84002

Report

Town of Amesbury

Lake Attitash
Watershed Management Plan

January 25, 1999

Contents

List of Figures

Figure

* All tables and figures in Section 2 are located at the end of the section following the text.

List of Tables

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Section 1
Introduction

1.1 Lake Attitash, Tuxbury Pond, and Powwow River

The Town of Amesbury receives its public drinking water supply from the Powwow River, Tuxbury Pond, and Lake Attitash. **Figure 1-1** shows a locus map of the area and the relationship of the three water bodies.

Lake Attitash is a 360-acre natural lake located in the Towns of Amesbury and Merrimac, Massachusetts. Lake Attitash flows to Meadow Brook, which can then flow either to the Powwow River, or to Tuxbury Pond. The direction of flow from Meadow Brook is managed by the Town of Amesbury using control structures on Meadow Brook. In addition to being a water supply, Lake Attitash is well known and enjoyed as a popular recreational resource, with boating, water-skiing, fishing, and swimming. A population of about 1,000 residents lives around the lake shore (CDM estimate, 1999). For a number of years, residents have been concerned about water quality in the lake, particularly algae and aquatic weed growth.

Tuxbury Pond is a smaller, 108-acre pond located within the Town of Amesbury and the Town of South Hampton, New Hampshire. Tuxbury Pond is an impoundment on the Powwow River, which extends up into New Hampshire, and down through Lake Gardner and out to the Merrimack River.

1.2 Purpose and Scope

The Town of Amesbury, with support and participation of the Lake Attitash Association, received a Lakes and Pond Grant from the Massachusetts Department of Environmental Management (DEM). The grant was given for the Town to hire a consultant to prepare a Watershed Management Plan for Lake Attitash.

The Town entered into an agreement with Camp Dresser & McKee Inc. The scope of work for the project is summarized below:

Task 1: Water Quality

- Compile and review available water quality data.
- Identify sampling plan for 1998 season; provide laboratory analysis.
- Recommend a long-term lake monitoring program.

Task 2: Watershed Mapping and Build-out Analysis

- Prepare maps showing watershed and subwatershed delineations for Lake Attitash, and Powwow River.
- Conduct simplified build-out analysis.

Task 3: Contamination Source Identification and Nutrient Loading Analysis

- Review available information on potential contamination sources, including any information from the town, DEP, and water quality data to assess potential water quality effects from land uses and

Lake Attitash Watershed

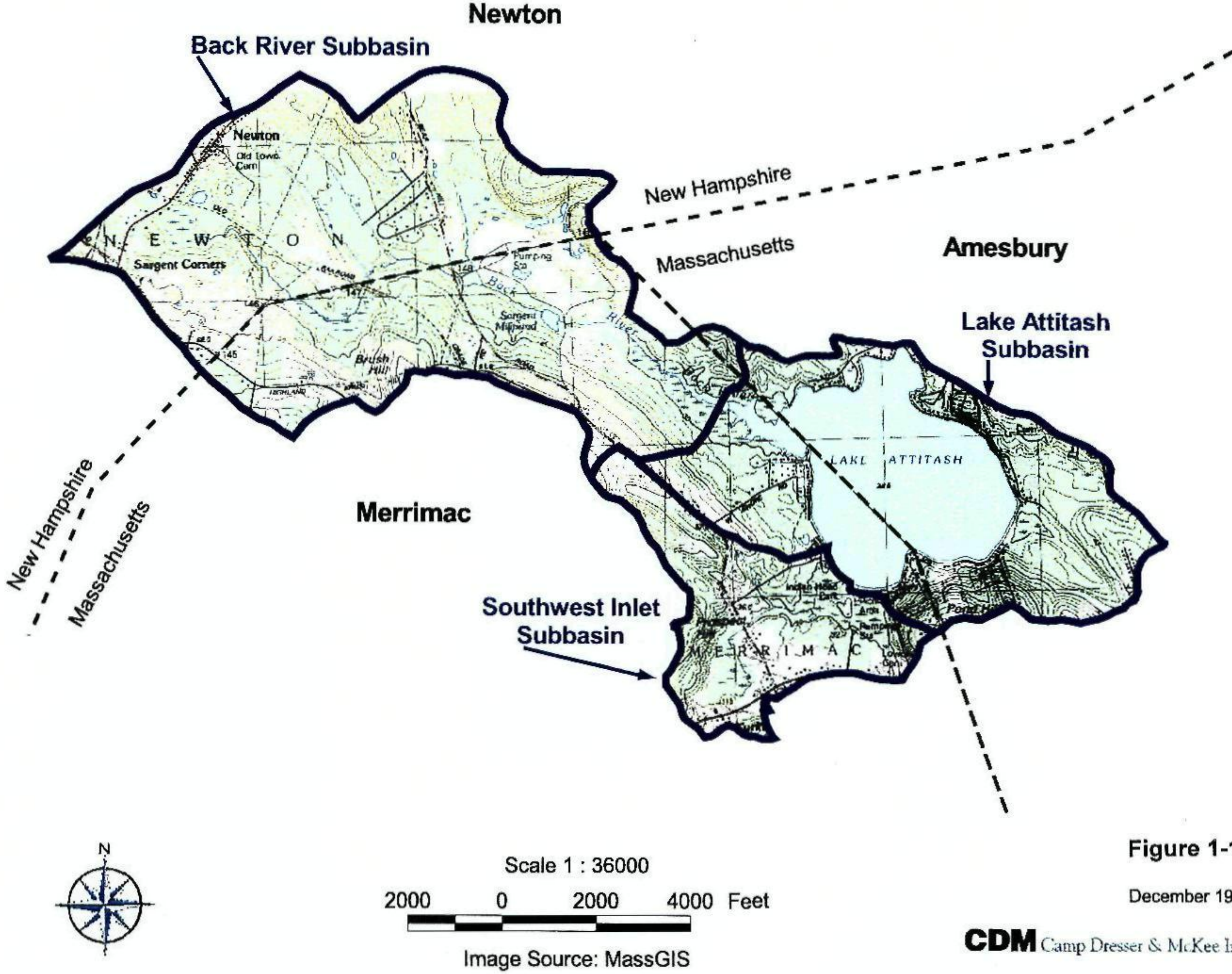

Figure 1-1

December 1998

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activity. (Note: The project scope was not intended to provide a detailed evaluation or focus on specific sites, but to evaluate the entire watershed based on land uses.)
- Apply the Watershed Management Model (WMM) to the Lake Attitash watershed to develop land use-based loadings for nutrients. Simulate potential loadings from future build-out conditions.
- Rank the sources by importance, considering the level of threat to public health, the contribution of nutrient loads, and the targeted parameters.
- Conduct a public workshop to review the findings through Task 3.

Task 4: Control Recommendations
- For each potential contamination source, develop actions to control the source.
- Conduct a public workshop to review the recommendations.
- Develop a plan to support implementation of the recommended actions.

Task 5: Best Management Practices
- Provide copy of DEP MegaManual and Watershed Management Reference Manual.
- Arrange for a tour for interested officials and citizens from Amesbury
- Develop a public education brochure for public distribution to describe the Lake Attitash Watershed Management Plan.

Task 6: Report
- Prepare Draft Lake Attitash Watershed Management Plan.
- Conduct a public meeting to present and receive comments on the Plan.
- Produce the Final Lake Attitash Watershed Management Plan.

The Town also sought for this project to provide information that could be helpful in developing a future plan for Tuxbury Pond and the Powwow River. Therefore, the monitoring program conducted by the Town and Lake Attitash Association under this grant included sites in Tuxbury Pond and on the river (see Section 2). In addition, recommendations applicable to Tuxbury Pond and the Powwow River are discussed in Section 4.3.

1.3 Report Contents

This report presents all of the analyses, conclusions, and recommendations made as part of the project.

Section 2 of this report presents and analyzes water quality data, including historical data and that collected under the current program in 1998. Section 3 discusses the potential sources of nutrients and contamination to Lake Attitash. Lastly, Section 4 presents detailed recommendations to address the potential sources and to continue monitoring.

Watershed management plans should be viewed as just that -- a plan. This report attempts to draw the best conclusions possible with the available information. As more data is available and as best management practices are implemented, lake conditions may change. Notwithstanding this point, the recommendations contained herein have been carefully crafted to provide the best opportunity for improving the water quality of Lake Attitash, which is the ultimate goal of all participants.

Section 2
Water Quality

2.1 Previous Studies

Lake Attitash, Tuxbury Pond, and the Powwow River each have been the subject of various water quality-related studies or monitoring programs in the past.

Lake Attitash was studied by the Massachusetts Department of Environmental Quality Engineering (DEQE), predecessor to DEP, in 1977 - 1978. This study included one year of monthly water quality sampling in the lake and its inlets and outlet, and analysis of watershed contributors of nutrients. Parameters measured included secchi disk depth, pH, phytoplankton, chlorophyll a, nitrate-nitrogen, Total Kjeldahl Nitrogen, total phosphorous, orthophosphorus, conductivity, and fecal coliform bacteria. Based on study results, the lake was characterized as a mesotrophic lake. Conclusions regarding water quality were as follows:

- Dissolved oxygen concentration of the water column was good [i.e., >5 parts per million (ppm)] throughout the study.
- Inorganic nitrogen concentrations were not considered a problem.
- The average total phosphorus concentration at the open water station (site 1) was considered a slight problem and potentially degrading the water quality of the lake.
- Nutrient inputs from the southwest inlet (site 2) were low and not considered a problem.
- Total phosphorus input from the Back River (site 3) was elevated over in-lake concentrations; this tributary was considered a nutrient source for the lake.
- The outlet (site 4) showed major bacterial contamination during the summer. The high coliform counts were considered the result of septic system failure.
- Phytoplankton did not present an observed nuisance problem during the study. However, algae blooms were reported between completion and publication of the study.

The Lake Attitash Association (LAA), formed in 1993, also has conducted water quality monitoring at in-lake and watershed locations. The LAA has monitored Lake Attitash for four years (1994 to 1998) as part of the Massachusetts Water Watch Partnership (Mass WWP) administered by the University of Massachusetts at Amherst. During this four year period the most comprehensive sampling programs were conducted in 1994 and throughout the summer of 1998. Results from the 1994 program are summarized below and reported in detail in the *Lake Attitash Water Quality Study April 1994 - October 1994*, prepared by the LAA; results from the 1998 study are presented in this report.

The primary goals of the 1994 study were to determine whether water quality in Lake Attitash and its tributaries had improved or declined relative to 1977/78 results, to quantify rates of eutrophication, and to determine whether the Back River was still a nutrient source for Lake Attitash, as concluded in the 1977/78 study. Key conclusions of the 1994 report are as follows:

- Algae count and secchi disk (clarity) data appeared to show a decline in Deep Station (DS1) lake water quality since 1977.
- Total phosphorus and nitrate-nitrogen results did not conclusively show an increase in these nutrients.

- The watershed connected to the Southwest Inlet was noted as a possible phosphorus source for the lake, based on high phosphorus readings at the inlet after a major rainstorm.
- Total phosphorus levels in the Back River Inlet (site 3) were usually higher than Upper Back River and Lower Back River (sites 5 and 6 respectively), suggesting the existence of one or more significant phosphorus sources between sites 5 and 6, and site 3.
- Nitrate-nitrogen level differences between sites 5 and 6 suggested a source between the two stations. However, even the highest nitrate-nitrogen values were relatively low and seemed to indicate no nitrate-nitrogen problem in themselves.
- The PowWow River and Tuxbury Pond appeared to have moderate nutrient levels.

The LAA has funded aquatic vegetation surveys for both Lake Attitash and Tuxbury Pond. A single date survey (which also included water quality analysis for sites 1 through 4) was conducted by Aquatic Control Technologies (ACT) on August 24, 1993. In addition, a single algae count was conducted by ACT in August 1994 during an algae bloom. The ACT report provided a map showing the distribution of aquatic macrophytes and reported the following conclusions:

- Overall, Lake Attitash was found to maintain a desirable, high diversity of aquatic plants.
- The plant growth in the lake was characterized as "abundant" along the lake's northern shoreline and northwest coves. Vegetation was found to be common to abundant along the lake's western and southwest shoreline, and vegetative density was considerably less along the southeast and eastern shores of the lake.

The Powwow River, as the Town of Amesbury's primary water supply, is monitored by the Water Treatment Plant operators. Raw water is sampled daily for turbidity, color, and pH, and river water is sampled biweekly for coliform bacteria.

The Town of Merrimac Water Department also collects some surface and groundwater samples on the Upper Back River. Samples are analyzed for nitrate-nitrogen, and other parameters.

2.2 1998 Monitoring

As part of the scope of this project, water quality monitoring was conducted between July 1998 and October 1998 to provide additional information. CDM recommended a sampling program, including parameters, locations, and frequency; the program is summarized in **Table 2-1**. (Note: All tables and figures are located following the text.) **Figure 2-1** shows a map with sampling site locations; these are listed below:

<u>Back River</u>
Site 21: Middle Back River at Bear Hill Road
Site 5: Lower Back River below Sargent Millpond
Site 6: Lower Back River, Sargent Farm
Site 6A: Lower Back River, Sargent Farm
Site 9: Lower Back River, below beaver dam

<u>Inlets</u>
Site 3: Back River, inlet to Lake Attitash
Site 2: Southwest Inlet

Lake
Site 1: Lake Attitash, Deep Station 1 at deepest point

Outlet
Site 4: Birches Dam, Lake Attitash

Other
Site 32: Meadowbrook Pond at Arch Brook
Site 7: Tuxbury Pond at Tuxbury Dam
Site 8: PowWow River at Hilldale Avenue

The 1998 monitoring focused on these components:

1. Monthly nutrient monitoring of lake inflow, in-lake, and outflow, and selected watershed locations
2. Monthly (Tuxbury Pond) and weekly (Lake Attitash) monitoring for algae and chlorophyll a
3. Weekly monitoring of in-lake dissolved oxygen profiles and secchi disk depth
4. Frequent watershed sampling, including trial of fecal coliform bacteria analysis and colorimetric test kits

All samples were collected by LAA volunteers, who have been trained by the Mass WWP in proper sample collection techniques. Nutrients, algae, and chlorophyll a were analyzed by LaPuck Laboratory, a certified professional laboratory. Fecal coliform bacteria were analyzed by the Amesbury Wastewater Treatment Facility laboratory. LAA volunteers conducted the colorimetric tests for nitrate-nitrogen using test kits from HACH Company. Note that the nutrient data from the colorimetric method are reported separately from the LaPuck Laboratory data. All water quality data are contained in Appendix A.

LaPuck Laboratory performed all analysis following guidelines in *Standard Methods for the examination of Water and Wastewater* (APHA 1976). Quality Assurance/Quality Control (QA/QC) measures included blanks, QC samples of standard solutions, and calculation of recoveries. Sampling and analysis procedures and the QA/QC program followed by LAA volunteers are presented in the Lake Attitash Association Water Monitoring Program Instructions (1994).

2.3 Lake Attitash

2.3.1 Trophic Status

Lakes can be classified based on their biological productivity, which can be measured by physical, chemical and biological parameters. The resulting classifications place each lake on a "Trophic Status" continuum. The trophic structure of a community refers to the pathways by which energy is transferred and nutrients are cycled through the community trophic levels (Wetzel 1983). Different community trophic structures result in different levels of biological productivity. Lakes with very low concentrations of plant nutrients, and therefore low levels of biological productivity, are called "oligotrophic". In contrast, eutrophic lakes have high levels of plant nutrients, and as a result have high levels of biological productivity (EPA Clean Lakes Program Guidance Manual, 1980). Mesotrophic lakes fall between oligotrophic and eutrophic on the trophic status continuum; in general terms, they are characterized as having "moderate" biological productivity.

Although transition from oligotrophic to eutrophic status is a naturally occurring process, the rate is often increased by human activity. Concern about increased rates of eutrophication caused by humans has led to development of low cost methods for monitoring changes in lake trophic status. Three of the most commonly applied and reliable measures used to estimate the trophic status of a lake are secchi disk depth, chlorophyll a, and total phosphorus (EPA Lake and Reservoir Restoration Guidance Manual). Numerous trophic classification systems incorporate one or all of these parameters; typically there is some variation and overlap in classification ranges. **Table 2-2** presents typical ranges from two classification systems; these two systems are used to classify Lake Attitash.

Measurements of secchi disk depth, chlorophyll a, and total phosphorus are available for Lake Attitash from the 1977/78 study and throughout periods of the 1994-1998 sampling program. These data were compared to published values to provide an objective classification of the Lake's trophic status.

Figure 2-2 presents summer secchi disk depth measurements from 1977/78 and 1993 through 1998. Boundaries between trophic status are shown as horizontal lines. Comparison of secchi data from the 70s and the 90s shows a transition from a mesotrophic system to a eutrophic system.

Examination of total phosphorous levels from the 90s further supports the characterization of Lake Attitash as eutrophic. Mean total phosphorous values are presented in **Table 2-3** along with their corresponding trophic status indications. Total phosphorous values reported for 1977 are typical of a mesotrophic to eutrophic system while the mean total phosphorus values reported for the period 1994-1998 indicate a eutrophic to hypereutrophic system. Chlorophyll a values from 1977 were characterized as indicative of oligotrophic conditions. Chlorophyll a values recorded throughout the summer of 1998 fall within the range of values expected of eutrophic to hypereutrophic systems (see table 2-2 and appendix A).

2.3.2 Dissolved Oxygen Profiles

Dissolved oxygen profiles were taken at site 1 from late spring through early fall in 1977, 1994, and 1998. The dissolved oxygen profiles from 1977 show that the lake was well mixed throughout the summer and never fell below 5 parts per million (ppm, =mg/l) (**Figure 2-3**). Conversely, dissolved oxygen profiles measured in 1994 and 1998 show dissolved oxygen levels dropping near zero, indicating the existence of an anoxic (oxygen deficient) environment in the hypolimnion (lower level of the lake) **(Figures 2-4 and 2-5)**. This phenomenon is common in eutrophic systems and provides further confirmation of the lake's eutrophic status.

Low dissolved oxygen in the hypolimnion is a concern for two primary reasons. Fish and other aquatic organisms may be excluded from the oxygen-poor environment. Exclusion can cause problems for bottom feeders by reducing their access to food and for temperature sensitive species such as trout by preventing their access to colder water near the bottom. Anoxic conditions are also a concern due to increased potential for release of phosphorous from lake sediments.

2.3.3 Algae and Chlorophyll a

1977-78

The 1977/78 study included four chlorophyll a samples collected from station 1 in May, July, and August 1977 and April 1978. All four samples were within the range of 0 to 3 ug/l (micrograms per liter, or parts per billion (ppb)) which was reported as indicative of an oligotrophic system. Algae counts ranged from 174 cells/ml to a high of 1,632cells/ml. A range of 0 - 2,000 cells/ml was reported as indicative of an oligotrophic system (based on Weber, 1974).

1994-98

Chlorophyll a and algae results from the 1998 study present a different picture. Chlorophyll a and algae samples were collected weekly from July to October at site 1. Chlorophyll a ranged from 323ug/l to 1,970ug/l. As discussed previously, these results fall within the range of values expected for hypereutrophic systems based on both trophic classification systems presented in Table 2-2. Algae counts ranged from a high of 3,900 cells/ml in late August, to 398 cells/ml in late September.

2.3.4 Nutrients

1977-78 Nitrogen and Phosphorous

Summer in-lake nitrate-nitrogen concentrations were below 150 ug/l (micrograms per liter or ppb) and were considered to be representative of clean water, based on standards being used at the time (1979) by the Division of Water Pollution Control Lakes Classification Program. Total phosphorus concentrations in the epilimnion (upper level of the lake) averaged 30 ug/l. These values were described as "borderline" and considered to be potentially degrading (DWPC 1979). None of the hypolimnetic samples for phosphorus indicated nutrient release from the sediments.

Nutrient inputs from the southwest inlet (site 2) were described as low. Total phosphorus at the Back River inlet (site 3) exceeded the EPA recommended criteria of 50 ug/l by 10-20 ug/l. Total phosphorus input at site 3 was elevated over open water concentrations and the inlet was described as a nutrient source for the lake. Nitrogen and phosphorus results for the lake outlet (site 4) were similar to open water concentrations and not considered a concern.

1994 and 1998 Nitrogen

Nitrate-nitrogen. Nitrate-nitrogen is the most soluble from of Nitrogen and the from most readily used by aquatic biota. Nitrate-nitrogen was measured at six sites during the 1994 study (sites 5, 6, 3, 1, 7 and 8). Although levels at sites 3 and 6 were significantly higher than the other sites on several occasions, all levels were relatively low (ranging from 2 ug/l to 549 ug/l).

During the 1998 study, the 1994 sites plus seven additional sites (21, 6A, 9, 2, 1, 4 and 32) were monitored. **Figure 2-6** shows 1998 results for the Back River sites. Sites 6A, and 6 stand out as being substantially higher than the remaining sites and potentially of concern. **Figure 2-7** shows the nitrate results for Lake Attitash sites as well as Tuxbury Pond and the Powwow River; values were consistently low at these sites.

Analyses of nitrate using the colorimetric method were consistent in that there appears to be an increase at Site 6 or 6A, while the levels usually decrease downstream at Sites 9 and 3. Further, comparison of the colorimetric nitrate results for the Lower Back River (Sites 9, 3) and the Southwest inlet (Site 2) show them to be similar.

Ammonia-nitrogen. Ammonia-nitrogen was measured monthly during the 1998 study at all thirteen sites. Although there are no historical data with which to compare the 1998 values, they provide useful baseline data and are themselves informative. Of the thirteen sites, site 6 stands out as having a mean ammonia-nitrogen value which is an order of magnitude higher than any of the remaining sites (see **Figures 2-8 and 2-9**).

1994-98 Phosphorus

Total phosphorous. Analysis for Total phosphorous measures all forms of phosphorous including organic (e.g., phosphorus bound in plant fragments), inorganic (e.g., phosphorus in soil particles), particulate phosphorous, and dissolved phosphorus. The majority of the total phosphorus values collected at site 1 in 1994 and between 1995-1997 fell within the eutrophic range based on the EPA classification system (Table 2-2). Site 1 (at the surface) was sampled once during the 1998 study; site 1 (at 25 foot depth) was sampled four times. Total phosphorus results from the deep sampling in August were very high, possibly reflecting phosphorus resuspension from the sediments. **Figures 2-10** and **2-11** show the 1998 Total phosphorus results from the Back River sites, and Lake Attitash, Tuxbury Pond and Powwow River respectively. Sites 21, 5, 6, and 9 on the Back River and sites 1, 4, and 32 on Lake Attitash all had mean values over 1,000 ug/l and maximum values over 10,000 ug/l.

Soluble Reactive Phosphorous. Soluble reactive phosphorous (SRP, sometimes referred to as orthophosphorous) is the fraction of total phosphorous that is soluble (dissolved, rather than particulate) and is easily taken up by aquatic biota. While total phosphorous is more significant as a diagnostic tool, comparison of SRP to total can aid understanding of the processes occurring. SRP was measured only during the 1998 study. Measurements ranged from below detection limit (30 ug/l) at sites 3, 1, 7, and 8, to a maximum of 12,340 ug/l at site 4. SRP was consistently high at site 6; in addition, sites 4 and 32 each had one high reading. 1998 SRP data are shown in **Figures 2-12** and **2-13**. One date (9/28/98) shows high in-lake soluble reactive phosphorous at the deep site, which supports the possibility of sediment release.

Influences of Wetlands on Nutrient Regimes

Interpretation of the nutrient data collected in the 1990s is complicated by the presence of beavers and their subsequent creation of extensive wetland systems throughout the Back River. Several of the sampling sites were either converted to wetlands (sites 6, and 6A) or were located just downstream of large wetland systems (sites 2, 21, and 9). Wetland systems can develop anoxic conditions especially where waters are stagnant, soils are flooded for an extended period, or other sources of oxygen (i.e., wind mixing or inflows of well-oxygenated waters) are minimal. Under anoxic conditions, wetland systems have the potential to reduce Nitrate-nitrogen levels (through de-nitrification, a process favored under anoxic conditions) and to release soluble phosphorus. When oxygenated conditions return, these processes no longer dominate and plant uptake of phosphorus may cause a reduction rather than an increase in SRP. Recommendations for additional studies to improve understanding of nutrient dynamics are presented in Section 4.

2.3.5 Fecal Coliform Bacteria

1977-78

With the exception of one high total coliform count, total and fecal coliform were low at station 1 (in-lake) throughout the study period. Total and fecal coliform counts from the southwest inlet were also low and did not present a problem. Counts from the Back River inlet (site 3) varied over a wide range; the highest values occurred in August (13,000 total coliform and 3,600 fecal coliform). The August values were noted as representing a contamination problem. High coliform counts (1,100 total c. and 600 fecal) were also reported at the outlet to Lake Attitash (site 4) and attributed to septic leachate from cottages built close to the water.

