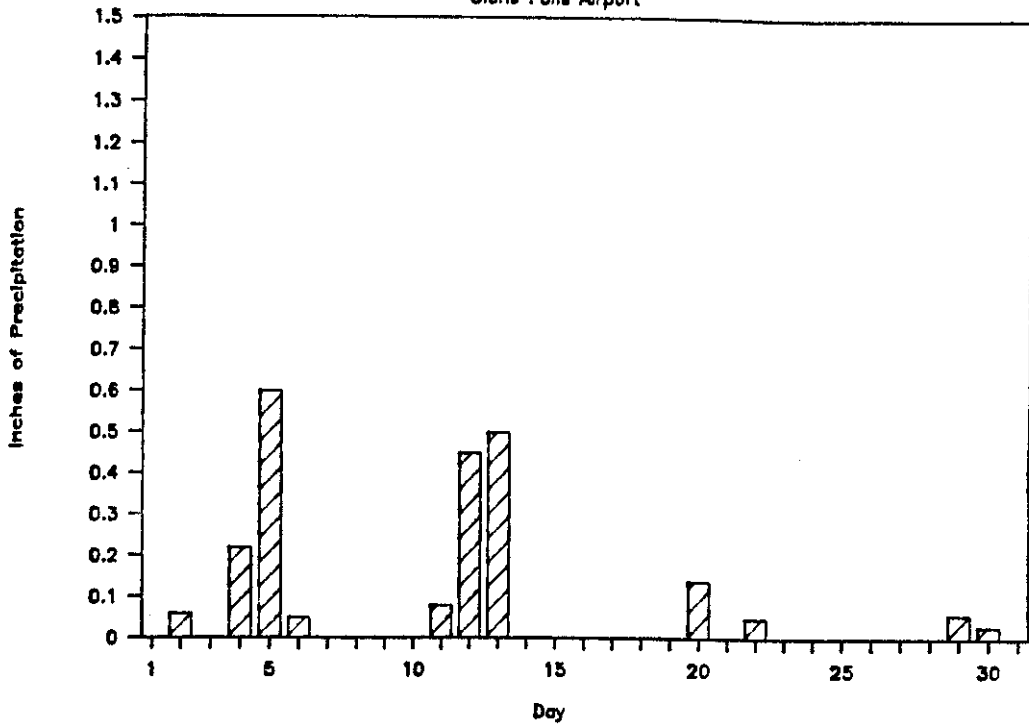
Sampling at the Bolton Landing Marina commenced on July 12, 1989. As per the proposed monthly sample collection, sampling was conducted on August 10, September 14, and October 12, 1989 to provide background or baseline water chemistry and microbiology data.

Stormwater runoff samples were collected on August 29 and 30, 1989. Although a more intensive stormwater collection was anticipated, the small amount of rainfall occurring on this date, 0.09 inches (Figure 1; NOAA, 1989), made collection of a larger number of samples inappropriate. The samples collected on August 29 preceded the rainfall event and comprise the prerunoff reference point. Samples collected on August 30 followed the end of the rainfall event by approximately twelve hours. A second attempt to collect stormwater samples on September 14 and 15 was more successful, with samples collected on September 14 preceding the rainfall event by several hours. The samples collected on September 15 followed a rainfall of 0.5 inches, however light rain delayed post rainfall sampling due to almost continuous rainfall through September 23 (Figure 2).



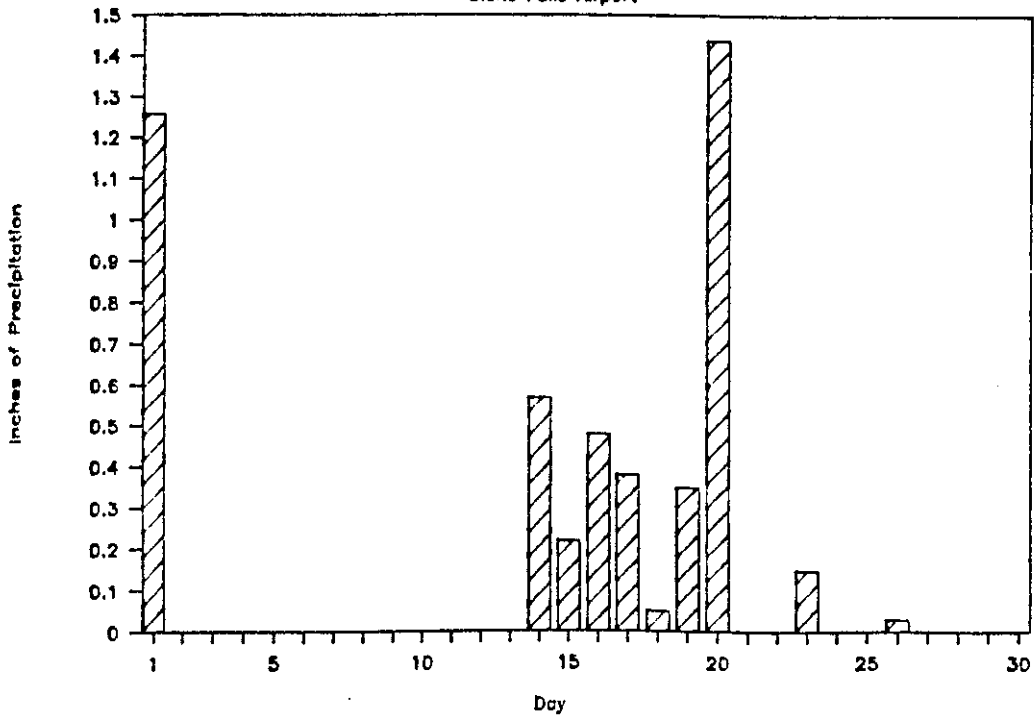
# August 1989 Precipitation

Glens Falls Airport



# September 1989 Precipitation

Glens Falls Airport



## RESULTS

Samples from each site were processed and analysed for pH, specific conductance, orthophosphorus, total phosphorus, nitrate, ammonia, chlorophyll a, total coliform bacteria, fecal coliform bacteria, cadmium, copper, lead, zinc and manganese.

### Microbiology

Results from samples for bacterial examination in, and adjacent to the Bolton Landing Marina are included in Table 1. The RFWI uses NYS Department of Health guidelines for contact recreation (i.e. swimming and bathing) as a reference for acceptable bacterial

Table 1. Total and Fecal Coliform Bacterial Counts for sites at the Bolton Landing Marina.

Site	Depth (m)	Date	Total Coliform/100 ml	Fecal Coliform/100 ml
Marina	1.0	12 July 89	30	less than 10
Marina	1.0	10 Aug 89	10	less than 10
Marina	1.0	30 Aug 89	50	20
Marina	1.0	14 Sept 89	10	10
Marina	1.0	15 Sept 89	less than 10	less than 10
Marina	1.0	12 Oct 89	80	less than 10
Marina	2.0	12 July 89	70	less than 10
Marina	2.0	10 Aug 89	10	less than 10
Marina	2.0	30 Aug 89	30	10
Marina	2.0	14 Sept 89	less than 10	less than 10
Marina	2.0	15 Sept 89	less than 10	less than 10
Marina	2.0	12 Oct 89	80	less than 10
Reference	1.0	12 July 89	120	10
Reference	1.0	10 Aug 89	30	less than 10
Reference	1.0	30 Aug 89	50	10
Reference	1.0	14 Sept 89	20	10
Reference	1.0	12 Oct 89	50	less than 10
Drywell		29 Aug 89	20	10
Drywell		30 Aug 89	10	less than 10
Drywell		14 Sept 89	less than 10	less than 10
Drywell		15 Sept 89	10	less than 10

levels in the nearshore waters of Lake George (see Table 2). The US Environmental Protection Agency (USEPA) also provides standards for maximum allowable levels of materials that can be discharged to waterways (Table 3).

None of the samples collected at the Bolton Landing Marina exceeded any of these standards. Results from the two stormwater events, (see Table 1) August 29-30 and September 14-15, did not reflect substantial changes in bacterial abundances from the prestorm levels.