1998

Fecal coliform was measured at six locations along the Back River, at the southwest inlet, during the 1998 study and at the outlet. Along the Back River, coliform counts were high but drop off significantly at site 9 and site 3. The Southwest inlet (site 2) typically had similar or higher coliform values compared to sites 9 and 3. Graphs for individual sites are shown in **Figures 2-14** to **2-20**.

2.3.6 Sediment

Appendix A includes sediment sample results from the 1977/78 and 1998 studies. The 1977/78 sample was collected in March 1978 from the bottom of Lake Attitash at site 1. The sample was analyzed for total phosphorus, total nitrogen, and several metals. On September 27, 1998 the LAA collected three sediment samples from the Back River, the shoreline of Lake Attitash, and the bottom of the Lake at station 1. These samples were analyzed by LaPuck Laboratories for orthophosphate, total phosphorus and ammonia-nitrogen. Although the samples from site 1 were collected at approximately the same location in 1978 and 1998, they were taken at different times of the year and are therefore not comparable due to expected seasonal differences in sediment nutrient concentrations.

2.3.7 Summary

Looking at all data collected for Lake Attitash, the following observations can be made:

1. General water quality of Lake Attitash has declined in the past decade, as evidenced by secchi disk readings of clarity, and total phosphorous concentrations.

2. The lake's dissolved oxygen levels also have worsened over time. In summer 1998, the hypolimnion (the bottom layer of the lake) was anaerobic, meaning that the oxygen was depleted and oxygen levels fell to zero. The anaerobic conditions have implications for fish as well as for possible release of phosphorous from sediment to the water column.

3. Lake Attitash experienced algae blooms in summer 1998. Historical data collected by ACT provide additional records of algae blooms during the summer of 1993 and 1994. While no algae blooms were recorded during the 1977/78 study, they were reported subsequent to its completion.

4. Two tributaries feed Lake Attitash; the Back River provides most of the flow, and the smaller unnamed stream referred to as the southwest inlet drains a small wetland and residential area. Along the Back River, nutrients are very high throughout the Back River and quite variable from one sampling date to the next. Some data suggest there may be some reduction in nutrients at the mouth of the Back River (site 3). These reductions could result from impoundments along the river formed by beaver dams. In the impounded sections of the river, water slows and particulate matter can settle, along with any attached nutrients. The impoundments also provide time for bacteria die-off. Plants could also play a role both in uptake of available phosphorous and then phosphorus release when the plants die. Note that the soluble reactive phosphorous is very low at sites 9 and 3.

5. Lake Attitash and its tributaries, Tuxbury Pond, and Powwow River from the outlet of Tuxbury Pond to the inlet of Lake Gardner are designated Class A water bodies due to their use as drinking water or back-up drinking water supplies (Massachusetts Surface Water Quality Standards 314 CMR 4.00). **Table 2-4** presents a summary of the Class A water quality standards and evaluates 1998 sampling results based on the standards. With the exception of site 7, none of the sites monitored during the 1998 study met the Class A water quality standard for fecal coliform of 20 colonies/100ml

(mean value). Sites 3, 9, 6, and 21 all met the Class B standard for fecal coliform (mean value of 200 colonies/100ml).

Table 2-1
Lake Attitash
Proposed program to supplement LAA MassWW
Sampling period: July 15 through September (total 10 weeks)

Parameter	Analysis	3 Addl upstream locations	5 Upper Back R.	6 Lower Back R	3A or 3 Back River	2 South-west Inlet	1 In-lake	4 Outlet (Birches)	Meadow Brook	8 Powwow above Tux	7 Tux Dam	Total Samples	Cost per sample
		Location											
Secchi disk	in field						W				W	20	0
Chlorophyll a	Lab -						W				M*	13	45
Algae speciation	Lab -						W				M*	13	40
Fecal coliform bacteri	WTP	W	W	W	W	W						50	0
Total phosphorus	Lab -	M	M	M	M	M	M (2)***	M	M	M	M	39	25
Dissolved phosphoru	Lab -	M	M	M	M	M	M (2)***	M	M	M	M	39	35
Ammonia nitrogen	Lab -	M	M	M	M	M	M (2)***	M	M	M	M	39	35
Nitrate-nitrogen	Lab -	M	M	M	M	M	M (2)***	M	M	M	M	39	40
Total phosphorus - colorimetric method	in field	W	W	W	W	W					W	80	0
Nitrate - colorimetric method	in field	W	W	W	W	W					W	80	0
Aquatic vegetation survey	ACT	monthly July, August, entire lake										3	**

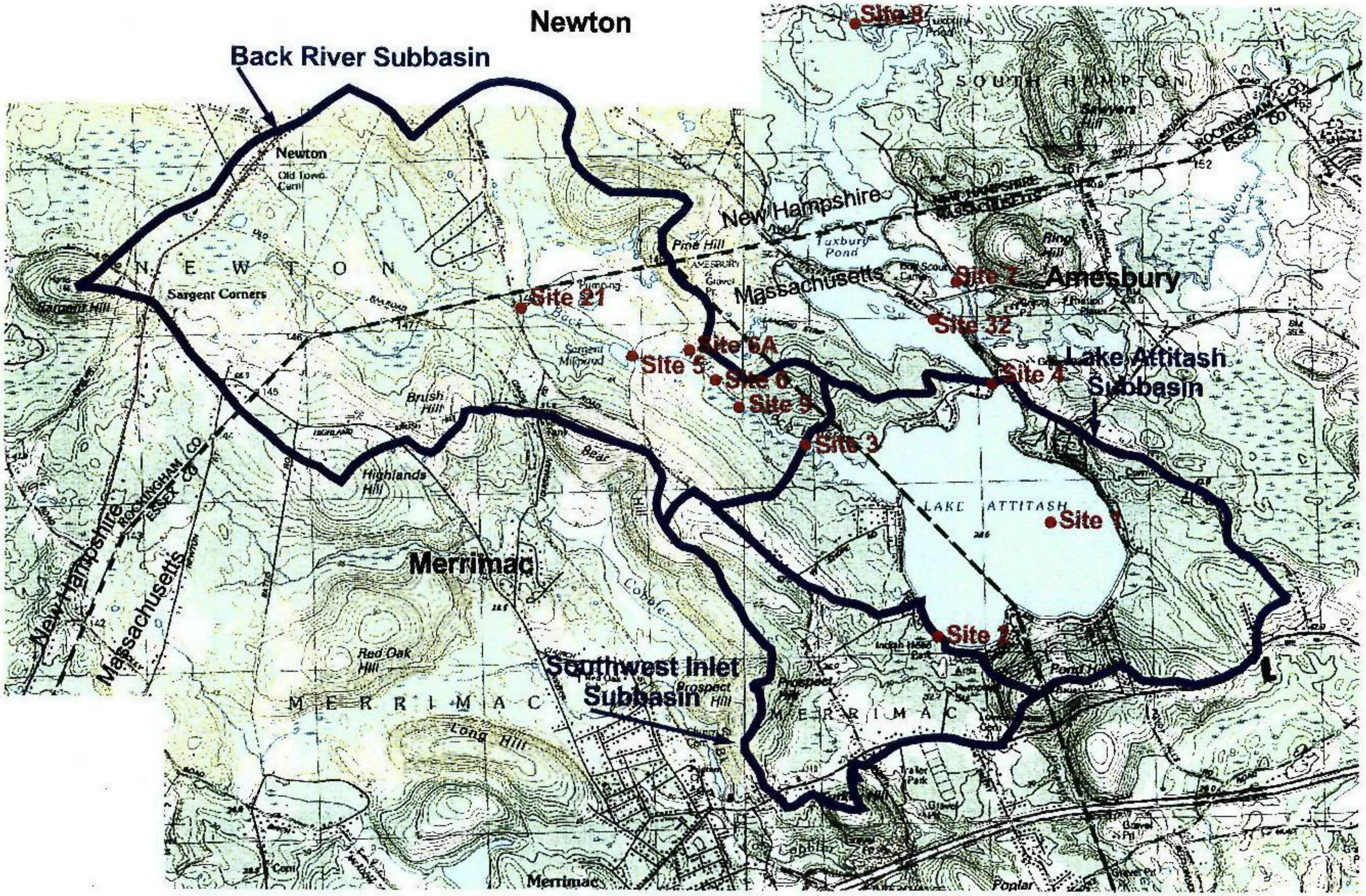
*These samples should be taken in Tuxbury Pond.

**Not included in cost estimate

***One at surface, one off bottom.

Total cost $6,370

Water Quality Monitoring Stations



Scale 1 : 36000

2000 0 2000 4000 Feet

Data Source : MassGIS and
MA Department of Food and Agriculture

Figure 2-1

December 1998

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Table 2-2. Two General Trophic Classification systems used to classify Lake Attitash.

Parameter	*Classification System*	*Oligotrophic*	*Mesotrophic*	*Eutrophic*	*Hypereutrophic*
summer secchi depth (m)	EPA, 1988	> 4	2 - 4	1 - 2	< 1
	Wetzel, 1983*	5.4 - 28.3	1.5 - 8.1	0.8 - 7.0	0.4 - 0.5
total phosphorus (ug/l)	EPA, 1988	3 - 12	12 - 25	25 - 45	> 45
	Wetzel, 1983	3 - 17	10.9 - 95.6	16 - 386	750 - 1200
chlorophyll a (ug/l)	EPA, 1988	< 4	4 - 10	10 - 25	> 25
	Wetzel, 1983	0.3 - 4.5	3 - 11	3 - 78	100 - 150

* Ranges presented are based on data of an international eutrophication program. Trophic status is based on the opinions of experienced investigators of each lake.

Figure 2-2 : Secchi Disk Depth and Trophic Status at Lake Attitash, 1977 & 1994 to 1998

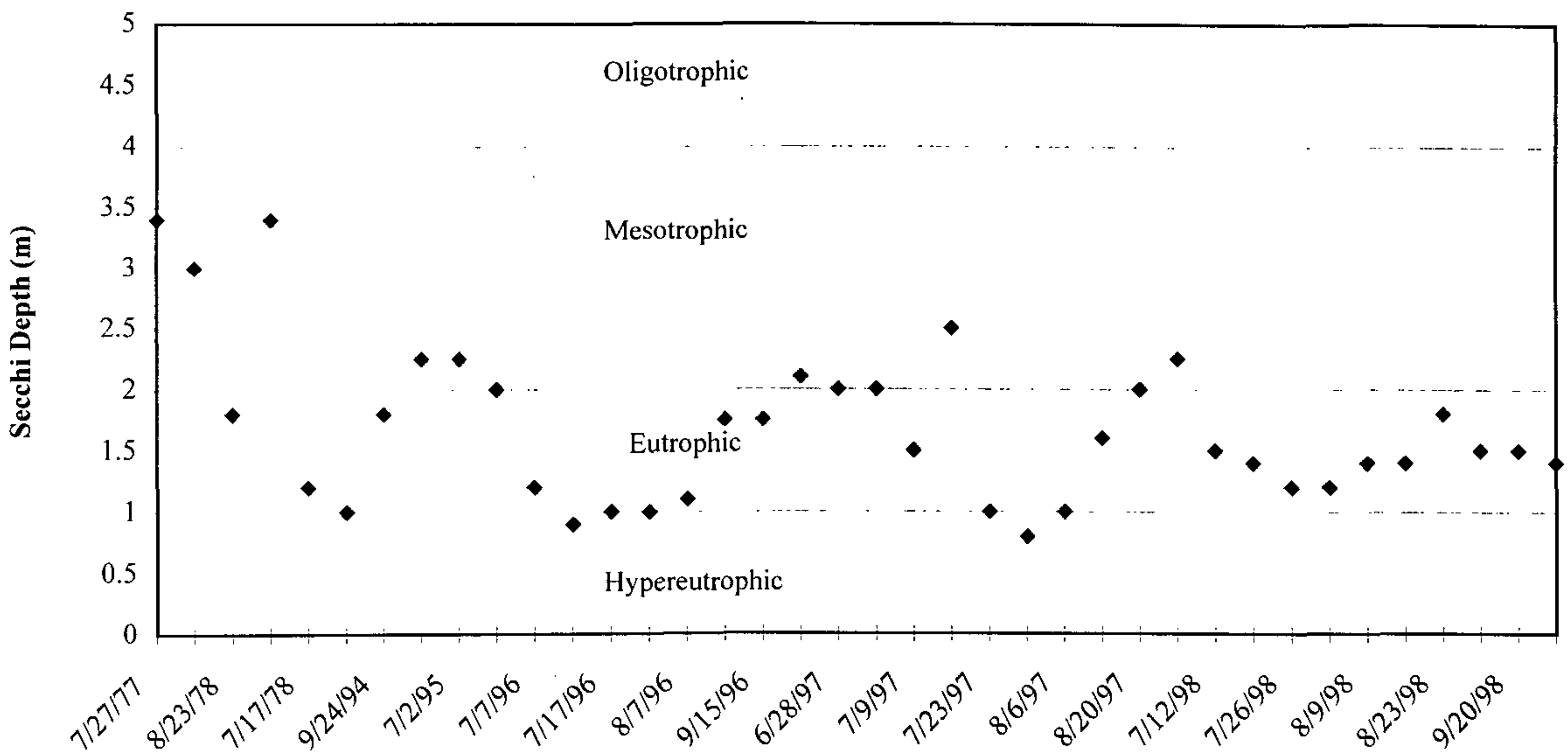


Table 2-3. Total Phosphorus and corresponding trophic status at Lake Attitash, 1977-78 and 1993-1998.

Total Phosphorous ug/l	**1977-78**			**1993-98**		
SITES	Mean	(N)	Trophic Status*	Mean	(N)	Trophic Status
Lake A. Surface 1	29	6	E	43	32	E
Lake A. Deep 1	17	7	M	10298	8	H-E

*Trophic Status estimates based on criteria from the *EPA Lake and Reservoir Restoration Guidance Manual, 1998* (see Table 2-2).

M = Mesotrophic
E = Eutrophic
H-E = Hypereutrophic
(N) = number of samples

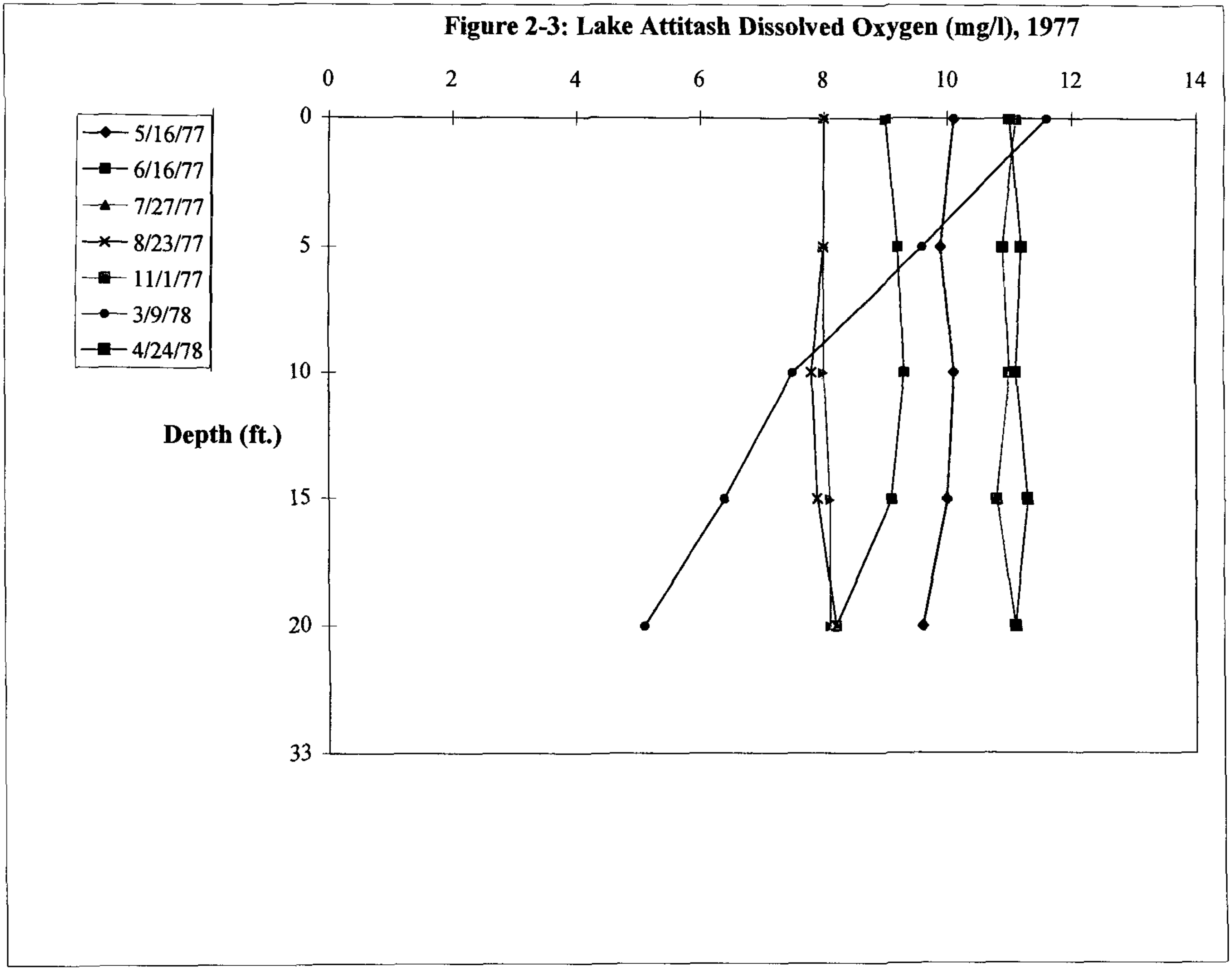


Figure 2-3: Lake Attitash Dissolved Oxygen (mg/l), 1977
0
2
4
6
8
10
12
14
Depth (ft.)
0
5
10
15
20
33
5/16/77
6/16/77
7/27/77
8/23/77
11/1/77
3/9/78
4/24/78

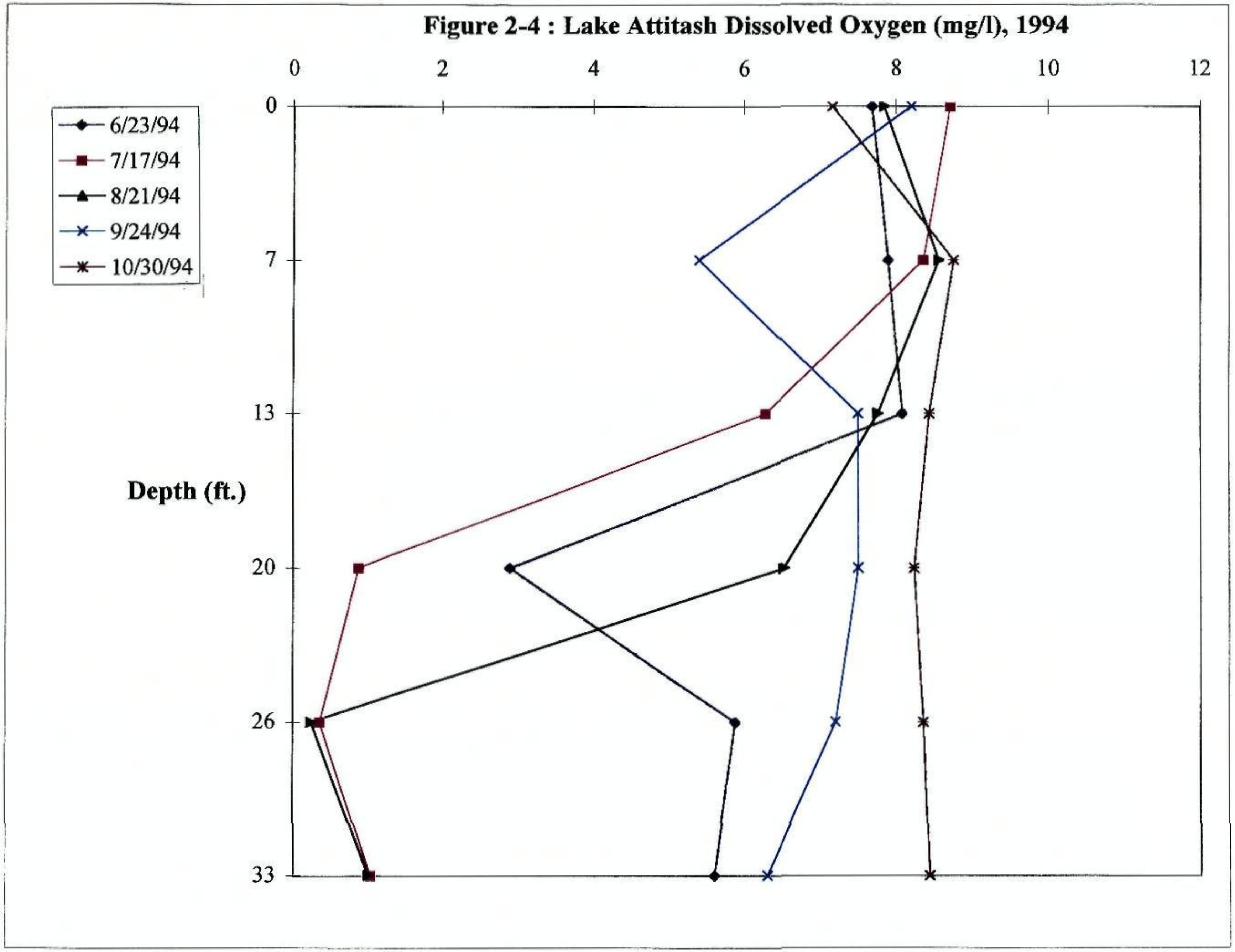
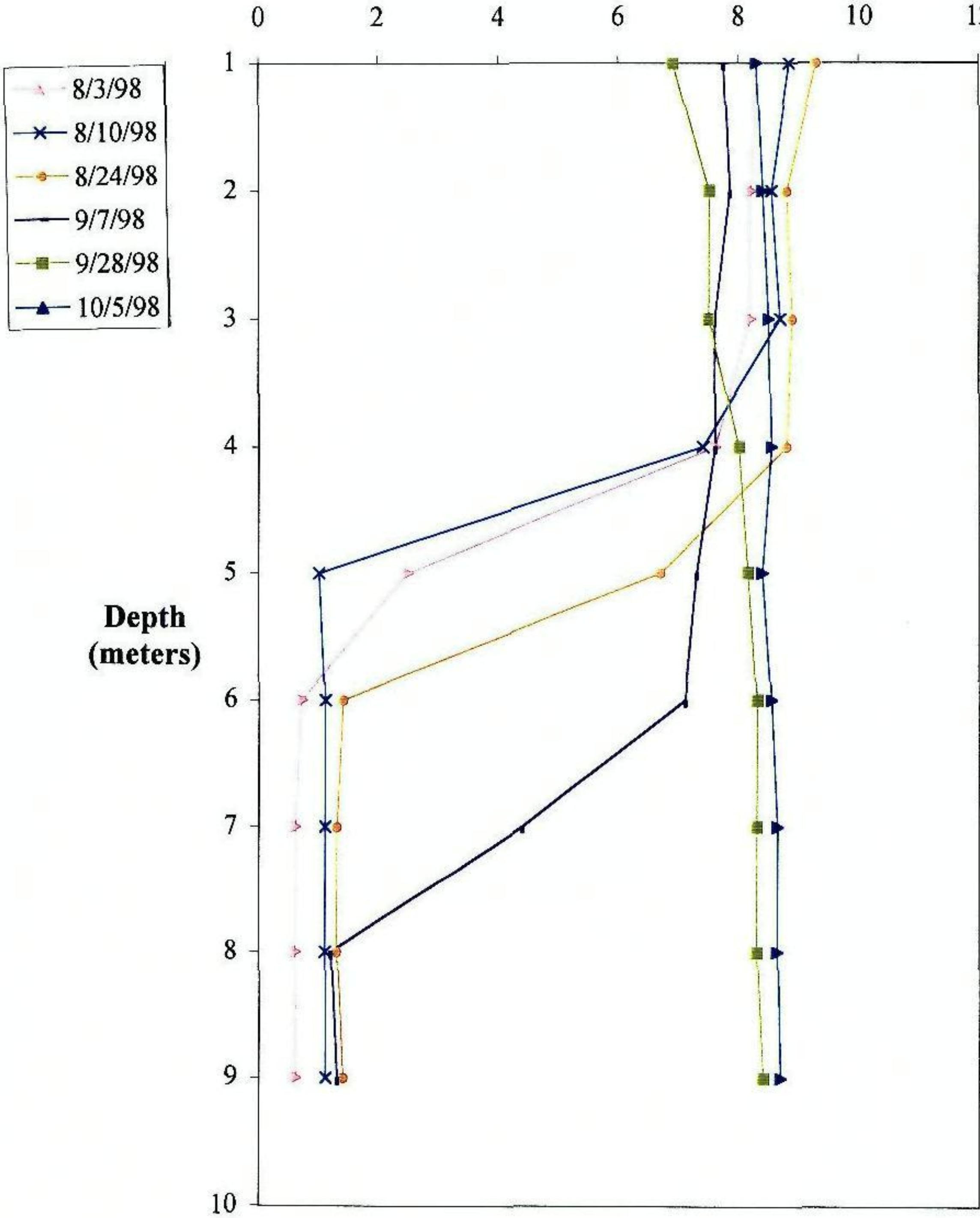