**Table 2. MAXIMUM ALLOWABLE LEVELS OF COLIFORM BACTERIA  
IN WATERS USED FOR CONTACT RECREATION  
(NYS Dept. of Health Regulations)**

Bacterial Test	Maximum 5 Sample Mean	Maximum Single Result
Total Coliform	2400 per 100 ml	5000 per 100 ml
Fecal Coliform	200 per 100 ml	1000 per 100 ml

**Table 3. USEPA Standards for Discharge to Waterways**

Parameter	Maximum Level
Cadmium	0.15 mg/l
Lead	0.20 mg/l
Nitrogen as Ammonia (Apr-Oct)	2.5 mg/l
Nitrogen as Ammonia (Nov-Mar)	4.0 mg/l
Coliform Bacteria, Fecal	400/100 ml
Copper	0.5 mg/l
Iron	2.0 mg/l
Manganese	1.0 mg/l
pH	6 - 9
Phosphorus	1.0 mg/l
Total Dissolved Solids	3500 mg/l
Total Suspended Solids	15 mg/l
Zinc	1.0 mg/l

## Chemical Analyses

Results for all chemical analyses are included in Tables 4 and 5. Table 4 contains the results of samples taken for nutrients, pH and algal productivity (chlorophyll). Table 5 provides the analytical results for a number of toxic metals frequently found in urban runoff waters.

Table 4. Results for pH, conductivity, nutrients and chlorophyll a from Bolton Landing Marina.

Site	Date	pH	Conduct umhos	Ortho P (ug P/l)	Tot. P (ug P/l)	chl a (ug/l)	Nitrate (mg N/l)	Ammonia (mg N/l)
Marina 1.0	07/12/89	7.99	104	2	6	1.8	lt 0.01	lt 0.01
Marina 1.0	08/10/89	7.88	104	lt 1	5	1.2	lt 0.01	0.01
Marina 1.0	08/29/89	7.83	103	2	7	2	lt 0.01	lt 0.01
Marina 1.0	08/30/89	7.83	101	2	5	1	lt 0.01	lt 0.01
Marina 1.0	09/14/89			1	7	1.4	0.01	lt 0.01
Marina 1.0	09/15/89	8.35	104	2	8		lt 0.01	lt 0.01
Marina 1.0	10/12/89	7.33	99	3	15		0.02	lt 0.01
Marina 2.0	07/12/89	7.94	101	1	5		lt 0.01	lt 0.01
Marina 2.0	08/10/89	7.75	102	lt 1	5		0.03	0.01
Marina 2.0	08/29/89	7.75	105	lt 1	5	1.1	lt 0.01	lt 0.01
Marina 2.0	08/30/89	7.75	100	lt 1	4	1	lt 0.01	lt 0.01
Marina 2.0	09/14/89			1	5	1.2	lt 0.01	lt 0.01
Marina 2.0	09/15/89	8.04	102	1	7		lt 0.01	lt 0.01
Marina 2.0	10/12/89	7.44	95	3	14	2.3	lt 0.01	lt 0.01
Reference 1.0	07/12/89	7.84	101	1	5	1.6	lt 0.01	0.01
Reference 1.0	08/10/89	7.82	101	lt 1	5	1.3	lt 0.01	0.01
Reference 1.0	08/29/89	7.65	100	lt 1	5	1	lt 0.01	lt 0.01
Reference 1.0	08/30/89	7.73	99	lt 1	5	1.1	0.01	lt 0.01
Reference 1.0	09/14/89			1	7		lt 0.01	lt 0.01
Reference 1.0	09/15/89	7.83	101	1	7		0.01	lt 0.01
Reference 1.0	10/12/89	7.51	94	1	9	2.1	lt 0.01	lt 0.01
Stormwater Well	08/29/89	6.86	400	4	3		1.76	lt 0.01
Stormwater Well	08/30/89	6.96	410	5	4		1.88	lt 0.01
Stormwater Well	09/14/89			3	3		1.68	lt 0.01
Stormwater Well	09/15/89	7.04	417	4	5		1.76	lt 0.01

Analytical results for pH and nutrient concentrations in the nearshore waters of the marina and the runoff waters from the stormwater well were substantially below the allowable levels of these materials in discharge waters (Table 3), or the more restrictive standards for drinking water (Table 6), as mandated by the USEPA.

For comparison purposes, a table of mean values and ranges for selected analytes at nearshore locations with various levels of development is included (Table 7). This data is derived from a study of the impact of shoreline development on nearshore water quality (Eichler and Boylen, 1989; 1990).

Analytical results for metal concentrations in the nearshore waters of the marina and the runoff waters from the stormwater well were rarely above the detection limits of these materials. These detection limits either conform to or exceed the allowable levels of these metals in discharge waters (Table 3), or the more restrictive standards for drinking water (Table 6), as mandated by the USEPA.

Table 5. Results for cadmium, copper, lead, manganese, and zinc from Bolton Landing Marina.

Site	Date	Cadmium mg/l	Copper mg/l	Lead mg/l	Zinc mg/l	Manganese mg/l
Marina 1.0	07/12/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	0.006
Marina 1.0	08/10/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Marina 1.0	08/29/89	lt 0.01	0.015	lt 0.05	lt 0.1	lt 0.005
Marina 1.0	08/30/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Marina 1.0	09/14/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	0.006
Marina 1.0	09/15/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Marina 1.0	10/12/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	0.007
Marina 2.0	07/12/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	0.006
Marina 2.0	08/10/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Marina 2.0	08/29/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	0.006
Marina 2.0	08/30/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Marina 2.0	09/14/89	lt 0.01	lt 0.005	lt 0.05	0.024	lt 0.005
Marina 2.0	09/15/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Marina 2.0	10/12/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Reference 1.0	07/12/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	0.006
Reference 1.0	08/10/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Reference 1.0	08/29/89	lt 0.01	lt 0.005	lt 0.05	0.015	0.007
Reference 1.0	08/30/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Reference 1.0	09/14/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Reference 1.0	09/15/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	0.009
Reference 1.0	10/12/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	0.008
Stormwtr Well	08/29/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	14
Stormwtr Well	08/30/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Stormwtr Well	09/14/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005
Stormwtr Well	09/15/89	lt 0.01	lt 0.005	lt 0.05	lt 0.1	lt 0.005

**Table 6. USEPA Primary and Secondary Drinking Water Standards.**

Parameter	Maximum Level
<b>Primary Standards</b>	
Cadmium	0.01 mg/l
Lead	0.05 mg/l
Nitrogen as Nitrate	10.0 mg/l
Coliform Bacteria, Total	1t 1/100 ml
<b>Secondary Standards</b>	
Chloride	250 mg/l
Copper	1 mg/l
Iron	0.3 mg/l
Manganese	0.05 mg/l
pH	6.5 - 8.5
Total Dissolved Solids	500 mg/l
Zinc	5 mg/l

Table 7. Average concentrations and ranges for selected analytes from the nearshore waters of Lake George. Grouped by the level of development on the adjacent shoreline.

Lake George Nearshore Chemistry - 1988

Land Use	pH		Cond		TP		OP	
	mean	range	mean	range	mean	range	mean	range
Undeveloped	7.57	7.32-7.81	97.7	94.9-107.2	4.5	3.0-6.0	1.1	<1.0-2.0
	7.55	7.33-7.70	98.4	95.2-110.8	4.5	3.0-8.0	1.3	<1.0-2.0
Residential	7.53	7.36-7.79	97.9	93.0-105.7	5.4	4.0-7.0	1.1	<1.0-2.0
	7.56	7.43-7.68	98.7	95.3-108.4	5.5	4.0-7.0	1.3	<1.0-3.0
Commercial	7.44	7.22-7.68	96.9	92.0-107.1	7.5	4.0-15.0	1.9	<1.0-4.0
	7.64	7.48-7.80	96.4	94.0-110.0	5.0	4.0-6.0	1.1	<1.0-2.0
Marina	7.48	7.36-7.64	101.2	97.0-114.3	11.3	4.0-50.0	1.8	<1.0-4.0
	7.44	7.30-7.66	104.4	95.0-122.2	5.5	4.0-7.0	1.4	<1.0-3.0

	Nitrate		Ammonia		Chla	
	mean	range	mean	range	mean	range
Undeveloped	<.01	<.01	<.01	<.01-.01	1.1	0.8-1.5
	<.01	<.01	<.01	<.01-.01	1.0	0.6-1.4
Residential	<.01	<.01	<.01	<.01-.01	1.3	0.8-2.2
	<.01	<.01	<.01	<.01	1.4	0.9-2.4
Commercial	0.02	<.01-.14	0.01	<.01-.02	1.3	0.9-3.1
	<.01	<.01-.01	<.01	<.01	1.3	0.8-1.8
Marina	<.01	<.01-.01	<.01	<.01	1.3	0.9-2.2
	<.01	<.01-.01	<.01	<.01-.01	1.2	0.9-1.8