Figure 2-4 : Lake Attitash Dissolved Oxygen (mg/l), 1994
0
2
4
6
8
10
12
0
7
13
20
26
33
Depth (ft.)
6/23/94
7/17/94
8/21/94
9/24/94
10/30/94

Figure 2-5 : Lake Attitash Dissolved Oxygen (mg/l), 1998



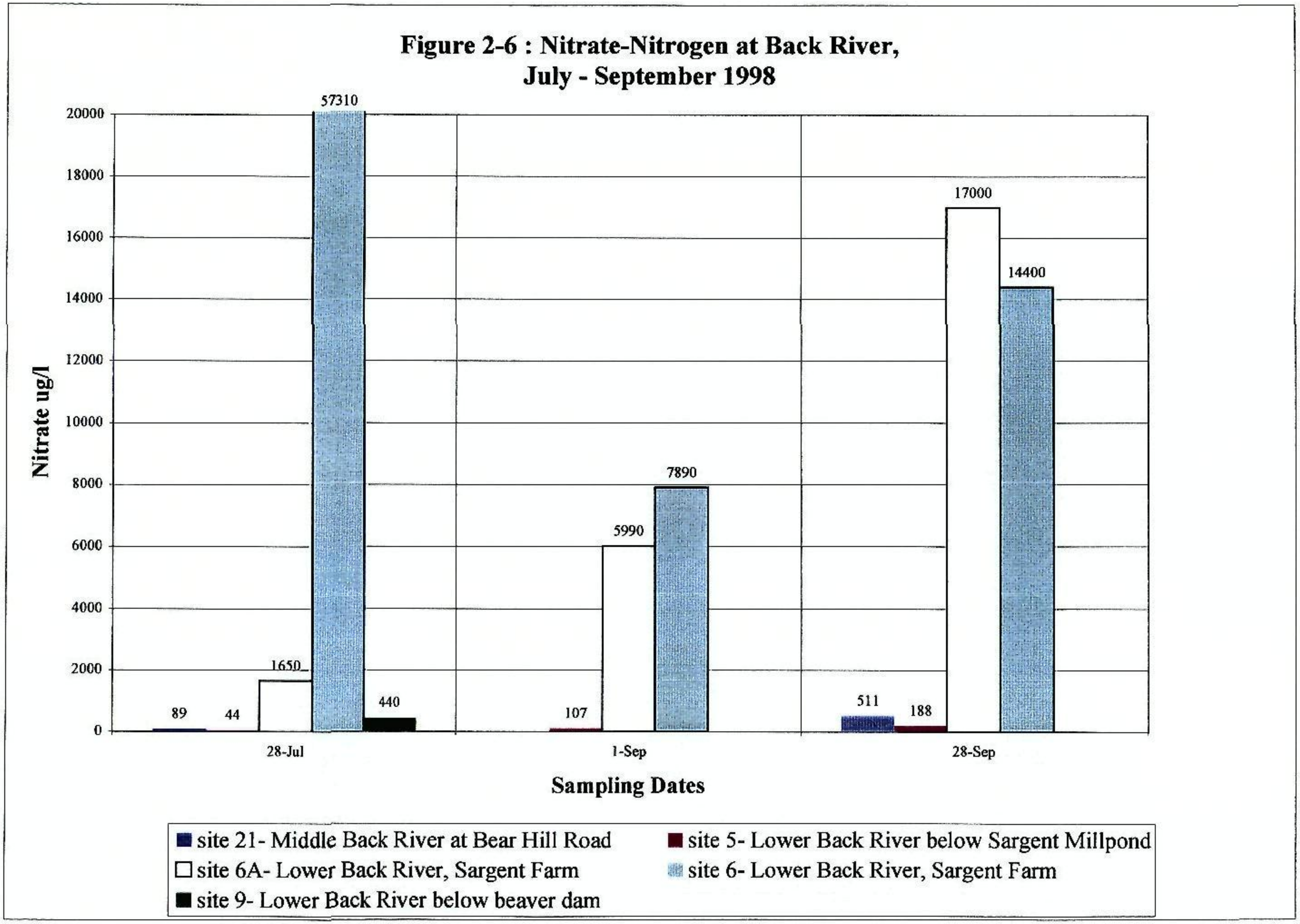


Figure 2-6 : Nitrate-Nitrogen at Back River,
July - September 1998
Nitrate ug/l
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
57310
89
44
1650
440
107
5990
7890
511
188
17000
14400
28-Jul
1-Sep
28-Sep
Sampling Dates
site 21- Middle Back River at Bear Hill Road
site 5- Lower Back River below Sargent Millpond
site 6A- Lower Back River, Sargent Farm
site 6- Lower Back River, Sargent Farm
site 9- Lower Back River below beaver dam

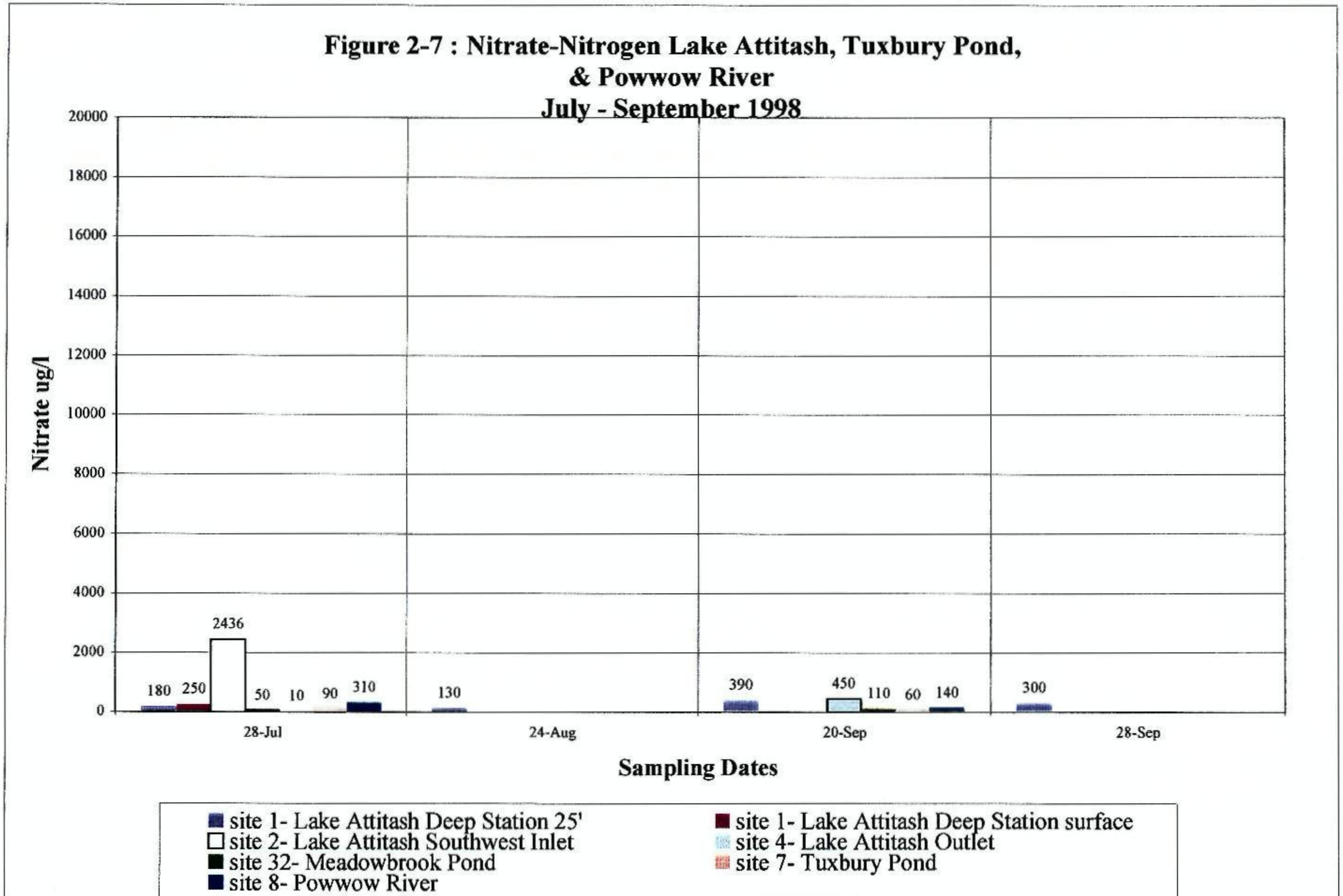
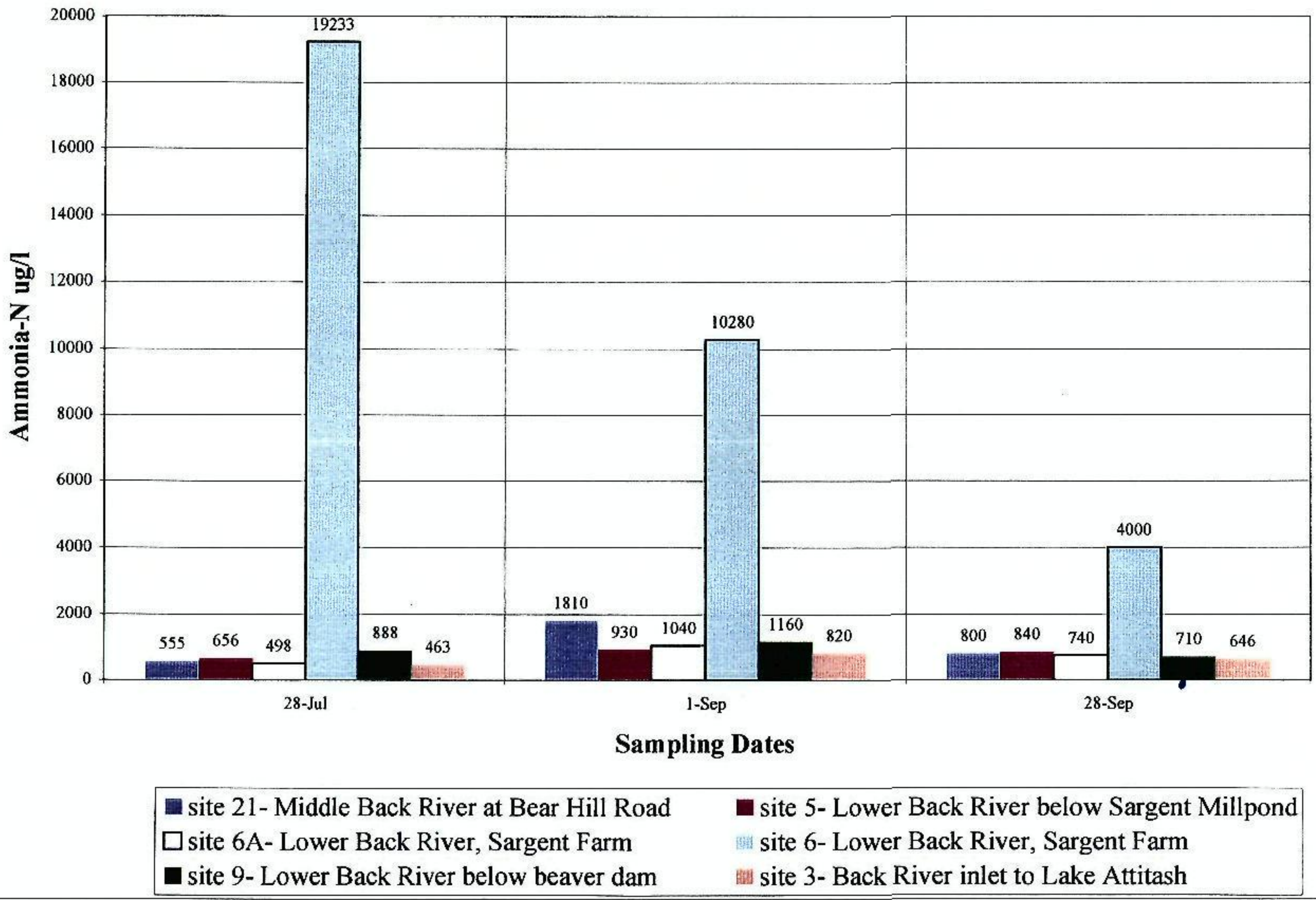


Figure 2-7 : Nitrate-Nitrogen Lake Attitash, Tuxbury Pond,
& Powwow River
July - September 1998
Nitrate ug/l
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
2436
180
250
50
10
90
310
130
390
450
110
60
140
300
28-Jul
24-Aug
20-Sep
28-Sep
Sampling Dates
site 1- Lake Attitash Deep Station 25'
site 1- Lake Attitash Deep Station surface
site 2- Lake Attitash Southwest Inlet
site 4- Lake Attitash Outlet
site 32- Meadowbrook Pond
site 7- Tuxbury Pond
site 8- Powwow River

Figure 2-8 : Ammonia-Nitrogen at Back River, July - September 1998



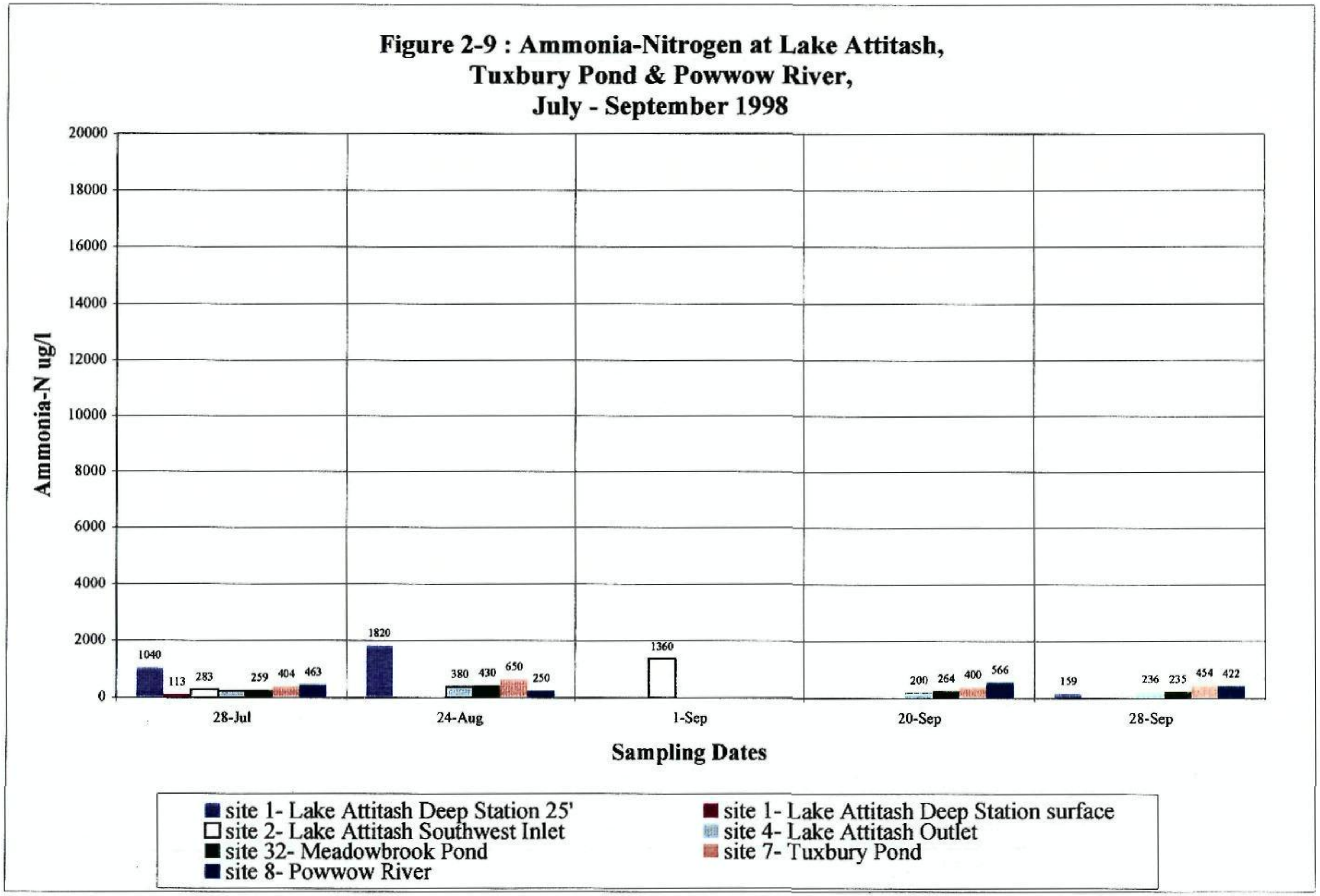
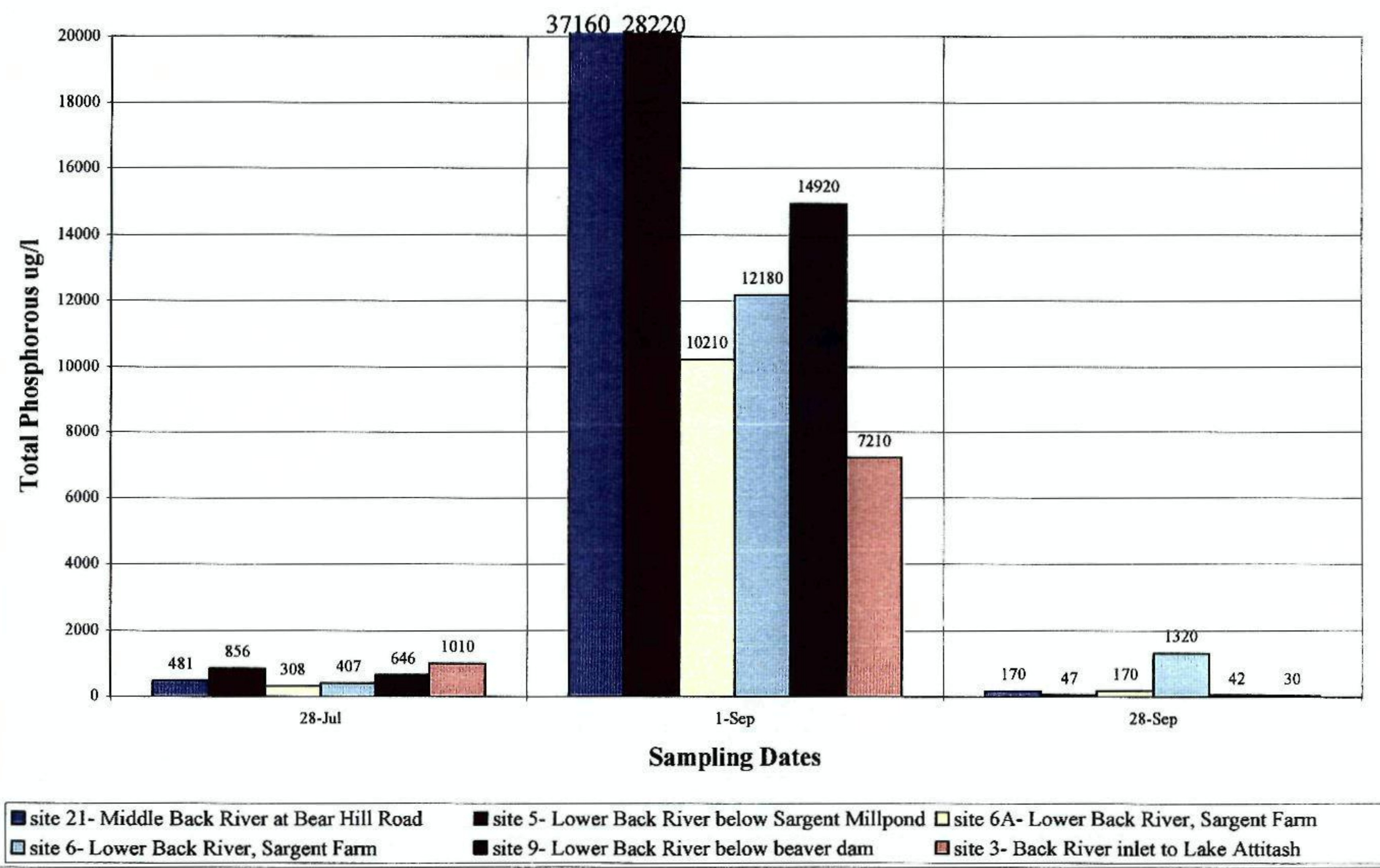


Figure 2-9 : Ammonia-Nitrogen at Lake Attitash,
Tuxbury Pond & Powwow River,
July - September 1998
Ammonia-N ug/l
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1040
113
283
259
404
463
1820
380
430
650
250
1360
200
264
400
566
159
236
235
454
422
28-Jul
24-Aug
1-Sep
20-Sep
28-Sep
Sampling Dates
site 1- Lake Attitash Deep Station 25'
site 1- Lake Attitash Deep Station surface
site 2- Lake Attitash Southwest Inlet
site 4- Lake Attitash Outlet
site 32- Meadowbrook Pond
site 7- Tuxbury Pond
site 8- Powwow River

Figure 2-10 : Total Phosphorous at Back River, July - September 1998



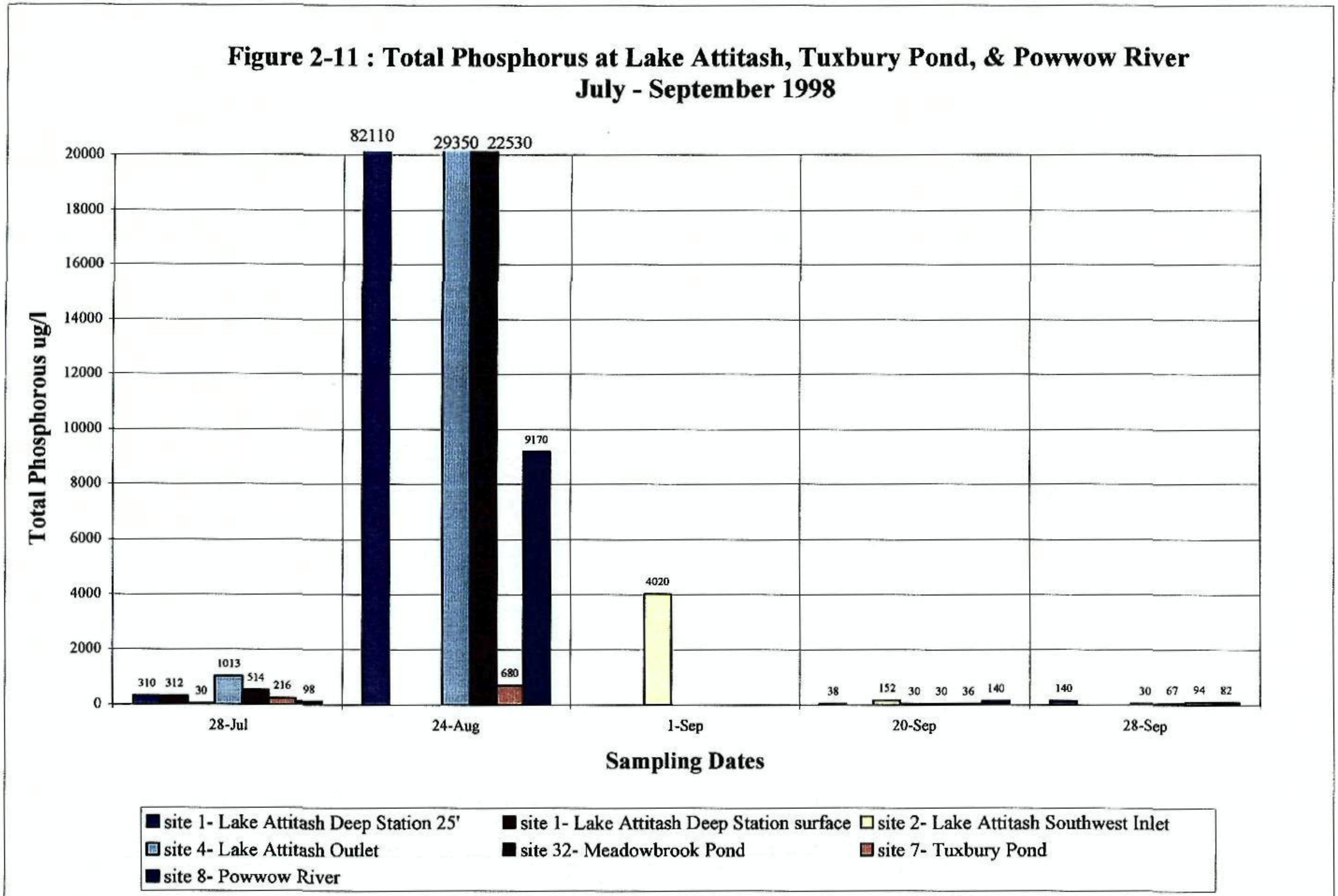
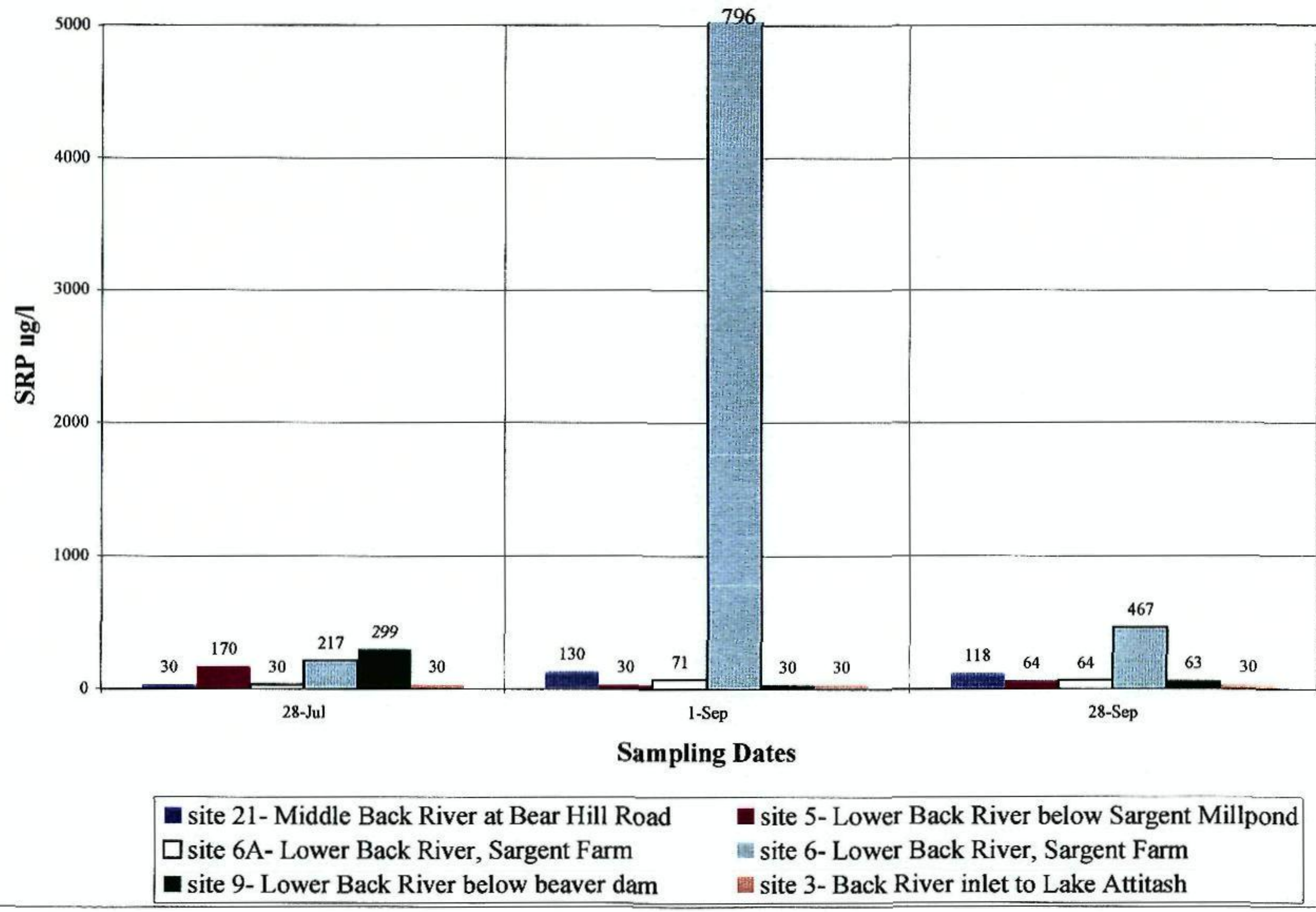


Figure 2-11 : Total Phosphorus at Lake Attitash, Tuxbury Pond, & Powwow River
July - September 1998
Total Phosphorous ug/l
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
82110
29350
22530
9170
4020
680
310
312
30
1013
514
216
98
38
152
30
30
36
140
140
30
67
94
82
28-Jul
24-Aug
1-Sep
20-Sep
28-Sep
Sampling Dates
site 1- Lake Attitash Deep Station 25'
site 1- Lake Attitash Deep Station surface
site 2- Lake Attitash Southwest Inlet
site 4- Lake Attitash Outlet
site 32- Meadowbrook Pond
site 7- Tuxbury Pond
site 8- Powwow River

Figure 2-12 : Soluble Reactive Phosphorus at Back River, July - September 1998



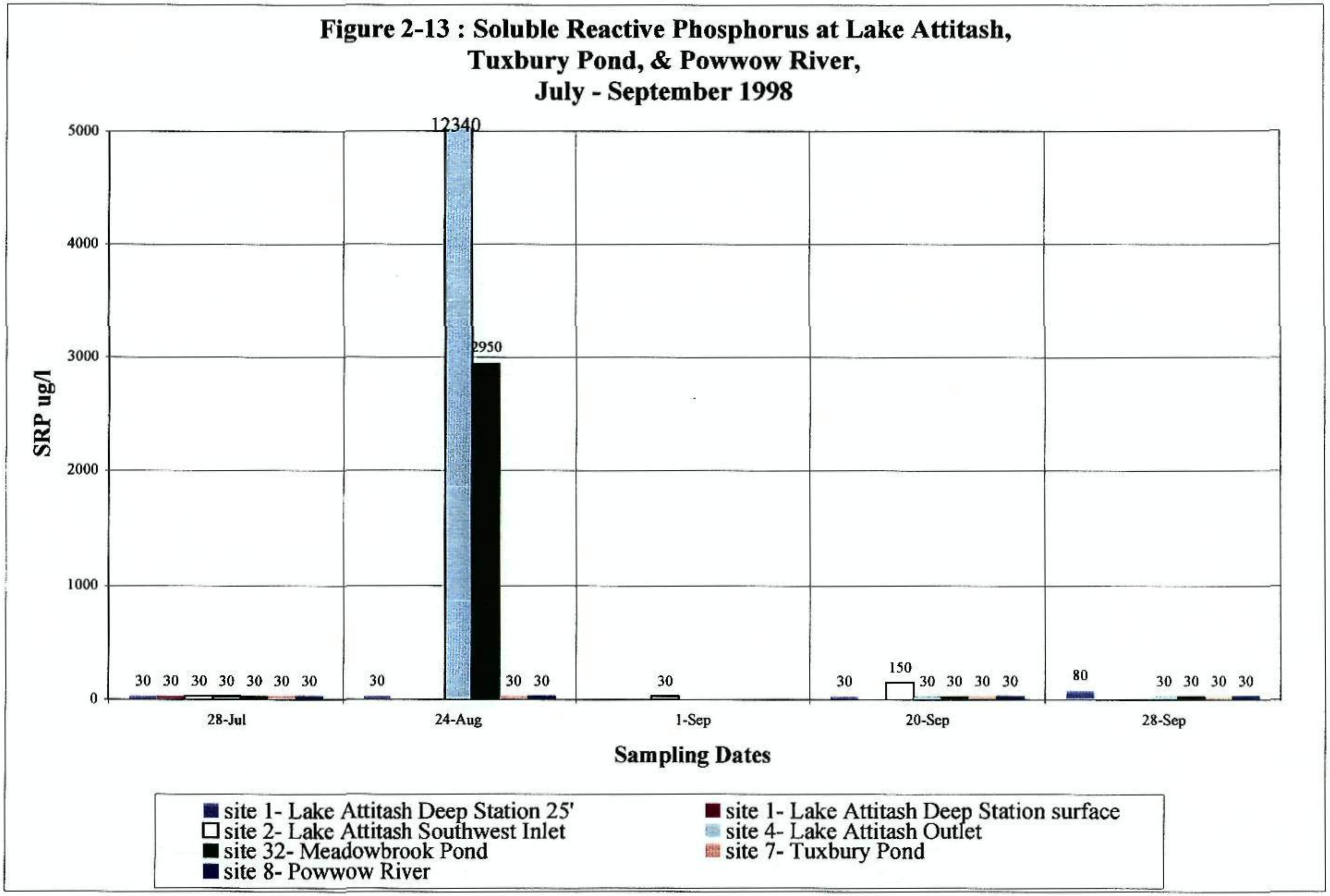


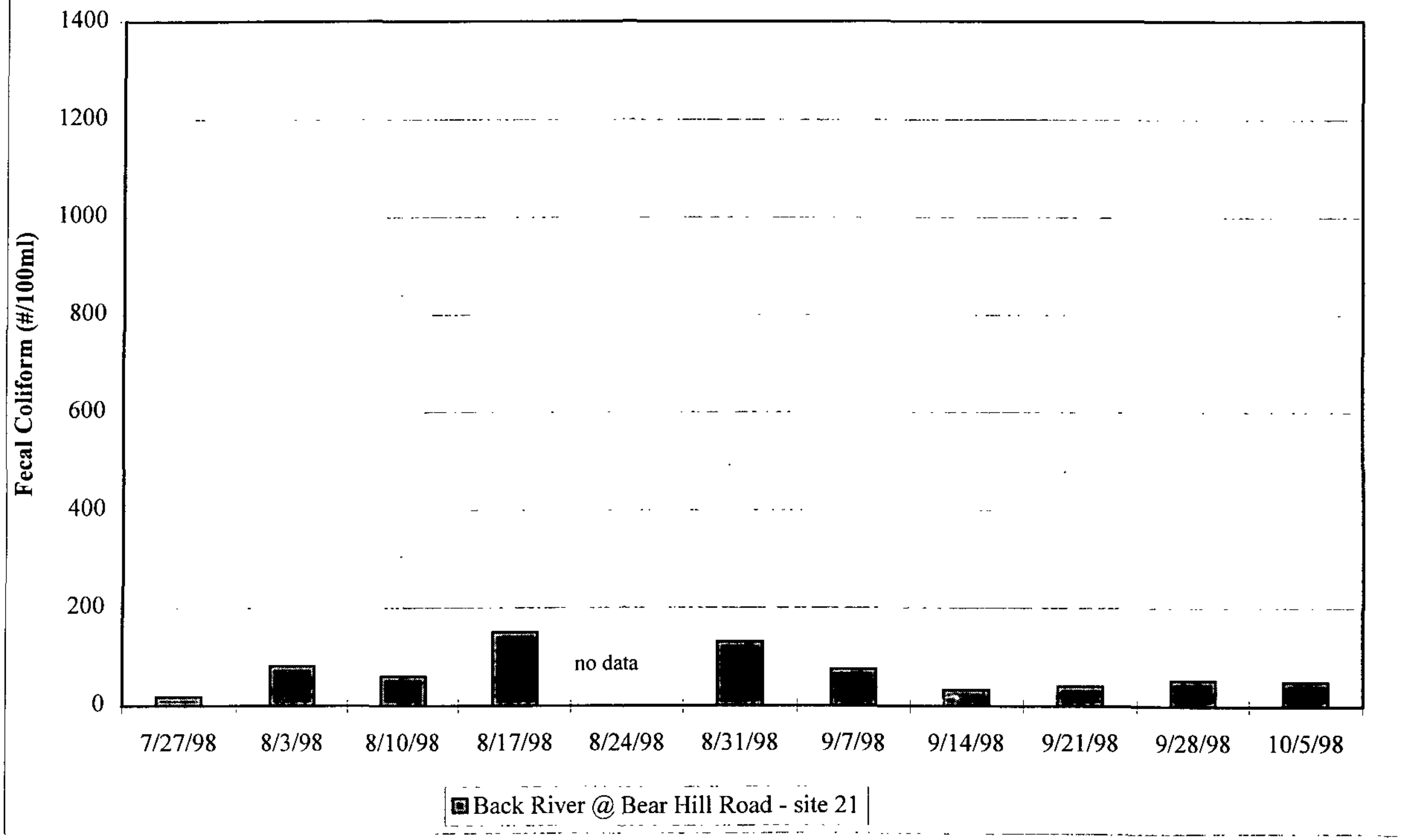
Figure 2-13 : Soluble Reactive Phosphorus at Lake Attitash, Tuxbury Pond, & Powwow River, July - September 1998
SRP ug/l
5000
4000
3000
2000
1000
0
12340
2950
30 30 30 30 30 30 30
30
30 30
30
30
150
30 30 30 30
80
30 30 30 30
28-Jul
24-Aug
1-Sep
20-Sep
28-Sep
Sampling Dates
site 1- Lake Attitash Deep Station 25'
site 1- Lake Attitash Deep Station surface
site 2- Lake Attitash Southwest Inlet
site 4- Lake Attitash Outlet
site 32- Meadowbrook Pond
site 7- Tuxbury Pond
site 8- Powwow River

Table 2-4. Results from the 1998 sampling program for the Lake Attitash Watershed, evaluated based on Massachusetts Surface Water Quality Standards for Class A waterbodies as reported in 314 CMR 4.00.

	Dissolved Oxygen	*Temperature*	*Fecal Coliform*
Class A Standards	> 6ppm, > 75% saturation	<68° F cold water <83° F warm water	mean = 20/100ml
site 1	standard not met	*standard met*	NM
site 2	NM	NM	standard not met
site 4	NM	NM	standard not met
site 3	NM	NM	*standard not met
site 9	NM	NM	*standard not met
site 6A	NM	NM	standard not met
site 6	NM	NM	*standard not met
site 5	NM	NM	standard not met
site 21	NM	NM	*standard not met
site 32	NM	NM	standard not met
site 7	NM	NM	*standard met*
site 8	NM	NM	standard not met

* Class B standard of mean = 200 colonies/100ml was met
NM = not measured

Figure 2-14: Back River Monitoring- Fecal Coliform 1998



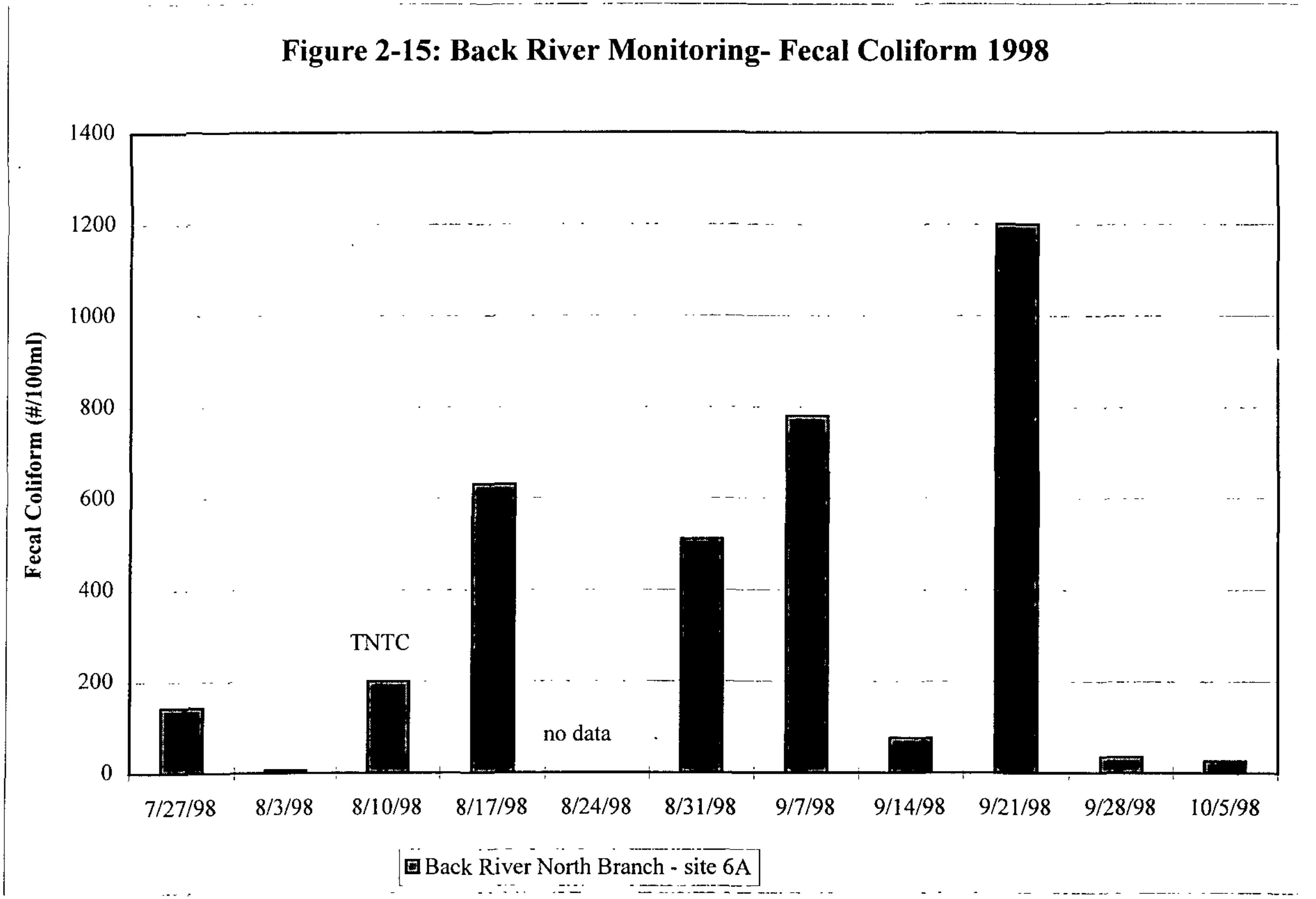


Figure 2-15: Back River Monitoring- Fecal Coliform 1998
Fecal Coliform (#/100ml)
1400
1200
1000
800
600
400
200
0
TNTC
no data
7/27/98
8/3/98
8/10/98
8/17/98
8/24/98
8/31/98
9/7/98
9/14/98
9/21/98
9/28/98
10/5/98
Back River North Branch - site 6A