Lake George Nearshore Chemistry - 1989

Land Use	pH		Cond		TP		OP	
	mean	range	mean	range	mean	range	mean	range
Undeveloped	7.78	7.67-7.85	98.2	93.8-101.6	8.8	4.0-26.0	1.0	<1.0-2.0
	7.76	7.64-7.83	98.6	95.6-103.3	3.8	3.0-5.0	<1.0	<1.0-1.0
Residential	7.75	7.65-7.82	97.2	93.3-101.0	7.5	5.0-10.0	1.1	<1.0-2.0
	7.79	7.70-7.85	98.9	94.9-102.0	5.3	4.0-9.0	<1.0	<1.0-1.0
Commercial	7.63	7.53-7.73	96.8	90.4-101.2	7.7	4.0-12.0	1.3	1.0-2.0
	7.80	7.74-7.85	98.3	94.9-103.2	6.0	5.0-9.0	<1.0	<1.0-1.0
Marina	7.70	7.53-7.79	99.7	97.1-102.6	5.0	4.0-6.0	<1.0	<1.0
	7.54	7.40-7.65	107.3	99.2-113.0	7.8	4.0-11.0	1.4	<1.0-2.0

	Nitrate		Ammonia		Chla	
	mean	range	mean	range	mean	range
Undeveloped	<.01	<.01	<.01	<.01	0.9	0.5-1.1
	<.01	<.01	<.01	<.01-.01	0.8	0.4-1.1
Residential	<.01	<.01	<.01	<.01	1.1	0.6-1.4
	<.01	<.01-.10	<.01	<.01	0.5	0.3-0.7
Commercial	<.01	<.01-.10	<.01	<.01	0.9	0.1-1.8
	<.01	<.01	<.01	<.01	0.9	0.4-1.2
Marina	<.01	<.01-.01	<.01	<.01	1.1	0.9-1.3
	.01	<.01-.04	<.01	<.01-.01	1.5	0.8-2.1



## FINDINGS

1. Levels of total and fecal coliform bacteria in the waters adjacent to the Bolton Landing Marina are similar to a nearby reference site, outside the environs of the marina, and within New York State limits for contact recreation.
2. Nearshore waters of the marina are slightly more alkaline, higher pH, and contain greater amounts of dissolved materials as measured by specific conductance than shorelines without marinas.
3. Soluble and total phosphorus concentrations at the 1.0 meter marina site were higher than the reference site, however results from the 2.0 meter site were comparable to the reference site.
4. Waters from the stormwater well were lower in pH and total phosphorus while being higher in soluble phosphorus, specific conductance and nitrate than lake sites.
5. All analytical results for chemical water quality were within state and federal guidelines for drinking water. Bacterial results were within guidelines for contact recreation, i.e. swimming.

## RECOMMENDATIONS

Although a picture of the effects of the marina on the nearshore water quality of Lake George has been provided by the data from this study, this is only a snapshot in time. A minimum of a second year of data collection is necessary to reach any level of certainty that what was observed during 1989 is typical of conditions at this location.

Site selection was generally satisfactory, however the stormwater well site was not wholly appropriate. This well received a substantial quantity of groundwater, flowing continuously throughout the period of sampling. In the future, we suggest that a different portion of the stormwater collection system be used, such that undiluted runoff waters are collected.

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APPENDIX 1

Analysis	Method	Instrument
pH	Electrometric (EPA Method 150.1)	Orion, Model 811
Specific Conductance	Wheatstone Bridge (EPA Method 120.1)	Cole Parmer Model 1081
Nitrate	Cadmium Reduction (EPA Method 353.2)	Technicon Autoanalyser II
Ammonia	Automated Phenate (EPA Method 350.1)	Technicon Autoanalyzer II
Total Phosphorus	Colorimetric (EPA Method 365.2)	Bausch & Lomb Spec 710
Ortho Phosphorus	Colorimetric (EPA Method 365.2)	Bausch & Lomb Spec 710
Metals	Direct Aspiration <sup>1</sup> Atomic Absorption Spectroscopy	Perkin-Elmer Model 403
Chlorophyll <u>a</u>	Methanol Extraction	Bausch & Lomb Spec 710
Total Coliform Bacteria	Membrane Filtration	
Fecal Coliform Bacteria	Membrane Filtration	

EPA Methods listed in this table are derived from: USEPA, Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Cincinnati, OH.