Figure 2-16: Back River Monitoring- Fecal Coliform 1998

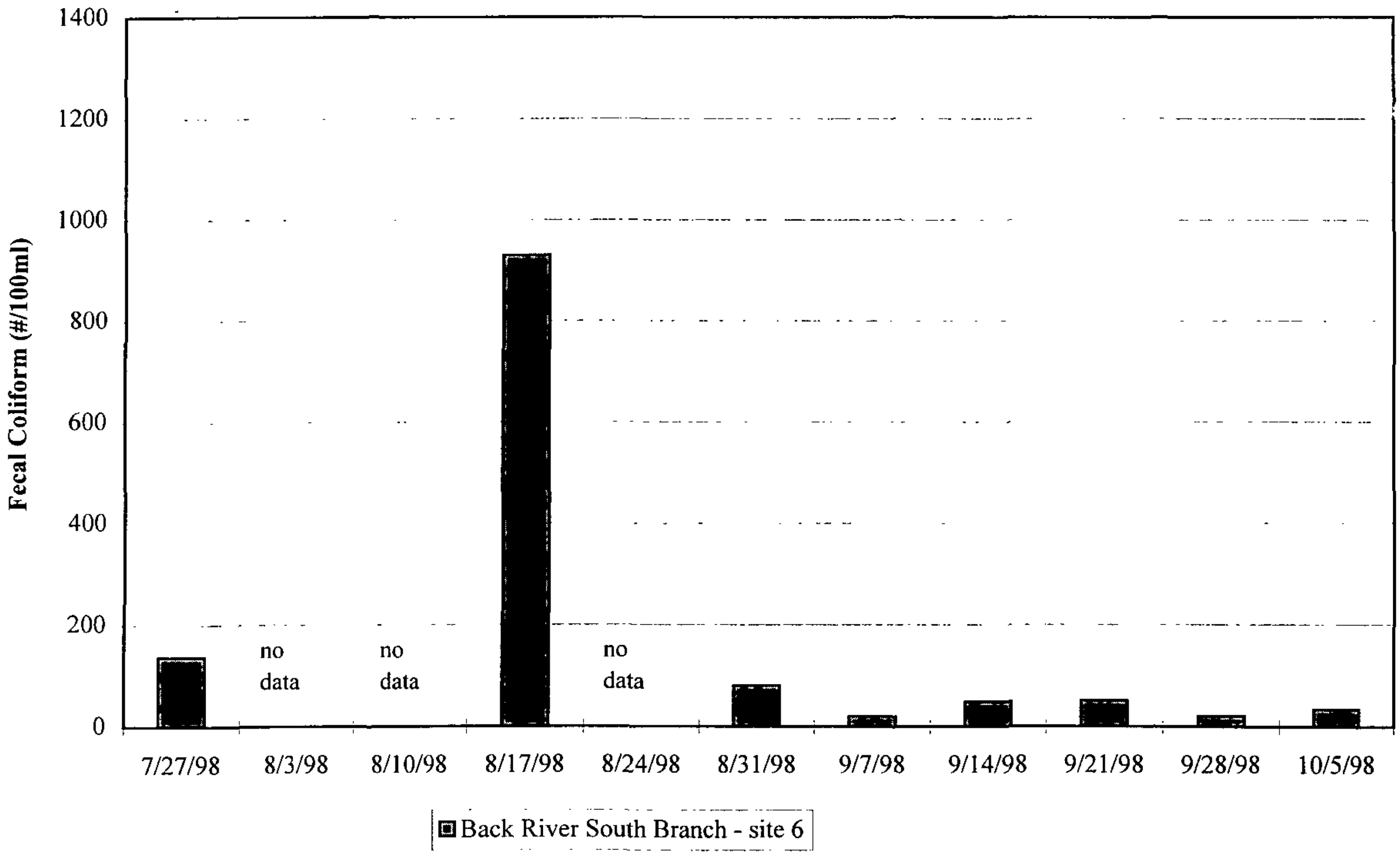


Figure 2-17: Back River Monitoring- Fecal Coliform 1998

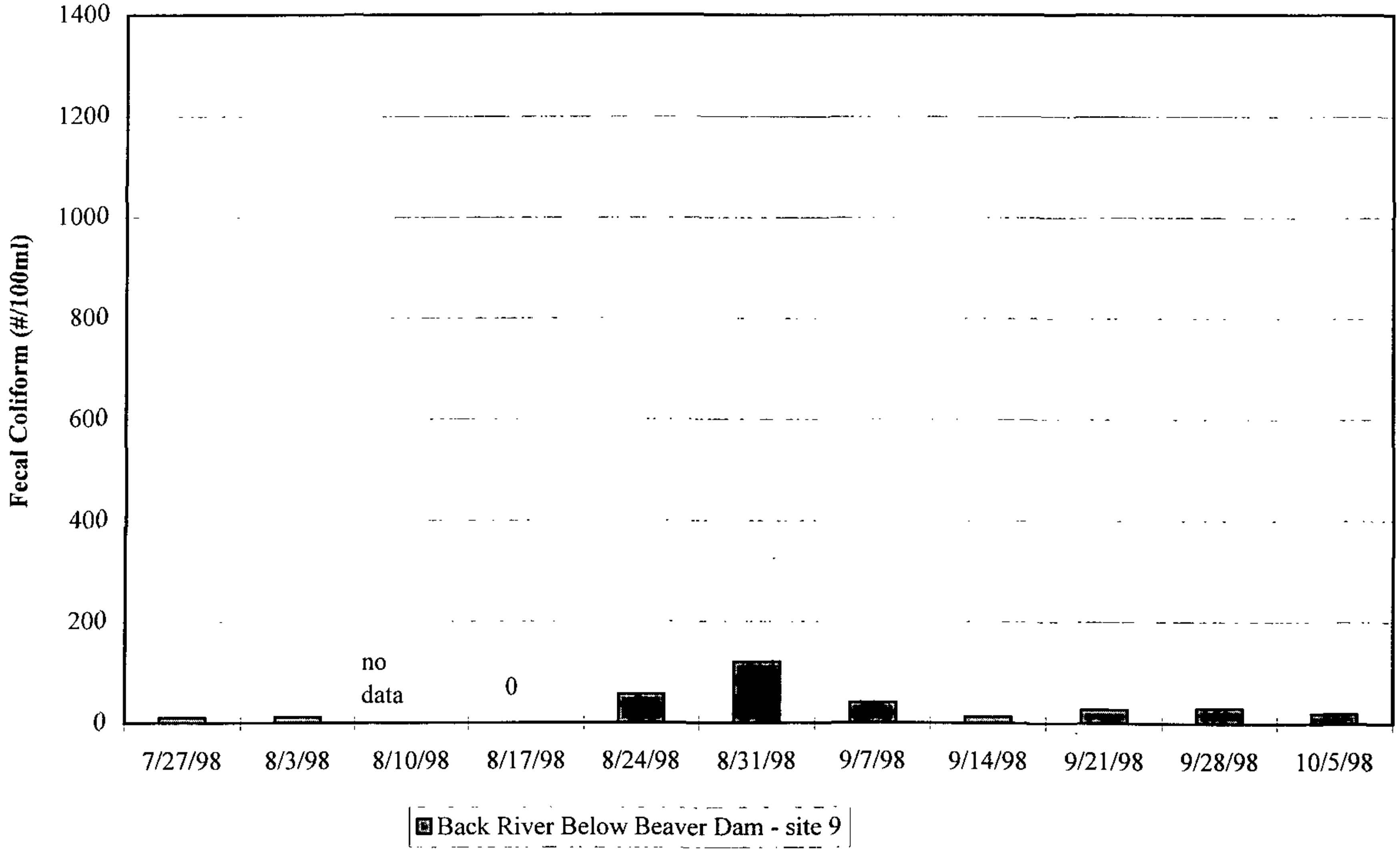


Figure 2-18: Back River Monitoring- Fecal Coliform 1998

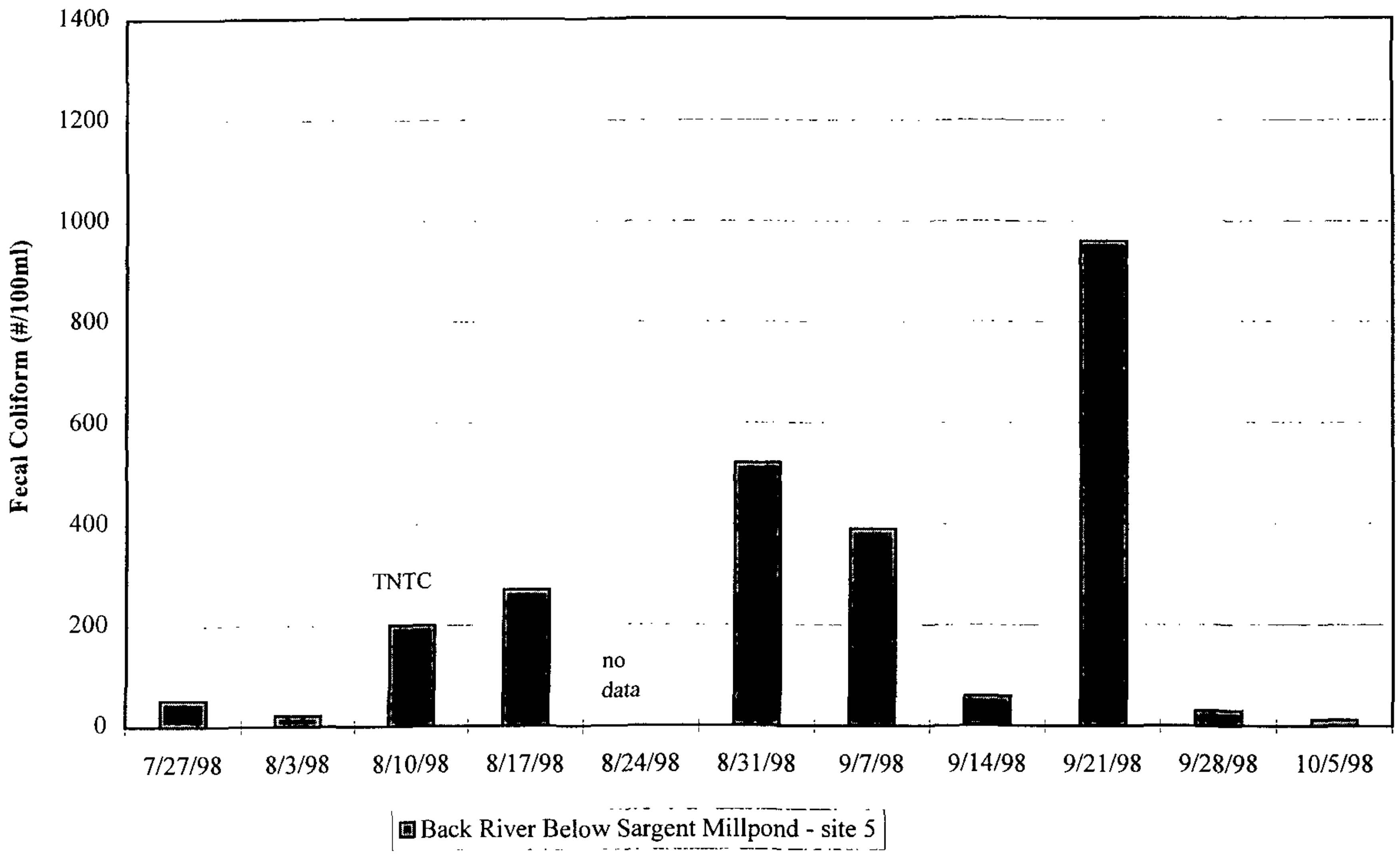


Figure 2-19: Lake Attitash Monitoring- Fecal Coliform 1998

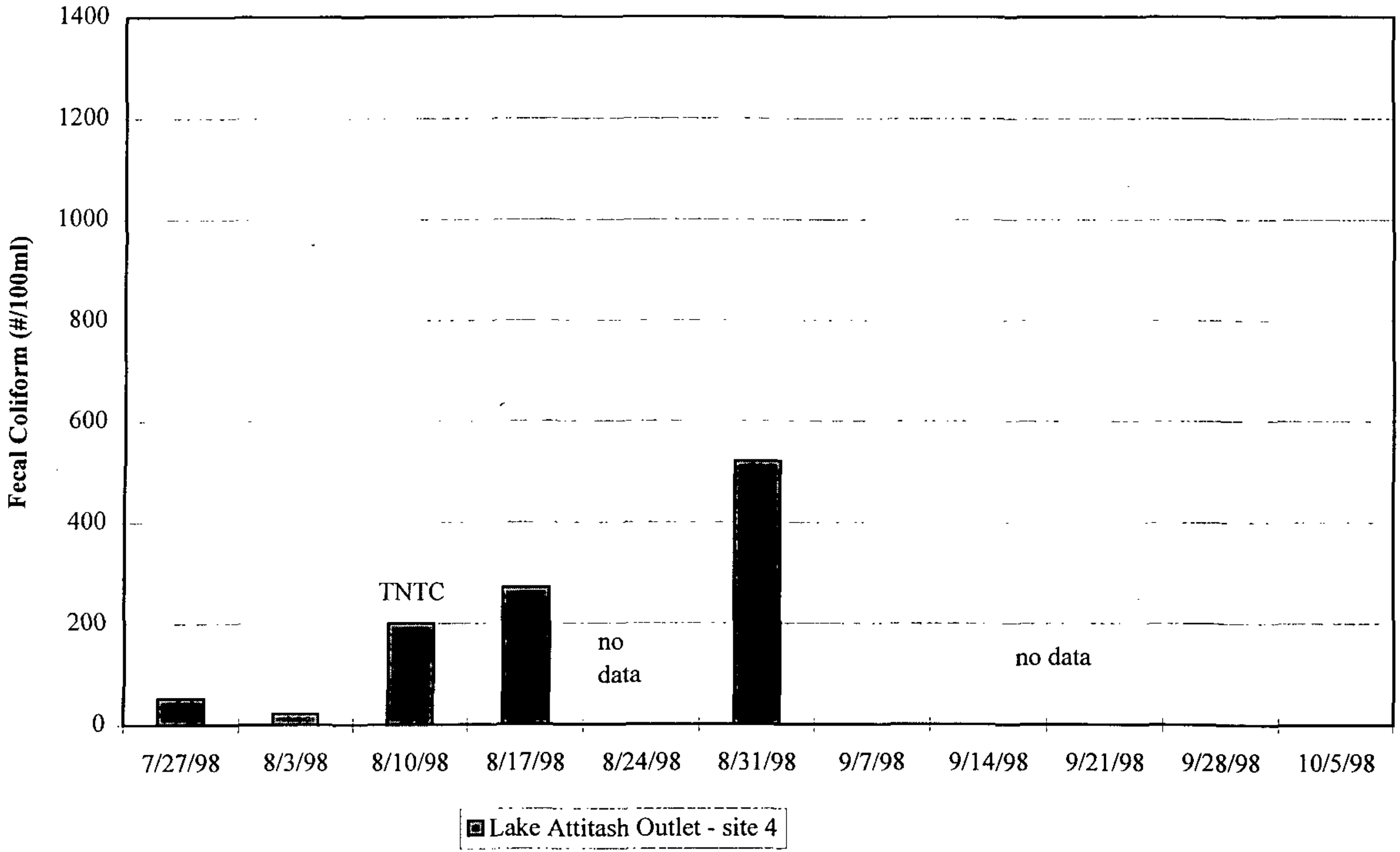
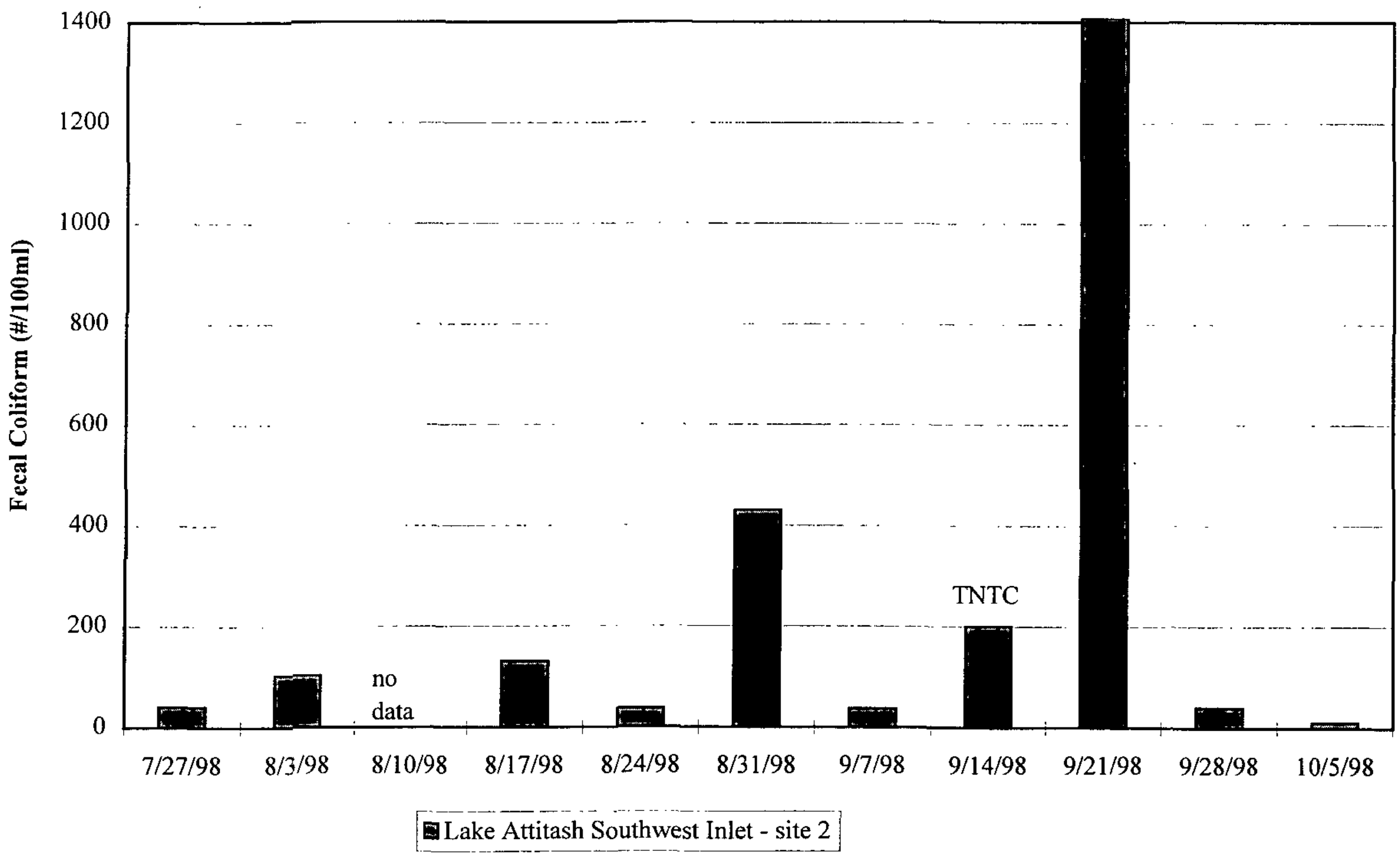


Figure 2-20: Lake Attitash Monitoring- Fecal Coliform 1998



APPENDIX A

Lake Attitash Phosphorus Data

Lake Attitash													
Total Phosphorus (ug/l)													
	21	5	6A	6	9	3	2	1	1	4	8	7	32
Date	U. Back	Below Millpond	L. BackN	L. BackS	Back belowD	Back Outlet	SW Inlet	Surface In-lake	Deep In-Lake	LakeA Outlet	PowWow River	Tux Dam	Mbrk Arch
5/16/77						40	40	40		30			
6/16/77						40	20	20	20	20			
7/27/77						70	0	20	20	30			
8/23/77						60	40	30	30	30			
11/1/77						30	50	40	20	30			
3/9/78						40	0	20	10	20			
4/24/78						20	0	20	20	20			
8/24/94						60	60	30		10			
4/24/94		20		27		32		15		16	27	12	
5/31/94		23		32		29	23	21			15	20	
6/23/94		2		8		13	10	15			10	9	
7/21/94		15		11		25	27	25			19	19	
8/11/94								41					
8/13/94		21		60									
8/21/94		31		23		31	42	29			23	12	
9/26/94		52		48		54	264	24			10	17	
10/30/94		7		13		12	31	34			8	10	
4/1/95							13			20			
4/22/95							22				30	18	
4/23/95								49					
5/14/95						23							
5/20/95													
6/8/95											23	23	
6/10/95								20					
6/24/95						25		18					
7/2/95						24		15					
7/30/95						39			22				
8/12/95						44			23				
9/10/95						33			27				
9/23/95						30			22		18	19	
10/15/95											18	18	
10/23/95							41	41					
10/24/95						57							
5/5/96						11	16						
5/7/96								18					
6/9/96						28		22					
7/12/96								29					
7/13/96		24											
7/14/96						110		23					
8/4/96								24					
8/7/96								135					
8/14/96								246					
8/18/96								34					
9/15/96						37							
9/22/96						89		21					
10/13/96						24		26					
11/10/96						26							
5/14/97							21	13					

Lake Attitash Phosphorus Data

Lake Attitash
Total Phosphorus (ug/l)

Date	21 U. Back	5 Below Millpond	6A L. BackN	6 L. BackS	9 Back belowD	3 Back Outlet	2 SW Inlet	1 Surface In-lake	1 Deep In-Lake	4 LakeA Outlet	8 PowWow River	7 Tux Dam	32 Mbrk Arch
6/13/97		23									14	8	
6/18/97								22					
6/28/97						34.5		19					
7/3/97		27											
7/20/97						91		21					
8/17/97											15	10	
8/20/97						48.5		19					
9/29/97		10											
10/17/97		9											
4/25/98						16		19					
4/26/98											9	8	
5/4/98													
6/1/98											6	18	
6/2/98								22					
6/3/98		17											
6/7/98						13							
6/20/98		23				33		28			4	9	
7/28/98	481	856	308	407	646	1010		312	ND	1013	98	216	514
8/24/98									82110	29350	9170	680	22520
9/1/98	37160	28220	10210	12180	14920	7210	4020						
9/20/98					147		152		38	ND	140	36	ND
9/28/98	170	47	170	1320	42	ND			140	ND	82	94	67
1977MEAN						43	21	29	17	26			
1990MEAN	12604	1635	3563	1284	3939	291	339	43	10298	4344	487	63	5775
MIN	170	2	170	8	42	11	10	13	22	10	4	8	67
MAX	37160	28220	10210	12180	14920	7210	4020	312	82110	29350	9170	680	22520
N	3	18	3	11	4	32	14	33	8	7	20	20	4

Soluble Reactive Phosphate (ug/l)

Date	21 U. Back	5 Below Millpond	6A L. BackN	6 L. BackS	9 Back belowD	3 Back Outlet	2 SW Inlet	1 Surface In-lake	1 Deep In-Lake	4 LakeA Outlet	8 PowWow River	7 Tux Dam	32 Mbrk Arch
6/16/77*						30	10	10	10	10			
7/28/98	ND	170	ND	217	299	ND	ND	ND	ND	ND	ND	ND	ND
8/24/98									ND	12340	ND	ND	2950
9/1/98	130	ND	71	7960	ND	ND	ND						
9/20/98					ND		151		ND	ND	ND	ND	ND
9/28/98	118	64	64	467	63	ND			78	ND	ND	ND	ND
1990MEAN	83	78	45	2881	91	ND	50	ND	20	3085	ND	ND	738
MIN	ND	ND	ND	217	ND	ND	ND	ND	ND	ND	ND	ND	ND
MAX	130	170	71	7960	299	30	151	10	78	12340	ND	ND	2950

ND = No Detect, < 30 ug/l for Total Phosphorus and SRP
ND = 0 for calulation of means
* = Orthophosphorus

Very high but see noted 4/1/99

Lake Attitash Nitrogen Data

Lake Attitash

Total Kjeldahl Nitrogen TKN (ug/l)

DATE	3	2	1	1 deep	4
5/16/77	80	900	720	NT	900
6/16/77	650	400	420	400	500
7/27/77	810	NF	310	630	520
8/23/77	930	1400	780	900	1000
11/1/77	1100	1300	800	620	650
3/9/78	780	FZ	650	380	450
4/24/78	430	NF	380	400	380
8/24/83	2700	2300	2700	NT	1400

Notes and Abbreviations:
NT = not taken
NF = no flow
FZ = frozen
UR = under range

Nitrate-Nitrogen NO3 (ug/l)

	21	5	6A	6	9	3	2	1	1	4	8	7	32
DATE	U. Back	Below Millpond	L. BackN	L. BackS	Back belowD	Back Outlet	SW Inlet	Surface In-lake	Deep In-Lake	LakeA Outlet	PowWow River	Tux Dam	Mbrk Arch
5/16/77						100	0	NT	100	100			
6/16/77						100	100	0	0	0			
7/27/77						100	NF	0	100	0			
8/23/77						100	0	0	0	0			
11/1/77						100	0	0	0	0			
3/9/78						0	FZ	500	100	100			
4/24/78						500	NF	200	200	200			
8/24/94						80	50	50	NT	50			
4/24/94		47		77		307					11	17	
5/31/94		11		28		14							
6/23/94		41		145		5		18			56	5	
7/21/94		78		171		5		5					
8/11/94								2					
8/13/94		128		215									
8/21/94								2					
9/26/94		5		11		549		36					
10/30/94		5		6		5		5					
7/28/98	89	44	1650	57310	440	470	2436	245	180	50	310	93	9
8/24/98									130				
9/1/98		107	5990	7890									
9/20/98									388	0	141	62	113
9/28/98	511	188	17000	14400					295				
1977MEAN						143	25	117	71	57			
1990sMEAN	300	65	8213	8025	440	179	1243	45	248	33	130	44	61
MIN	89	5	1650	6	440	0	0	0	0	0	11	5	9
MAX	511	188	17000	57310	440	549	2436	500	388	200	310	93	113

Lake Attitash Nitrogen Data

Lake Attitash

1998 Watershed Study

Nitrate-Nitrogen Colorimetric Test - NO3 (ug/l)

DATE	21	5	6A	6	9	3	2	7
7/26/98	500	1580	4200	31830	1600	600	0	1500
8/2/98	100	1100	900	NF	500	600	400	1800
8/9/98	1840	3880	100	NF	NT	NT	NT	600?
8/16/98	650	600	2180	6040*	300	700	UR	1200
8/23/98	NT	NT	NT	NT	800	800	500	300
8/30/98	1780	640	4200	7040	2300	0	1800	NT
9/6/98	3270	350	4080	3070	3200	600	2900	1200
9/13/98	4600	UR	3800	13400*	800	100	600	0
9/20/98	3300	0	7000	8800*	200	4300	0	600
9/27/98	3400	UR	5700	3000	UR	300	500	2600
10/4/98	NT	NT	NT	NT	UR	300	300	NT
MEAN	2160	1164	3573	11235	1213	830	778	1150
MIN	100	0	100	3000	200	0	0	0
MAX	4600	3880	7000	31830	3200	4300	2900	2600

Notes and Abbreviations:

NT = not taken

NF = no flow

FZ = frozen

UR = under range

* = standing water

Ammonia-Nitrogen NH4 (ug/l)

	21	5	6A	6	9	3	2	1	1	4	8	7	32
DATE	U. Back	Below Millpond	L. BackN	L. BackS	Back belowD	Back Outlet	SW Inlet	Surface In-lake	Deep In Lake	LakeA Outlet	PowWow River	Tux Dam	Mbrk Arch
7/28/98	555	656	498	19233	888	463	283	1040	113	213	463	404	259
8/24/98								1820		380	250	650	430
9/1/98	1810	930	1040	10280	1160	820	1360						
9/20/98										200	566	400	264
9/28/98	800	840	740	4000	710	646		159		236	422	454	235
MEAN	1055	809	759	11171	919	643	822	1006	113	257	425	477	297
MIN	555	656	498	4000	710	463	283	159	113	200	250	400	235
MAX	1810	930	1040	19233	1160	820	1360	1820	113	380	566	650	430

Lake Attitash Secchi Disk Data

Lake Attitash

Date	In-lake Secchi (m)	Trophic Status
5/16/77	2.7	NA
6/16/77	4	NA
7/27/77	3.4	O
8/23/77	3	M
11/1/77	4	NA
3/9/78	1.2	NA
4/24/78	2.6	NA
8/23/78	1.8	E
5/31/78	2.9	NA
6/23/78	3.4	O
7/17/78	1.2	E
8/21/78	1	E
9/24/94	1.8	E
10/30/94	1.75	NA
4/22/95	1.75	NA
5/20/95	1.75	NA
6/24/95	2.25	M
7/2/95	2.25	M
7/9/95	2	E
6/13/96	2.1	NA
7/7/96	1.2	E
7/15/96	0.9	HE
7/17/96	1	E
8/3/96	1	E
8/7/96	1.1	E
9/8/96	1.75	E
9/15/96	1.75	E
10/5/96	2.1	NA
5/14/97	2	NA
5/21/97	2.2	NA
5/28/97	2.2	NA
6/4/97	2.6	NA
6/18/97	2.2	NA
6/25/97	2.1	M
6/28/97	2	E
7/2/97	2	E
7/9/97	1.5	E
7/16/97	2.5	M
7/23/97	1	E
7/30/97	0.8	HE
8/6/97	1	E
8/13/97	1.6	E
8/20/97	2	E
5/30/98	2.5	NA
6/6/98	2.25	NA

Categories from EPA Clean Lakes Program Guidance Manual, December 1980

Summer = June - September

Trophic State	Secchi Depth (m) summer
Oligotrophic	>4
Mesotrophic	2 to 4
Eutrophic	1 to 2
Hyper Eut.	<1

NA = not applicable b/c not summer measurement
O = oligotrophic
M = mesotrophic
E = eutrophic
HE = hypereutrophic

Secchi data continued

Date	In-lake Secchi (m)	Trophic Status
6/14/98	2	NA
6/21/98	2.25	M
7/12/98	1.5	E
7/19/98	1.4	E
7/26/98	1.2	E
8/2/98	1.2	E
8/9/98	1.4	E
8/16/98	1.4	E
8/23/98	1.8	E
9/13/98	1.5	E
9/20/98	1.5	E
9/27/98	1.4	E
10/4/98	1.6	NA

Lake Attitash Chlorophyll and Algae Data

Chlorophyll (ug/l)						
Date	site 9	site 3	site 1	site 2	site 7	site 32
16-May-77			2.93			
16-Jun-77						
27-Jul-77			2.13			
23-Aug-77			2.13			
24-Apr-78			1.65			
29-Jul-98			363		48	
4-Aug-98			487			
12-Aug-98			1,970			
24-Aug-98	887	552		581		552
25-Aug-98			399		584	
1-Sep-98			323			
7-Sep-98						
21-Sep-98			790		451	
29-Sep-98			621		451	

Algae						
Date	site 9	site 3	DS1	site 2	site 7	site 32
16-May-77			1,632			
16-Jun-77			731			
27-Jul-77			457			
23-Aug-77			257			
1-Nov-77			174			
23-Aug-93			60,000			
24-Aug-94			30,000			
29-Jul-98			98.42*		89.17*	
4-Aug-98			32.69*			
12-Aug-98			132*			
18-Aug-98			1,500			
24-Aug-98	910	780	3,900	2200	1560	
20-Sep-98			398			

1977, 93 & 94 algae data are cells/ml

*Algae data reported as biomass (mg/l) when high turbidity of sample prevented accurate cell count

Lake Attitash Sediment Data: 1977, 1998

Lake Attitash Sediment Analysis					
DATE	March. 1977	March. 1977	Sept. 1998	Sept. 1998	Sept. 1998
SITE	Deep Station 1	Deep Station 1	Back River	Lake A Shore	Deep Station 1
UNITS	ppm (mg/kg)	AVE Mass	ppm (mg/kg)	ppm (mg/kg)	ppm (mg/kg)
TKN	7,800	9,450			
Total Phosphorus	1,100	1,100	2.79	0.727	0.569
Manganese	740	866			
Iron	47,000	34,000			
Chromium	50	30			
Copper	51	107			
Lead	200	317			
Zinc	220	300			
Cadmium	2	3			
SRP			0.251	0.106	0.15
Ammonia-Nitrogen			2.3	2.65	4.68

Section 3
Lake Attitash Watershed

3.1 Description

The Lake Attitash watershed is 2,486 acres in size. The watershed extends from the lake northwest, falling in the owns of Amesbury Massachusetts, Merrimac Massachusetts, and Newton New Hampshire. To understand and evaluate the watershed, CDM has divided the watershed into three subbasins:

(1) The Lake Attitash direct subbasin includes the areas around the lake that drain directly to the lake (e.g., without forming or entering tributary streams). This subbasin is 586 acres in size and is dominated by residential development and wetlands.

(2) The Back River subbasin is 1,525 acres, and includes all the watershed lands that drain to the Back River. To enable analysis, sampling point 3 has been used to define the divide between the Back River and the Lake Attitash subbasins. The Back River subbasin features a variety of land uses, including two agricultural sites, residential developments, wetlands, former gravel pits, and forests.

(3) The Southwest Inlet subbasin includes the portion of the watershed that drains to the so-called Southwest inlet to the lake. This area includes the only commercial land uses in the watershed, an extensive wetland along the Southwest inlet, and some residential development. The Southwest inlet subbasin totals 375 acres.

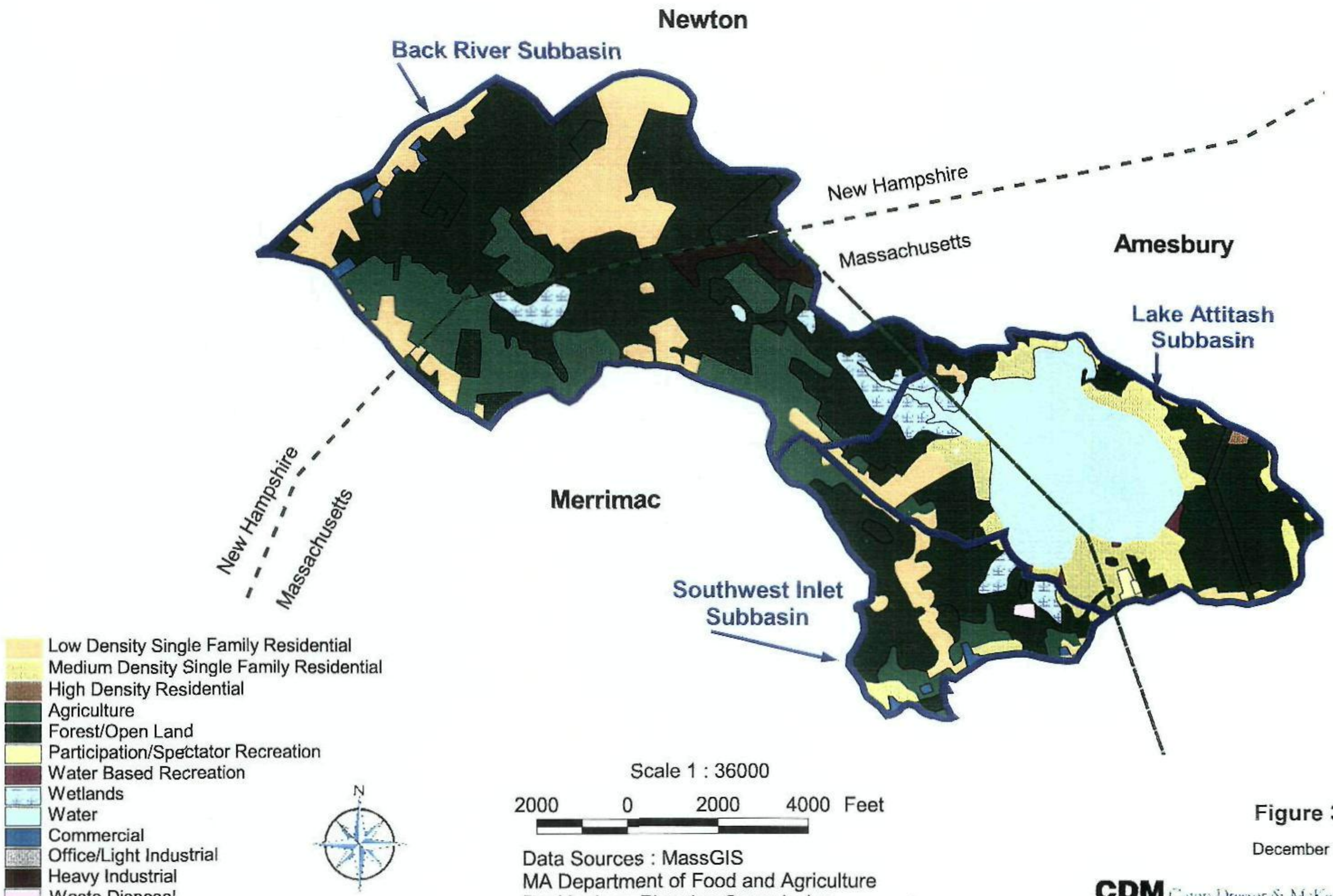
Land use data for the watershed are available from MassGIS (for the Massachusetts portions) and the Rockingham Planning Commission (for the New Hampshire portions). The Lake Attitash watershed is characterized by relatively dense residential development around the lake shore, some lower density residential development along major roadways, several large farm tracts, and some remaining undeveloped forest portions. Overall, approximately 23% of the watershed is developed, 16% is agriculture, and 61% is undeveloped forests and wetlands. **Figure 3-1** and **Table 3-1** show the watershed land uses.

3.2 Phosphorus Loads to the Lake

To be able to develop a watershed management plan, it is necessary to understand not only the concentrations of phosphorus (as discussed in Section 2), but the phosphorus loads to the lake. Phosphorus loads are the determining factor in eutrophication and plant and algae growth. While comparison of phosphorus concentrations can be useful in looking at possible phosphorus source locations, it is the balance of loads that determines the lake's health.

In this section, two technical methods are used to better understand the phosphorus loads to Lake Attitash. First, a land use-based watershed loading model is used. This helps to determine which land uses are contributing significant phosphorus loads to the lake -- and thus helps to focus improvement efforts. Second, preliminary hydrology and phosphorus budgets are developed. In this approach, data are typically collected over an entire year and used to develop an annual budget of the flows and the amount of

Land Uses of Lake Attitash Watershed



Data Sources : MassGIS
MA Department of Food and Agriculture
Rockingham Planning Commission

Figure 3-1

December 1998

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Table 3-1
Land Use Areas in Lake Attitash Subbasins

	Area (acres)				
Land Use	**Back River Subbasin**	**Southwest Inlet Subbasin**	**Direct Runoff Subbasin**	**Total**	**Percent of Watershed**
Forest/Rural Open	835	223	319	1377	55%
Urban Open	33	3	13	49	2%
Agricultural/Pasture	317	66	14	398	16%
Low Density Residential	280	40	43	364	15%
Med. Density Residential	0	23	91	114	5%
High Density Residential	0	1	76	77	3%
Commercial	10	8	0	18	1%
Industrial	0	0	0	0	0%
Highways	0	0	0	0	0%
Water/Wetlands (excluding lake)	50	11	29	89	4%
Total	1525	375	586	2486	100%
Percent of Total Area	61%	15%	24%	100%	

phosphorus entering and leaving the lake. The annual budget helps to determine whether the lake's phosphorus inputs and outputs balance. If more phosphorus is flowing out of the lake than entered the lake from the watershed, this would suggest that there are sources within the lake (such as sediment releasing phosphorus during anoxic conditions). Unfortunately, we did not have one year of monthly data with which to construct an annual budget. An attempt was made to develop hydrological and phosphorus budgets with the available information, and this is presented below. However, the annual budgets must be viewed as preliminary.

Massachusetts recently completed a revised version of the Eutrophication and Aquatic Plant Management in Massachusetts -- Draft Generic Environmental Impact Report, February 1997 issued for public review November 1998 (referred herein as Massachusetts Lakes GEIR). This document contains valuable information concerning lake eutrophication issues in Massachusetts, including statewide data, case studies, etc. (Note: A copy of this document has been provided to the Amesbury Town Engineer.)

The Massachusetts Lake GEIR includes a survey of 32 phosphorus budgets of lakes in Massachusetts. These included both the land use-based technique and the hydrologic transport mass balance approach. Side by side comparison shows that the two methods usually gave similar results. This supports using land-use based models when available data are inadequate to support a detailed hydrologic mass balance.

3.2.1 Land Use-Based Watershed Loading Model

Explanation

CDM developed a land-use based watershed loading model for Lake Attitash. The model is based on formulas in the Watershed Management Model (WMM), which has been applied to many state- and federally- approved projects. The model's objective is to estimate, using land use information for the subject drainage area, the annual phosphorus load (measured in pounds per year) contributed by individual subbasins.

The model has four primary inputs:

1. Areas for each land use category in each of the subbasins of the watershed (previously shown in **Table 3-1**). These data were obtained from GIS, including Massachusetts data from MassGIS and New Hampshire data from the Rockingham Planning Commission.

2. Annual average precipitation in the watershed of 42 inches/year. This rate was obtained from the Weymouth Great Pond Diagnostic/Feasibility Study.

3. Runoff coefficients for each land use category, shown in **Table 3-2.** Runoff coefficients are based on the imperviousness fraction expected for each land use. CDM had previously calibrated runoff coefficients to correspond with MassGIS land use categories (for the study of the Charles River watershed), thus these coefficients were readily available.

4. Event Mean Concentrations (EMCs) for each land use category, also shown in **Table 3-2.** EMCs have been developed by or for the U.S. Environmental Protection Agency specifically for this type of loading analysis. (See further discussion below.)

Table 3-2
Runoff Coefficients and EMCs used in Model

Type	Impervious fraction	Runoff coefficient	Phosphorus EMC (mg/L)
Forest/Rural Open	0.005	0.05	0.03
Urban Open	0.7	0.62	0.24
Agricultural/Pasture	0.005	0.05	0.95
Low Density Residential	0.1	0.13	0.37
Med. Density Residential	0.3	0.3	0.42
High Density Residential	0.5	0.46	0.48
Commercial	0.9	0.79	0.3
Industrial	0.7	0.62	0.3
Highways	0.9	0.79	0.26
Water/Wetlands	0.567	0.51	0.03

Table 3-3
Phosphorus Loading by Land Use in Lake Attitash Subbasins

	Annual Total Phosphorus Load (lb/yr)				
Land Use	Back River Subbasin	Southwest Inlet Subbasin	Direct Runoff Subbasin	Total	Percent of Watershed
Forest/Rural Open	13	3	5	21	3%
Urban Open	46	4	19	69	9%
Agricultural/Pasture	155	32	7	194	24%
Low Density Residential	130	19	20	169	21%
Med. Density Residential	0	27	107	135	17%
High Density Residential	0	2	160	161	20%
Commercial	23	18	0	41	5%
Industrial	0	0	0	0	0%
Highways	0	0	0	0	0%
Water/Wetlands (excluding lake)	7	2	4	13	2%
Total	**374**	**107**	**322**	**803**	100%
Percent of Load by Subbasin	47%	13%	40%	100%	

The model's formula is simple. The area for each land use category in each subbasin is multiplied times the annual average precipitation, and times the runoff coefficient and event mean concentration appropriate for that land use category. The result is the loading expected from that particular land use category for that subbasin. Results are presented in **Table 3-3**.

Results

Table 3-3 shows that phosphorus loading is highest from agricultural and residential land use areas. Phosphorus loading from residential areas was the highest, at 465 lb/yr, but loading from agricultural areas was also high, at 194 lb/yr. Most of the loading from high and medium density residential areas originates in the direct runoff area around the lake (267 lb/yr), but some loading also originates in low density residential areas in the Back River subbasin (285 lb/yr). Most of the agricultural loading originates in the Back River subbasin, where it constitutes the majority of the loading. The Southwest subbasin contributes much lower phosphorus loading than both the Back River and Direct subbasins.

Selection of Phosphorus Loading Rates (EMCs)

Several commentors at one of the public meetings expressed concern over the use of standard loading rates, and the "site-specificity" of the model. While it may be surprising to the layperson that such loading rates could be applicable to their watershed, in fact, this is the case.

In the 1980s, EPA conducted the National Urban Runoff Program Study, measuring pollutants in stormwater throughout the country. The goal of this study was to enable characterization of pollutants without the expense and difficulty of actual sampling, by relying upon land use data in combination with these EMCs. Additional stormwater data and EMCs were developed by EPA in the Lake Champion Study (EPA). CDM has compiled and evaluated these values to determine the most appropriate EMCs for use in the Lake Attitash watershed; the selected EMCs are shown in Table 3-2, and have previously been used for state-approved CDM studies.

Discussion

Other specific questions concerned whether the model uses data for Lake Attitash, and whether the model accounts for specific best management practices (whether at agricultural sites or in residential areas, such as not using lawn fertilizers containing phosphorus). The loading rates do not account for such factors. They do rely on a large amount of data that has been statistically analyzed to determine the best rate for each land use type.

It was also asked whether the model breaks down the load further, such as the amounts attributed to lawn, erosion, etc. The model does not provide this breakdown.

Lastly, the model can be updated with site-specific data. To develop loading rates unique to Lake Attitash, an extensive amount of stormwater sampling would be required. This sampling would have a high cost, and thus may take funds away from implementation projects. Based on the common use of the land use model in lake and watershed studies and its support by the state (Massachusetts Lake GEIR, 1998) CDM believes the model is appropriate for this use. It is important to remember that the purpose of the model is to better understand, on a watershed scale, what subbasins and what land uses are most critical. The model is <u>not</u> intended to analyze a particular agriculture site or to highlight a particular neighborhood versus another. Such analyses do require site-specific data, which can be expensive and time-consuming to collect.

3.2.2 Preliminary Annual Water Budget

A preliminary annual hydrology budget for the water year 1998 (10/1/97-9/30/98) was prepared for Lake Attitash and is presented in **Table 3-4**. The following explains how each item was estimated:

- Direct Precipitation is the amount of flow contributed by direct rainfall onto the lake surface. This is equal to the lake area (351 acres, derived from GIS) multiplied by the annual estimated rainfall (43.71 in/yr).
- Direct Runoff was estimated using the spreadsheet model, which multiplied each land use area times the rainfall and the appropriate runoff coefficient (see discussion above).
- Flows for the Back River and Southwest subbasins each were estimated by performing a streamflow transposition on daily flow data for an official USGS gage. To do this, a USGS gage site is selected to be representative of the subject area, in this case the Back River. CDM selected Beaver Brook at New Pelham, New Hampshire as the nearest USGS gage with similar watershed characteristics. Then, using the ratio of the Back River drainage area to the gage drainage area, a simulated streamflow record for the Back River is developed. The daily streamflows are then summed to create monthly and annual flows in the river. The same exercise was performed for the Southwest inlet.
- Outlet flows are the total flows from the lake. Outlet flows were estimated to the extent possible using WTP records of the water level elevation at Meadow Brook.
- The evaporation was based on a typical rate for this climate of 24 in/year.
- The change in storage is based on the difference in lake level. For this annual analysis, it was assumed that the lake level was the same on October 1, 1997 and on September 30, 1998, giving zero change in storage.
- Lastly, to balance the water budget, the remainder of flow is assumed to come from groundwater.

The preliminary annual water budget has some limitations based on data. The item with the lowest confidence estimate is the outlet flows. CDM utilized a hydrologic model to relate Meadow Brook level to flow from the brook (and thus from the lake). This relationship should be reasonably accurate. However, because daily water levels are not recorded, assumptions were made for each month based on the available records. Given these assumptions, the monthly flow from the lake was estimated at 0.3 cfs for June through October; 4.6 cfs for November through February; and 41.9 cfs, 45.8 cfs, and 45.8 cfs for March, April, and May respectively. If the outlet flows are approximately correct, then the budget indicates the lake receives 45% of its inflows from groundwater. Additionally, the selected streamgage for the flow simulations for the Back River and Southwest inlet may not adequately represent groundwater flows through these tributaries. A more detailed analysis of outlet flow could be useful to develop an annual hydrology budget with greater accuracy.

Table 3-4
Preliminary Annual Water Budget

Item	*Description*	*cfs*
Inflows		
Direct Precipitation	lake area*rainfall	1.76
Direct Runoff	subbasin area*rainfall*runoff coeff	0.53
Back River	flow transposition	4.29
Southwest	flow transposition	1.05
Direct Groundwater	(as needed to balance)	6.12
Outflows		
Outlet	from WTP records of MB level	12.78
Evaporation	lake area*evaporation	0.97
Change in Storage	from WTP records of lake level	assume 0

Table 3-5
Preliminary Annual Phosphorus Budget

Item	***Source***	***Total P Concentration mg/l***	***Annual Flow cfs***	***Total P Load lbs/yr***
Inflows				
Precipitation	(Wetzel, 1983)	0.03	1.76	104
Runoff	stormwater sampling	data pending	0.53	not available with present data
Back River	mean of 1998 samples	5.3	4.29	44,633
Southwest	mean of 1998 samples	2.1	1.05	4,328
Groundwater	(Wetzel, 1983)	0.02	6.12	240
Sediment Release	often estimated as the difference needed to balance the budget	n/a	n/a	not available with present data
Outflows				
Outlet	mean of 1994-98 samples	4.3	12.78	106,199
Evaporation	n/a	0	0.97	0
Settling/uptake	difficult to quantify; if weed harvesting, could account for here	not available with present data		not available with present data

3.2.3 Preliminary Annual Phosphorus Budget

Table 3-5 summarizes the preliminary phosphorus budget. The table shows annual loads calculated using site-specific data, as explained in the table.

Note that the annual estimated loads cannot fairly be compared with the land use-based loads presented above because the site-specific data do not cover a one-year period, and thus do not capture all the seasons. Ideally, the phosphorus budget should be based on monthly samples of all inflows and outflows from the lake. The monthly total phosphorus concentrations would then be multiplied by the flow from each source. Monthly concentration and flow data for a 12-month period are not currently available. Instead, this preliminary budget was constructed using the available concentration data, which is focused during the summer months, and flow estimates. Thus, this preliminary budget should be viewed as a prototype for one that can be developed in the future when more complete data may be available.

3.2.4 Conclusions

The land use-based model shows that the agriculture and residential areas contribute the greatest amounts of phosphorus to the lake. The model also shows that the Back River subbasin contributes 47% of the watershed phosphorus load, with 40% from the direct subbasin, and 13% from the Southwest inlet basin. Given their relative sizes, the direct subbasin appears to contribute a disproportionate amount of phosphorus, because it is more densely developed than the other areas.

As explained above, the annual hydrological and phosphorus budgets must be viewed as preliminary, since limited data were available to develop them. The annual budget is inconclusive regarding the significance of lake sediment as a source of phosphorus. Note that the Massachusetts Lakes GEIR also asserts that it can be difficult to estimate internal phosphorus loading. As discussed in Section 2, however, the 1998 monitoring shows that the lake's hypolimnion (bottom layer) becomes oxygen-starved in summer, which is an indication that phosphorus resolubilization may be occuring.

3.3 Future Development (Build-Out Scenario)

3.3.1 Build-Out Scenario

A simplified build-out analysis was conducted solely to evaluate the potential changes in land uses. A build-out analysis is a term for an exercise to try to predict how land use would look in the future, if all the land available for development is developed based on current zoning. Sometimes, build-out analyses focus on predicting population increases or with dwelling units; in this case, the main purpose was to consider land use changes. A gross estimate of possible number of future dwelling units was also made, for general information.

The simplified build-out analysis followed these basic steps:

1. Land use maps were used to identify lands that may be available for development (forest, fields, open land, agriculture).

   Land use coverages for the watershed were assembled on GIS. The land uses that are generally not available to be developed in the future were identified and excluded. These include lands that are already developed (residential, commercial, industrial, etc.), water, and wetlands. Note that the land use coverage of wetlands is often not accurate at a site-specific scale, but is usually considered adequate for a regional-scale analysis such as this one.

2. Lands that are permanently protected from development were identified.

   These lands include properties owned by the New Hampshire Department of Fish and Game; the Town of Newton, Town of Merrimac, and Town of Amesbury; and Massachusestts Department of Environmental Management. The permanently protected lands were identified from several sources: MassGIS Open Space coverage; Town of Amesbury Open Space Plan; Massachusetts Department of Food and Agriculture Agriculture Preservation Restrictions (APR) Program; and review of Town of Newton property records. It is possible that individual parcels may not be shown as permanently protected if they are not included in one of these four sources. CDM made reasonable efforts to ensure that the major protected properties are included.

3. Lands that are under a protective tax status were identified. These lands can be developed if the owner removes them from the program and pays a financial penalty.

   Massachusetts and New Hampshire offer owners of open space a reduced tax rate if the landowner complies with certain land use restrictions and enters the program for a minimum period of time. In Massachusetts, this is referred to as "Chapter 61," including 61 for forest lands, 61A for agriculture, and 61B for conservation and recreation lands. In New Hampshire, the tax status is referred to as "Current Land Use."

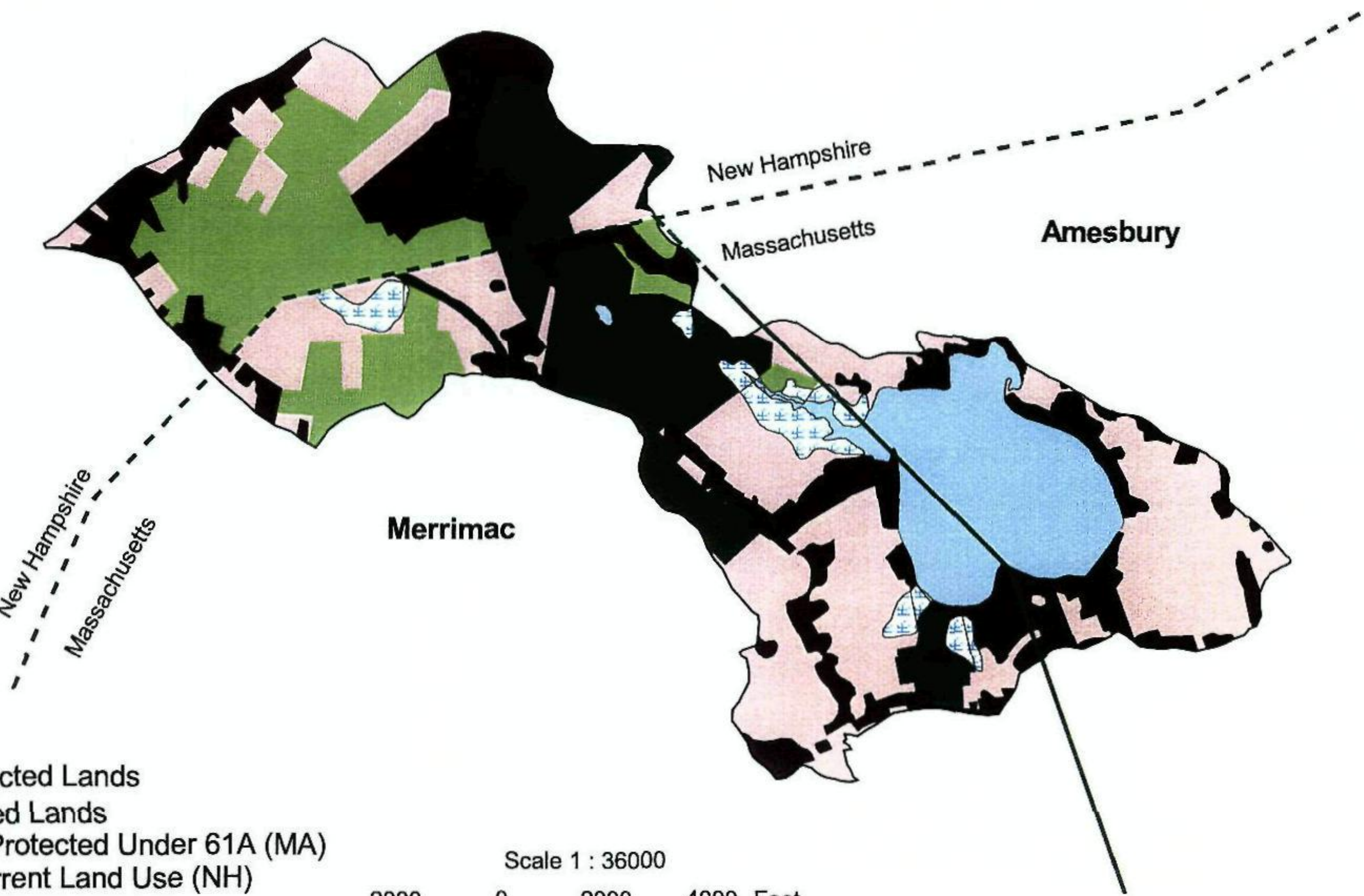
   Chapter 61 and Current Land Use lands were identified using the MassGIS Open Space coverage for Amesbury and Merrimac, and Newton town records for the Newton portion. MassGIS Open Space coverage is known to have some accuracy problems, particularly with Chapter 61 properties. However, this was the best, readily available source of data. **Figure 3-2** shows the GIS coverage resulting from steps 1 through 3.

   It is important to understand that, unlike the permanently protected lands, the Chapter 61 or Current Land Use lands can be developed if the owner removes them from the program and pays a financial penalty. When property values and development pressures are high, it can be financially attractive to owners to convert such lands, since the developed value will easily pay the penalty. Many owners place their land in this status because they desire to keep it as open space.

4. A generalized zoning coverage was created in GIS.

   CDM collected zoning maps and codes from Amesbury, Merrimac, and Newton. A generalized map was then created of the various zoning districts in the watershed, as shown in **Figure 3-3**. (The zoning map is considered generalized, as some small zoning districts were not digitized; the districts that were not included are those in which the lands are already developed, and thus have no relevance to a build-out analysis.)

Protected Lands and Lands Available for Development



Unprotected Lands
Protected Lands
Lands Protected Under 61A (MA) and Current Land Use (NH)
Developed Lands
Wetlands
Water

Scale 1 : 36000

2000 0 2000 4000 Feet

Data Sources : MassGIS
MA Department of Food and Agriculture
Rockingham Planning Commission
The Town of Newton, NH

Figure 3-2

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Zoning

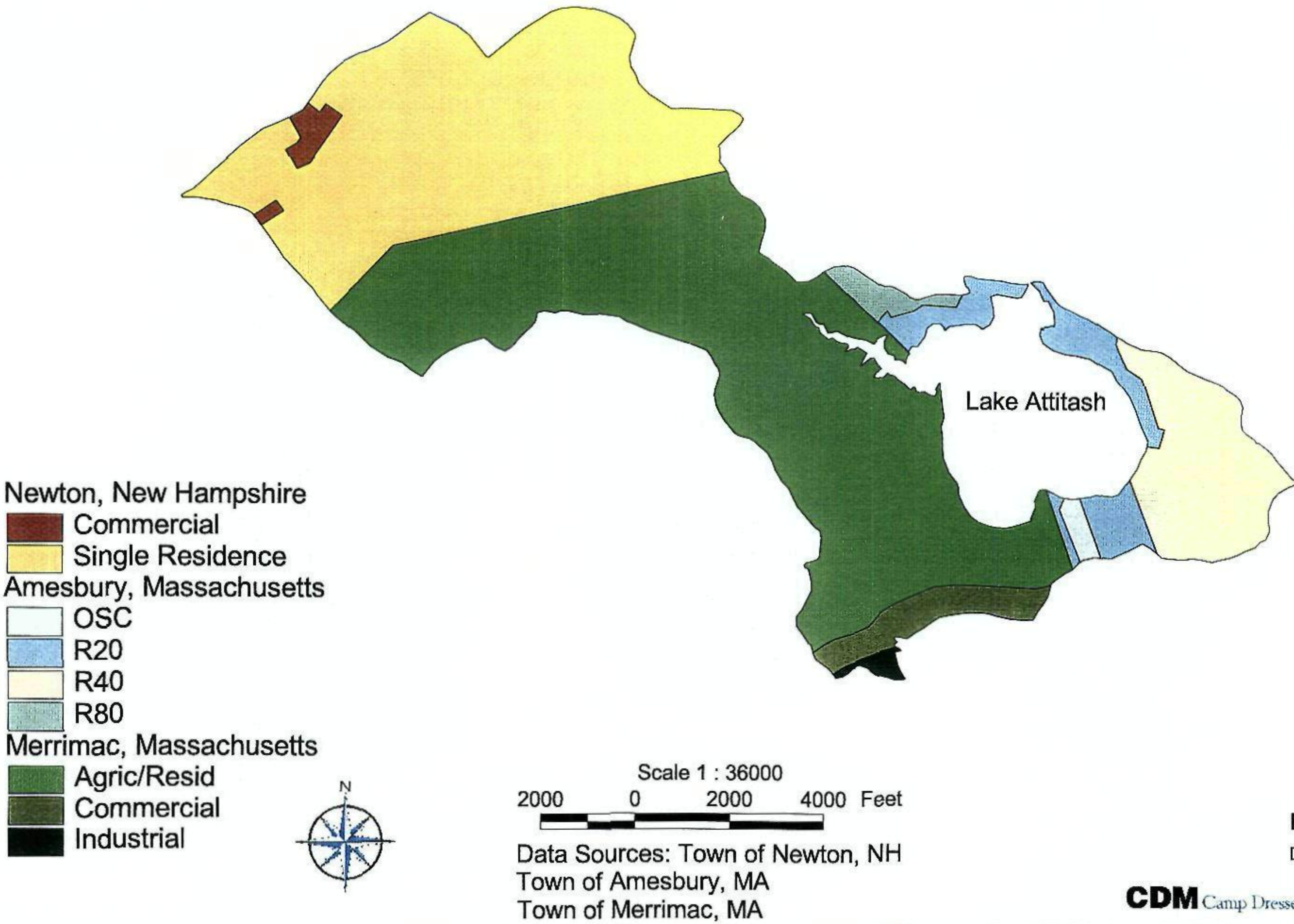

Figure 3-3

December 1998

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5. GIS was used to create a table of the lands available for development, by town, and by zoning district.

   Using a process called intersect, the GIS coverages were merged. Then, the areas of the lands available for development were determined in acres, for each of the different zoning districts. For example, the GIS computed the number of acres in the Town of Merrimac that are currently forested, that are available for development, and within the Agriculture/Residential zoning district. These areas were also determined separately for the Chapter 61 and Current Land Use lands, since these lands could remain in open space forever, or could be removed from the program and made available for development.

6. Residential densities for each zoning district were applied to the GIS data table to estimate the potential future number of dwellings.

   For each zoning district, the zoning code was reviewed to determine the basic density (e.g., minimum lot size). The minimum lot size was adjusted slightly higher (or lower density) to account for roads and odd lot shapes. The number of developable acres in that zoning district was then divided by the revised lot size to estimate the number of potential dwellings.

Table 3-6 summarizes the results of the build-out analysis. The results show the following:

- If Chapter 61 and Current Land Use properties remain as open space, there are potentially 770 acres available for development within the Lake Attitash watershed. This acreage could translate into an estimated 660 dwellings.

- If Chapter 61 and Current Land Use properties are removed from those programs, there are an additional 690 acres (or, a total of 1,460 acres) that are potentially developable. At maximum build-out, this could equate to an additional 400 dwellings. This shows the significance of these protected lands to the watershed.

Obviously, this simplified build-out analysis is a maximum, worst-case scenario that does not take into consideration the economic and social factors that also influence development. This exercise is useful in increasing the understanding of how the watershed could continue to change in the future.

3.4 Potential Contamination Sources

3.4.1 Method

A major step in developing a watershed management plan is analyzing the potential sources of contamination. To evaluate the potential sources in the Lake Attitash watershed, the following methods were used:

(1) Review of water quality data presented in Section 2, especially comparison of upstream and downstream samples to determine if there is a source, and comparison of data for the different subbasins to help determine the significance of each geographical area.

(2) Use of the phosphorus loading estimates, described above.

Table 3-6:
Lake Attitash: Simplified Build-out Analysis

Town	Subcategory	Forest/ Open	Pasture/ Cropland	Total	Potential Dwellings	Comment
Amesbury						
	Chapter 61 Lands	0	0	0	0	R40 and R80; small section R20 (mostly developed)
	Unprotected Lands	260	1	261	222	
	Subtotal	*260*	*1*	*261*	*222*	
Merrimac						
	Chapter 61 Lands	168	180	348	134	mostly all Ag-Res (2 acre); small commercial area
	Unprotected Lands	382	94	476	271	
	Subtotal	*550*	*274*	*824*	*405*	
Newton						
	Chapter 61 Lands	343	0	343	176	mostly Single Res A
	Unprotected Lands	30	0	30	15	
	Subtotal	*373*	*0*	*373*	*191*	
Total						
	Chapter 61 Lands	511	180	691	310	
	Unprotected Lands	672	95	767	508	
	Total	*1183*	*275*	*1458*	*818*	

(3) Review of available maps, including land use maps and USGS maps, and USDA Soil Conservation Service maps.

(4) Review of aerial photographs (1988) provided by the Town of Amesbury.

(5) Consideration of verbal comments offered by individuals throughout the course of the project as anecdotal information (such as, "there are large numbers of birds on the lake that were not there previously").

These sources of site-specific watershed information were used, along with the authors' experience and information in the professional literature, to evaluate the significance of each potential contamination source in the watershed.

3.4.2 Overview

Point and Nonpoint Sources

Sources of pollution are described as two types: point sources, and nonpoint sources. Point sources generally indicate a piped discharge directly to the water body, and could be treated sewage, combined sewer overflow, or industrial wastewater. There are no point sources of pollution in the Lake Attitash watershed.

Nonpoint sources are much more complex. The category nonpoint source includes virtually the entire watershed, which by definition is land from which runoff drains to the water body. One New England state report offers a well-worded explanation of nonpoint source pollution:

> "Nonpoint source pollution ...doesn't originate from a specific point like a pipe; instead it results from everyday human activities like gardening and lawn care, boating, pesticide use, septic systems, construction," (Maine DEP, Watershed: An Action Guide)

Nonpoint sources are broad-based, generally land use related, and cumulative rather than individual. In the Lake Attitash watershed, nonpoint sources range from residential stormwater (both overland flow and that piped through stormdrains), agricultural sites, roads, on-lake activity, and development.

Key Parameters

The discussion of potential contamination sources focuses on the key water quality parameters of concern, which are:

(1) Microbiological contaminants, including coliform bacteria, viruses, and other pathogens, which are important to drinking water supplies, and

(2) Nutrients, especially phosphorus, which is the limiting factor for plant growth and the most critical parameter for control of eutrophication.

Other contaminants, such as sediment, heavy metals, oil and grease, and petroleum hydrocarbons, are also mentioned. Note that phosphorus may be transported via adhering to sediment, so often sediment erosion is considered a potential source of phosphorus.

Watershed Land Use History

Lastly, one of the challenges in understanding the sources of contaminants to Lake Attitash is the land use history of the watershed. Four main changes have occurred in the watershed:

(1) While there has been agriculture in the watershed for many years, it has changed. In the past, there was a very large piggery in the upper watershed, and a number of dairy farms along the Back River area and possibly in the Southwest Basin area (off Route 110 in Merrimac). Instead, most of the agriculture is hay and corn crops. There are few grazing animals, and they are primarily horses. The composting operation at the Sargent farm began approximately in the 1980s. Thus, the entire nature of agriculture has changed. The removal of grazing animals and the concentrated feedlots has likely removed sources of pathogens and nutrients, while the addition of composting may represent a new source.

(2) The residential areas around Lake Attitash, formerly on septic systems, were sewered in the 1980s. This is a very significant change, since septic systems in poorly suited soils can discharge phosphorus to groundwater or even through breakouts, directly to surface water. The state's 1977 study highlighted septic systems as a major problem in the watershed. It is estimated that there were approximately 350 septic systems in the area. Based on literature data, these systems could have contributed up to (15 mg/L in septic tank effluent) 3,000 lb/year of phosphorus to the lake. Although this source has been removed, there may still remain significant phosphorus in lake sediment from the many years that they were in use.

(3) In the past decade, beaver populations in Massachusetts have exploded. The increase in population has been seen throughout the Lake Attitash watershed, as well as on Meadow Brook. Residents have stated that the beavers moved into the area approximately 5 to 10 years ago, and beaver activity continues to increase. Currently, there are numerous beaver dams on the Back River. This again can impact water quality. The damming can create small impounded areas, where sediment and phosphorus can be settled out. On the other hand, the impoundments can then have plant and algae growth which is later released to the lake, whether in the fall as plants die or during high flows. Also, beavers can carry *Giardia*, a protozoa of concern in drinking water.

(4) There has been some development in the watershed since the state's 1977 study, although it appears to represent a small proportion of total development. It is believed that development pressure has increased in the recent past.

These factors complicate the task of determining what sources are contributing to the water quality problems of the lake.

3.4.3 Discussion

Below, each of the categories of potential contamination sources are discussed. For each, the potential pollutants, concerns, occurrence in the Lake Attitash watershed, and overall significance to water quality are evaluated.

Swimming

Potential Concerns: Swimmers, by virtue of direct contact of the body with the water, can introduce any pathogens carried in fecal matter, such as fecal coliform, bacteria, viruses, and protozoa including *Giardia* and *Cryptosporidium*. The greatest threat of pollution from swimmers is associated with young children and children in diapers. In fact, every year there are beaches that are closed due to a high number of children swimming.

Note that swimming is not permitted in direct water supplies, per Massachusetts DEP Drinking Water Regulations. Since Lake Attitash is a tributary supply, feeding the Powwow River, and does not contain a direct supply intake, this regulation does not apply.

Occurrence: Swimming season in Lake Attitash generally occurs from mid to late June through Labor Day. The greatest density of swimmers is at the public beach, located next to the Southwest inlet and near the state boat launch and associated parking area (although there is no swimming allowed at the launch area).

Significance: Evaluating the water quality for the lake, there were occasionally high counts coming from the upper and middle Back River. Bacteria levels at the confluence of the Back River with the lake (sites 9 and 3) and levels at the Southwest inlet (site 2) were typically similar, although the Southwest inlet had much higher counts on two dates in September. Coliform was not monitored in-lake during the 1998 season (because the objective of monitoring coliform was to determine if it could be useful as a low-cost method of source detection along the Back River).

Boating

Potential Concerns: Boat motors can introduce gasoline, oil, and grease to the water. In addition, studies show that boats of even modest horsepower can stir up lake sediment at shallow depths. One study (Yousef for EPA, "Assessing effects on water quality by boating activity," 1974, reported in Wright and Wagner, 1991) suggests the following relationship between boat motor size and the depth to which the water column is mixed:

Motor Size hp	Effective Mixing Depth (feet)
10	6
28	10
50	15

A phosphorus increase from boating has been documented in several lakes. As boating activity stirs up bottom sediments, lakes with organic bottom sediments rich in nutrients will experience increases in phosphorus which can increase algal growth. Also, propellers may remove rooted plant communities, thus exposing sediments to easier resuspension. A literature review conducted by Wright and Wagner in 1991 noted that "there has been considerable variability [in level of impact] across the range of lakes studied."

Studies of lakes in New Hampshire and Florida have shown found phosphorus load increases from motorized watercraft from 8 to 80 ug/L, and from 7 to 166 ug/L, respectively (Schloss, 1990; Yousef, 1980). A Massachusetts study found the characteristics of sediments to be a critical factor with mucky, organic sediments leading to phosphorus impacts, while sandy sediments were less prone to such impacts (Wagner) This same link between lake bottom sediment characteristics and phosphorus increase was observed in studies at New Hampshire lakes (Squam Lake and Beaver Lake, Conway Lake).

Lastly, another potential impact from powerboats is inputs from wasted fuel. In older outboard engines, unused fuel may be 10 to 27 percent. Unleaded fuel contains phosphorus as do fuel additives often used with older engines. However, the author's conclusion was that the input of phosphorus from fuel is very small compared with other sources of phosphorus.

Occurrence: Boating season in Lake Attitash generally occurs from May/June through September/October, with a lower level of year-round activity. Massachusetts DEM maintains a boat launch open to the public at the south end of the lake in Merrimac.

Significance: Boating activity on Lake Attitash probably contributes to some turbidity in the shallower areas. The significance of boating to algal and aquatic weed growth depends on the significance of internal phosphorus cycling. The preliminary annual phosphorus budget suggests that the sediment could be a significant source. However, limitations to the available data affect the reliability of the phosphorus budget, as discussed above.

Birds on Lake

Potential Concerns: Large numbers of birds roosting on the water surface can introduce contaminants to a lake, pond, or river. In New England, there are numerous examples of this phenomenon, typically involving gulls, Canada geese, mergansers, and other ducks. Most often, the large numbers of roosting birds occur from fall, as the birds migrate inland away from coastal areas and seek large inland water bodies, until either complete ice-over, or to the spring migration back to the coasts. In terms of water quality effects, the cases reported to the USDA Animal Damage Control office (which assists with bird harassment programs) usually involve fecal or total coliform and pathogens such as Salmonella as the concern.

Occurrence: Local residents have reported large numbers of gulls on Lake Attitash, but a historical record of bird populations and roosting on the lake is not available.

Significance: Given the lack of historical and current data, it is difficult to assess how significant the birds may be to lake water quality. Based on best judgement, it is likely that the birds do contribute phosphorus loads to the lake, but the highest contribution is probably during early fall through early winter. Further, the birds do not appear to be significant compared to the high phosphorus loads from land use sources.

Wetlands and Related Wildlife Activity

Potential Concerns: Many processes occur in a wetlands ecosystem. One process is the growth, and breakdown of vegetative matter (plants). As nutrients enter and enrich the wetlands, plants grow in response. Then, as the plants die due to exposure (fluctuating water levels) or at the end of the growing season (fall) or of their life cycle, the plants decompose. Decomposition can release phosphorus back into the system, or as plants settle on the bottom can form organic, phosphorus-rich sediments.

A further process occurs when the waterways reach anaerobic conditions. As part of decomposition, the vegetative matter consumes oxygen. If there is a large amount of decaying plants and little new source of oxygen (as with a stagnant or near-stagnant waterway), the oxygen level in the water will reach very low or zero levels (anaerobic conditions). At this point, there could be resolubilization of additional phosphorus that is stored in the sediment into the water column.

Wildlife also have a role in wetlands. In particular, beaver have created many impounded areas with their dams. These impoundments become areas of stagnant water, where water previously flowed freely. Thus, the beaver dams alter the wetland conditions and processes. In addition, beavers can be a concern to water supplies because they can carry *Giardia*, a protozoan that can infect humans.

Occurrence: There are extensive wetland systems associated with the Back River and the Southwest inlet. Further, there are many beavers residing throughout these areas of the watershed. Residents have reported verbally that beaver activity has greatly increased in the past decade. As noted above, there are multiple beaver dams that have flooded and created shallow, stagnant areas along the Back River.

Significance: Focusing on phosphorus, it is difficult to decipher the 1998 sampling data given the high degree of variation from date to date, and the knowledge of the extensive wetlands that are affecting these results. It seems likely that the beaver dam-impounded areas are anoxic at some point during the summer, and thus could release phosphorus from sediment. Unfortunately, extensive data would be needed to fully assess the role of wetlands. However, it appears from the body of data that there are continued sources in the watershed and that wetlands are probably not the major contributor of phosphorus to Lake Attitash.

Agriculture

Potential Concerns: Water quality concerns about agriculture depend upon what type of agricultural activities are being conducted. The main concerns associated with livestock are the access of grazing animals to waterways, where wastes can be directly deposited; the location and disposal of animal wastes; and erosion (accelerated by animal grazing/trampling).

With crops, the main concerns are erosion from land disturbance (tilling), the use of fertilizer (including manure spreading as an added fertilizer), and the use of pesticides. Hay is a low impact crop, since little fertilizer and pesticides are used, and hay crops are tilled less frequently. Annual crops, such as corn, are tilled and harvested every year, which may be a factor in erosion rate, and pesticide and fertilizer use are typically greater (than for hay).

Use of manures for fertilizer is a typical farm practice; it provides disposal of manure, and avoids the cost of chemical fertilizer. A study in Maine discusses three factors affecting the potential for pollution from manure spreading:

(1) underestimation of the nutrient content of manure and use of both manure and fertilizer,
(2) uneven distribution of spreading amounts (resulting in excess loading in some areas), and
(3) lack of storage facilities (indicating that spreading may occur at times or rates that are not synchronized with the crop's needs).

Occurrence:

There are two large, active agriculture sites in the Lake Attitash watershed. These include the Sargent farm, located in Merrimac off Bear Hill Road, and the Nicol farm, located in Newton off Highland Street and southeast of Route 108. These are discussed below.

There are some additional areas shown on the land use map as agriculture, but site-specific information was not available. These include some fields along Route 110 in Merrimac (behind the strip of residences along the road). Further evaluation of these areas would be useful to determine if there is any active agriculture or whether the land is now fallow fields.

In addition, there are an unknown number of "hobby" farms, which are residences or small farms with a small number of animals for personal use, and possibly commercial horseback riding stables. As with any agriculture, impacts are possible when proper management practices are not followed. Further evaluation of these sites, such as identifying their location and determining the number of animals, would be useful to better assess their potential impact.

<u>Sargent Farm</u>

The authors acknowledge the voluntary cooperation of the Sargent family, who have provided access to their property and answered questions about operations.

Description

Based on visual observation by the authors of this report, there are two main areas of potential concern:

(1) compost piles by runoff or infiltration
(2) manure/fertilizer application onto hay and corn fields with nutrient transport by
   a. direct runoff from field to stream, or
   b. infiltration into tile drains, which then carry flow to the stream, or
   c. infiltration into highly permeable soils (e.g., reclaimed gravel pits).

Compost Piles -- The compost piles are located relatively close to the river at the bottom of the hill from Bear Hill Road. The compost piles were located here at some point between 1988 and 1993. Several steps are already in place to control pollutant transport. These steps include covering of the piles with plastic, and berms intended to hold runoff from directly flowing into the streams. In the field above the compost piles, there are tile drains. One of the drain pipes runs near the piles; whether this drain is functional is not certain.

Manure/Fertilizer Applications -- The Sargent farm includes four field areas within the Lake Attitash watershed: one southwest of Bear Hill Road; the large field on the northeast side of Bear Hill Road, extending down close to the river; a field adjacent to Sargent Millpond and believed to be a reclaimed gravel area; and, further east, a small field near the gravel pits. It is believed the crops include both corn and hay. *Each of these fields, being in the watershed, drains to the Back River.* Based on observation, the factors that could contribute to possible nutrient transport from the fields include:

- The rate and timing of manure/fertilizer application (Note: detailed information concerning the rates of application were not requested),
- The presence of permeable soils, especially in the fields that are reclaimed gravel sites, such that groundwater may carry excess nutrients to the river,
- The possibility that tile drains may be carrying any excess nutrients from groundwater below the field into the river, and
- Although vegetated buffers are present between the fields and the river, they are relatively narrow, in some places less than 25 feet.

Water Quality Data

Water quality data collected in 1998 included several locations along the Back River intended, in part, to isolate subbasins and to help determine whether the Sargent site is a major source of phosphorus. The farm drains to sites 5, 6A, and 6; however, other lands including some former gravel mining areas also drain to these sites. Another factor is the presence of about three beaver dams below sites 6 and 6A (see preceding discussion).

Phosphorus -- In 1998, there were a total of three dates (7/28/98, 9/1/98, 9/28/98) on which all the Back River locations were sampled. Looking at this body of data, the total phosphorus concentrations are highly variable from one date to the next. While the concentrations are different at each location, they are fairly comparable, again considered as a set. On one date, the concentration at site 6 is much higher than the upstream samples. Considered altogether, the data show that there are sources of total phosphorus in the Back River subbasin, but do not point to the Sargent farm as a particular source.

The soluble reactive phosphorus data also shows variation. On all three dates, site 6 shows much higher concentrations than the upstream locations. A possible factor with this is that site 6 is located in a somewhat stagnant section of the river, and there may be some resolubilization of phosphorus from sediment. Note that soluble reactive phosphorus is essentially the form of phosphorus readily taken up by plants. Because it is quickly moving from one form to another, lake managers use total phosphorus as the main parameter.

Nitrogen -- Nitrate-nitrogen and ammonia were measured at the Back River stations on the same three dates. The nitrate consistently increases more than tenfold from the site below the Millpond to the other sites around the Sargent farm (sites 6, 6A). The ammonia concentrations also show a sharp and consistent increase on all three dates, but the ammonia increases from sites 21, 5, and 6 (all are fairly similar in value) to site 6A.

Coliform -- Fecal coliform data were collected for the Back River locations on eight dates in 1998. The data are variable, as is typical with coliform bacteria. On more than half of the dates, the coliform levels increase from site 21 to sites 5 and 6A. These fecal coliform increases between site 21 and 5 could be attributable to manure spreading, but it is impossible to say definitively. On three dates when the coliform was elevated at sites 5 and 6A, the coliform decreases at site 6. This may be suggestive of the presence of an impounded area, providing some detention time for bacteria die-off.

One issue that has been raised in the course of this project is the complication of the beaver dams and the fact that several sites are located in water that is sometimes stagnant (as discussed herein). CDM is recommending that the locations be changed; see Section 4.1.

NRCS

The agency with responsibility for agricultural water quality impacts is the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS). NRCS' position is to assist farm owners with the use of best management practices (BMPs). NRCS has a Technical Guide with conservation standards. In addition, NRCS uses the 1993 Guideline Specifications for Nonpoint Sources in Coastal Waters -- agriculture section, as one of its references for best management practices. NRCS assists farms in developing nutrient management plans and then in implementing the BMPs in the plan. In addition, NRCS holds various training workshops including some on nutrient management at farms.

The local NRCS office that covers the Amesbury and Merrimac areas is the Westford office. NRCS-Westford has been involved with the Sargent site for several years. Currently, NRCS is helping to developing a nutrient management plan for the site, and to address road and field runoff, including checking the tile drains.

The NRCS' Environmental Quality Incentives Program (EQIP) program is a possibility for future funding to assist BMPs at the Sargent farm. This program offers grants to farmers for environmental improvements. Funding selections are environmental benefits versus cost, and there is a maximum of $10,000 per site. Additional grant sources should be investigated, such as the Massachusetts Department of Food and Agriculture (DFA) Rivers Protection Act funds.

Nicol Farm

The authors acknowledge the voluntary cooperation of the Nicol family, who have provided access to their property and answered questions about operations.

Description

The Nicol Farm consists of a number of hay fields, and a horse barn and associated pastures and riding ring. Part of the farm was formerly a piggery. It is believed the piggery was established by the early 1900s, but by 1943 was no longer operating.

The Nicol farm uses horse manure as fertilizer on several fields, and septage as fertilizer for some of its hayfields. The manure and septage spreading is the focus of this discussion.

Horse manure contains a lower proportion of phosphorus than other animal manures such as cows. Based on about 15 animals, the annual load of phosphorus from the manures produced on the farm is estimated at 255 lb/year.

The farm began using septage about three years ago. Before commencing this practice, the Nicols conducted research into the benefits and any health issues associated with septage spreading (including review of a study by the Centers for Disease Control). A permit was obtained from the New Hampshire Department of Environmental Services pursuant to Env-Ws 800 Septage & Sludge Disposal Rules. The permit authorizes septage spreading on up to 80 acres. The permit authorizes application no closer than 100 feet from surface water. The farm maintains large (estimated 500 foot per communication from Nicols) buffers between fields and waterways. The permit application notes an anticipated volume of 100,000 gallons/month during the growing season.

The Nicols have their soil tested periodically and obtain recommendations from the County Extension Service on appropriate fertilizer types and rates. Soils from the Nicol Farm were sampled by the University of New Hampshire Analytical Services Laboratory. The laboratory determined phosphorus to be "very high," ranging from 70 to 175 ppm. It is believed that the soils are naturally high in phosphorus. (Another possibility is that former land uses, such as the piggery, resulted in this condition; however, the samples were collected from various fields including areas that were not part of the piggery.) As a result, the County Extension Service recommended fertilizer applications that did not include phosphorus, with the exception of recommending the addition of a small proportion of phosphorus prior to establishing new fields.

The fields are tilled and reseeded about every 4 to 5 years. The fields receive chemical fertilizer once in spring. Septage spreading is based according to crop needs, and occurs between April and November. The farm receives septage from only one hauler. Usually, the septage is injected. If septage is applied as a top dressing, lime is also applied. The septage is not pre-composted.

The EPA Guide to Septage Treatment and Disposal (1994) and EPA Handbook for Septage Treatment and Disposal (1984) show a range in the phosphorus content of septage, from 20 to 760 mg/L, with an average of 210 mg/L. Another publication shows average total phosphorus at two Massachusetts septage facilities to range from 46 mg/L (Orleans and Harwich) to 37 mg/L (Yarmouth) (Ronald Jager, "Status Report on the Water Environment Federation's Septage Handling Manual of Practice" and Michael Giggey and Karl Brantner, "Characterization of Septage for Design of Waste Treatment Facilities"). The latter also describes the effectiveness of treatment, noting that preliminary biological oxidation and settling removed about 60% of the total phosphorus, and that the use of lime has been observed to bind phosphorus sufficiently that there was inadequate available phosphorus for downstream biological treatment.

Based on the available information, there may be a possibility that the phosphorus present in the septage could be reaching the wetlands and upper tributaries to the Back River. Although the farm is careful to apply septage in response to crop needs, because septage contains phosphorus and the soils were found to be high in phosphorus, it is possible that there is excess phosphorus not being taken up by the crop. The application method (either injected below the surface or co-applied with lime) would tend to prevent surface transport of septage via surface runoff; and the fields have ample buffers. Leaching into groundwater and transport from groundwater to surface water may be possible.

Water Quality Data
The Back River sampling sites used in 1998 and in previous years do not extend further upstream than the river crossing at Bear Hill Road (site 21). A considerable area, of which the Nicol farm is a small part, drains to this site. The site has exhibited high phosphorus levels, suggesting that there are phosphorus sources upstream. The presence of multiple beaver dams and extensive wetlands above site 21 are also a factor; overall, the data are not sufficient to evaluate the possible phosphorus contribution from the Nicol farm.

Significance: Because the two large agriculture sites do use fertilizer and organic wastes as fertilizer for fields, there is potential for transport of phosphorus from these sites.

Developed Areas and New Development

The remaining categories of potential contamination sources below are developed areas, including residential, commercial/industrial, roads, construction, gravel mining, and logging. To preface the evaluation of such sources, it is helpful to first understand soil erosion. Erosion is undesirable because it adds sediment and pollutants to water bodies. In the process of erosion, soil particles are carried in streams and rivers and often deposited in impoundments (i.e., ponds and lakes). This direct addition of sediment is detrimental to water quality because (1) it can increase turbidity; and (2) nutrients, pesticides, and metals that are adsorbed onto the sediment are deposited into the water bodies. These problems are exacerbated once erosion depletes the topsoil, as (1) the rate of erosion increases, and (2) the pollutant filtering offered by natural vegetation is lost. Where soils are undisturbed, the natural erosion process is very slow because native vegetation roots usually bind the soil together. Although natural characteristics affect erosion rates, soil disturbance is the most significant factor in erosion occurrence and magnitude because it alters the natural hydrology, topography, and vegetation.

Residential Areas

Potential Concerns: Residential areas can potentially affect water quality in several ways. Residential areas, as with all development, change the natural environment to increase impervious areas (such as roofs, pavement) and decrease natural vegetation, which attenuates pollution in runoff.

Occurrence: Based on observation of lawns, and the past outreach that the Lake Attitash Association has conducted, it appears that fertilizer and pesticide use is relatively low in the areas immediately around the lake. Still, there are about 555 acres of residential development in the watershed, or 22% of the watershed. About one-third of this is classified as medium or high density. The location of residential development is also a factor. Because people value the lake as an aesthetic, wildlife, and recreational resource, there are many houses built around its shore. CDM has estimated approximately 330 residences in the immediate vicinity of Lake Attitash.

Significance: Without any intent or improper action, this development does contribute nonpoint source pollution to the lake. The land use-based model demonstrated that residential land use accounts for approximately 58% of the total watershed phosphorus load to Lake Attitash. Fortunately, measures can be taken to reduce this load, as discussed in Section 4.

Commercial/Industrial

Potential Concerns: Similar to residential development, commercial/industrial development changes the land permanently and contributes nonpoint source pollution to the lake. In addition to the pollutants of nutrients (including phosphorus) and sediment, commercial/industrial areas can have added concerns based on material and vehicle storage in paved yards. Thus, heavy metals, oil and grease, petroleum byproducts, and other contaminants may also appear in commercial/industrial runoff.

Occurrence: Based on windshield survey and the land use maps, the areas of commercial activity in the watershed are limited and there is no known active industrial. In particular, the area along Route 110 in Merrimac is the most urbanized commercial area. There may be some individual commercial establishments on Route 108 in Newton, but these resemble medium or low density residential in terms of land development type.

Significance: The land use-based model shows that commercial land uses account for only 5% of the annual watershed phosphorus load. It is also of note that the commercial areas are more distant from the lake, at the outer edges of the watershed. Although it is good policy to minimize pollution from any source by use of best management practices, the commercial areas are not significant to the phosphorus load to Lake Attitash. These areas may be a greater concern for petroleum related pollutants, depending upon outdoor storage practices, floor drains, etc.

Roads

Potential Concerns: Roads can be a contributor to water quality problems for several reasons. First, *erosion is often associated with roads, although proper drainage controls can* minimize this problem. Second, road runoff can contain concentrations of various pollutants, including suspended soils, phosphorus, metals, and others. These pollutants are deposited by automobile exhausts and tires, and accumulate on roads between rainfalls; they are eventually washed off the pavement by rain. Road maintenance activities also may contribute to runoff contamination, such as application of sand for snow and ice removal. Third, there is potential for a chemical or fuel spill from a traffic accident.

Occurrence: There are paved and dirt roads throughout the Lake Attitash watershed. A number of steep roads are located close to the lake.

Significance: The land use-based model incorporates roads into each individual land use. Thus, it is difficult to extract roads as a source discrete from the developed areas they serve. Still, based on observation, the roads probably account for a good part of runoff pollutant loads, because they provide an impervious surface upon which pollutants are deposited and accumulate, and then easily wash directly into the lake. In addition, many roads in the watershed have some associated erosion due to the road slopes and cuts.

Construction

Potential Concerns: Construction and land development, which involve relatively short-term soil disturbance, represent the most potential for human-caused erosion in the watershed. During construction, vegetative clearing, exposed earth, and changes in site contours can affect site surface runoff. Erosion rates and runoff rates from construction sites are much higher than from agriculture and developed lands. Erosion during construction contributes nutrients and sediments to nearby surface waters. After the construction phase, development can continue to affect surface water quality. Development of the site increases the impervious surface on the site and reduces the amount of natural vegetation. These changes may increase the quantity of runoff from the site and increase the pollutants in the runoff. If surface drainage is not adequately designed, additional erosion problems may eventually develop.

Occurrence: Based on comments from participants in the public meetings, and observation, there are increased development pressures in all three towns of the watershed. Some current subdivisions are located west of Brush Hill area, along Highland Street. One that is outside of the watershed, but within the Amesbury water supply watershed, is at the edge of Meadow Brook.

Significance: Construction is demonstrated to be a significant potential risk for erosion and pollutant transport, including phosphorus. Knowledge of methods to reduce erosion and control drainage on construction sites has increased in the past decade; however, it remains essential at the local level to ensure that the development is well designed and planned, and then conducted according to plan, so as to minimize its impact.

Gravel Mining

Potential Concerns: Mining involves the removal of natural materials from the ground, such as sand, gravel, stone, etc. Gravel mining is part of modern society, as naturally-occurring sands and gravels are removed from the ground and provided for building materials. The potential water quality concerns associated with gravel mining relate to three aspects:

> First, the process of mining by necessity disturbs the land surface and natural vegetation. Erosion and sedimentation controls are needed to properly control and treat runoff from the disturbed areas. In addition, poorly controlled mining may penetrate the water table, and thus provide another pathway for pollutants to enter waters.
>
> Second, gravel mining operations frequent truck traffic for transport of materials from the site. Roads to and from the mining area may be viewed as temporary and thus inadequately constructed or sited, from a water quality perspective. Any road crossings of waterways or wetlands would be of particular concern, as these are likely locations for erosion and transport of sediment into the waters.
>
> Third, after mining activity is discontinued, the site may have long-term impacts on water quality depending upon the post-mining condition of the area (e.g., if the site is regraded for drainage control and revegetated, or just left as is). There can also be a possibility of illegal dumping at such locations.

In another New England state, it is believed that most groundwater problems associated with gravel mining are not from operations, but from subsequent uses of the site such as illegal dumping. Gravel mining can cut into sand and gravel aquifers, reducing groundwater inflows or offering a quick route of entry to water bodies for other pollutants.

Occurrence: Review of aerial photographs show an extensive area of sand and gravel mining (as of 1988) in the vicinity of Pine Hill. The disturbed area is indicated on land use maps as Heavy Industrial use. The mining areas are connected by dirt roads that connect from Amesbury Road and to Bear Hill Road. This area drains to the Back River near sampling sites 5 and 6A. (The gravel mining areas to the east of Pine Hill drain to Tuxbury Pond.) It is believed that the gravel pits are inactive; however, the current condition of these lands is not known. Note that it is not known if these lands are under a single ownership or if it consists of multiple properties/owners.

Significance: The water quality data for this section of the Back River has shown elevated phosphorus values. It is not possible to determine the possible significance of the gravel pits within the drainage area to these sites, which also includes the Sargent farm. Review of current aerial photographs and conducting a detailed site walk (with permission of the owner or owners) is needed to assess the current condition of the mining areas, the likelihood of highly sedimented runoff, and the presence of any surface drainage (e.g., small or intermittent streams) or groundwater penetrations at the gravel pits. If conditions indicate that the mining areas are contributing sediment, sampling exposed soils for phosphorus concentration may aid in determining the significance of this source. Data from the Nicol farm shows high phosphorus levels; the mining area has similar/dissimilar soils as the Nicol farm based on USDA soil survey maps.

Sewer Leak(s)

Potential Concerns: Several individuals have expressed concern over the presence of a sewer line in a wetland are close to Lake Attitash (in the vicinity of the Southwest inlet and the beach area), and the possibility for a leak to introduce contamination into the lake. The sewer is part of the Town of Merrimac sewer system. Sewerage contains a variety of pollutants, including phosphorus, total and fecal coliform bacteria, and others. If the sewer line in question does have a leak, this would be a contributor to the bacteria levels observed in the lake in summer 1998.

Occurrence: The Town of Merrimac has a sewer pipe that is relatively close to the lake and to wetlands tributary to the lake. There is presently no information to indicate that the sewer has a break or is leaking. However, several residents are concerned about this possibility. Also, the Southwest inlet sampling site often had the highest fecal coliform value, and was always higher than site 3 (Back River). The only way to confirm that this is not occurring is sewer inspection (see Section 4.2, Recommendation 6).

Significance: Without testing of the sewer, its significance cannot be accurately assessed. A sewer leak would be serious as a health risk to the bathing beach. In terms of phosphorus, however, it is likely that a sewer leak is not significant in the context of the entire lake, as the water quality data shows that high levels of phosphorus are entering the lake from the Back River, as well as the Southwest inlet.

Logging

Potential Concerns: Logging also may contribute to erosion because of associated soil disturbances. The impact of logging varies greatly depending upon how the activites are conducted; for example, stream crossings and roadcuts and removal of vegetation seriously disturbs soils. In Massachusetts, logging of 10 cords or more requires obtaining a permit from the Department of Environmental Management. As part of the permit, loggers must agree to follow guidelines for BMPs that include measures to prevent water quality impact. However, the number of field staff available to enforce these regulations are quite limited, so the likelihood of improper logging practices will vary from site to site.

Occurrence: Little information is available concerning the extent of logging activity in the Lake Attitash watershed. Unfortunately, state agencies are not able to provide mapped information concerning logging permits. Based on review of aerial photographs (1988) and land use maps, it seems unlikely that there is much current logging activity. Most likely, there may be some limited tree cutting by individuals to provide cordage for winter heating.

Significance: Available information suggests logging is not a significant activity in the Lake Attitash watershed, and thus is not significant to phosphorus loads. Most tree cutting probably occurs in conjuction with land development, which has additional impacts of concern and is discussed separately above.

3.4.4 Summary

Table 3-7 summarizes the findings concerning the potential sources of nutrients and other contaminants in the Lake Attitash watershed. The sources are generally ranked based on available data.

Table 3-7:
Relative Ranking of Potential Contamination Sources

Potential Contamination Source	Microbiological	Phosphorus, Nitrogen	Sediment	Metals or Oil/Grease	Relative Ranking of Importance to Eutrophication in Lake Attitash	Comment
Swimming	X				Low	Children swimming in the lake may add some bacteria or virus to the lake.
Boating	X	X		X	Potentially Moderate	Determination of the significance of boating depends upon the relative importance of nutrient recycling from sediment. This requires a more detailed phosphorus budget. Note that the data shows that there are still very high phosphorus inflows to the lake. Even if lake sediment is an additional source, the loads from surface flows may still dominate.
Birds on Lake	X	X			Unknown; Probably Moderate	No data are available to describe the numbers and dates of bird populations on the lake.
Wetlands and Wildlife Activity	X	X			Unknown	Wetlands and beaver activity complicate the understanding and interpretation of phosphorus data, particularly along the Back River. Wetlands do not "generate" phosphorus, but may re-release phosphorus that has been previously discharged to the wetland and stored in wetland sediment or used by plants.
Agriculture	X	X	X		Moderate to Potentially High	Water quality data show that there are high phosphorus and nitrogen concentrations from the Back River subbasin, which has two main agriculture sites as well as hobby farms. The land use model suggests agriculture is significant to overall phosphorus loads. Additional monitoring at modified locations is necessary to better pinpoint the sources within the Back River subbasin.
Residential Areas	X	X	X	X	High	The land use model shows that the portion of the watershed that is residentially developed contributes an estimated 58% of the total phosphorus load.
Commercial/Industrial	X	X	X	X	Low	While runoff from commercial/industrial areas is similar or worse than that from residential areas, the amount of commercial/industrial land use in the watershed is very small.
Roads	X	X	X	X	High	Roads are probably a significant source of phosphorus, including road-related soil erosion and the deposition of phosphorus from vehicles. Note that the land use model does not treat roads as a separate category, but reflects the roads contributions within each land use.
Construction	X	X	X	X	Moderate	The impact and significance of construction depends largely on the implementation of best management practices and stormwater controls on the construction site.
Gravel mining		X	X	X	Potentially High	Inadequate data is available to assess the gravel pits; however, water quality data points to the area as a possible source.
Sewer Leak	X	X	X	X	Low	There is no information to suggest that there is a sewer leak. A leak would be significant for public health reasons, but probably low in terms of long-term eutrophication.
Logging		X	X		Low	It is believed that there is relatively little logging activity in the watershed.

Section 4
Recommendations

4.1 Long-term Water Quality and Flow Monitoring

4.1.1 Goals

Water quality and flow monitoring can provide valuable information about Lake Attitash, Tuxbury Pond, and the Powwow River system. The monitoring that was conducted by the state in the 1970s, and that has been conducted by the Lake Attitash Association since 1994 and more recently by the Association and the Town of Amesbury, has provided information essential to understanding the health of the lake and problem areas. The recommended future monitoring program builds on the past data, and aims to:

- focus study in problem areas where more data is needed,
- track the effectiveness of watershed programs,
- track long-term changes in water quality, and
- enable an updated/more detailed nutrient budget in the future.

4.1.2 Long-term Monitoring

The recommended long-term monitoring program is summarized in **Table 4-1.** This program is designed to capture key information to support the goals, stated above.

The estimated analytical costs associated with this monitoring schedule is $8,900 per year. If funds are not available, a less intensive monitoring program could be implemented at an estimated cost of $2,000 per year. This program is summarized in **Table 4-2.**

The recommended monitoring program includes the following elements:

1. Modification of several sample locations as follows:

   - Relocation of sample location intended to capture Sargent farm runoff to locate flowing segments, and eliminating two of the three sites.
   - Addition of sample locations in the upper Back River, possibly including the site currently being monitored by Merrimac Water.
   - Eliminating unnecessary duplication (e.g., multiple sites at Sargent farm and eliminate site 9 in favor of site 3), so that samples can be taken in other areas.

2. Monthly monitoring of phosphorus in Lake Attitash, at the two inlets, and the outlet. These data are necessary to construct a nutrient budget. (Note that development of a nutrient budget requires that samples capturing all inflows and outlets of the lake be taken on the same day. This coordination of samples is important because the actual nutrient loading changes every day, so it may not be possible to compare one inflow sampled on one date with another inflow sampled on another day. The nutrient budget is based on a set of samples that represent the inflows and outflows at the same time.)

Table 4-1:
Long Term Monitoring Program, Lake Attitash Watershed

Location and site number

Parameter	*Analysis*	New Upper Back R. Site	New Wetland Site	New Wetland Site	Middle Back River	Sargent Farm area	Back River Inlet	Southwest Inlet	In-Lake Surface	In-Lake Bottom	Lake Outlet	Meadowbrk	Powwow R. above Tuxbury	Tuxbury Dam
		New	New	New	21	rev. 6A	3	2	1	1	4	32	8	7
Secchi disk (summer)	in field								B-W					B-W
Chlorophyll a (summer)	Lab								B-W					B-W
Fecal Coliform Bacteria	WTP	M	M		M	M	M	M	M	M	M	M	M	M
Total Phosphorus	Lab	M	M		M	M	M	M	M	M	M	M	M	M
Soluble Reactive Phosphorus	Lab	M	M		M	M	M	M	M	M	M	M	M	M
Dissolved Oxygen (summer)	in field		M						B-W					
Aquatic vegetation survey	ACT								Y					
Total Kjeldahl Nitrogen (TKN)***	Lab								Y					

B-W = Bi-weekly M = Monthly Y = Yearly

Notes:

Sampling period: **March through October** except as noted (total 35 weeks)

Shaded cells indicate core sites which should be sampled year round (to the extent possible) to develop accurate nutrient budget data.

* These samples could be part of a more intensive wetlands study as suggested in section 4, recommendation 6; they are not included in the cost of this sampling program.

** Current site location should be changed as discussed in section 4.1.2.

*** TKN should be taken occasionally (i.e., once a year or every other year) to verify that Nitrogen is not limiting.

Table 4-2:
Long Term Monitoring Program (scaled back), Lake Attitash Watershed

Location and site number

Parameter	*Analysis*	New Upper Back R. Site	Middle Back River	Sargent Farm area	Back River Inlet	Southwest Inlet	In-Lake Surface	In-Lake Bottom	Lake Outlet	Powwow R. above Tuxbury	Tuxbury Dam
		New	21	rev. 6A	3	2	1	1	4	8	7
Secchi disk (summer)	in field						B-W				B-W
Chlorophyll a (summer)	Lab						B-W				B-W
Fecal coliform bacteria	WTP	M	M	M	M	M	M	M	M	M	M
Total phosphorus	Lab	M	M	M	M	M	M	M	M	M	M
Dissolved Oxygen	in field						B-W				
Aquatic vegetation survey**	ACT										

B-W = Bi-weekly M = Monthly

Notes:

Sampling period: **April through September** except as noted

Shaded cells indicate core sites which should be sampled year round (to the extent possible) to develop accurate nutrient budget data.

* Current site location should be changed as discussed in section 4.1.2.

** To be conducted once, during the summer, every two or three years.

3. Dissolved oxygen profiles of Lake Attitash and Tuxbury Pond.

4. Summertime weekly chlorophyll a monitoring in Lake Attitash and Tuxbury Pond.

5. Dissolved oxygen measurements and phosphorus sampling at two wetland locations.

6. Focused study of the upper Back River and Southwest inlet, which can be implemented for a shorter time period and using fewer parameters.

7. Flow monitoring (using a staff gage or by recording water level and developing a stage-discharge curve) at site 21, at the Merrimac Power & Light site, and at the Lake outlet.

4.1.3 Storm Events

If funds are available, storm sampling is recommended at site 2, site 3 or site 9, site 4 and site 1, and at the four storm drains around the lake that were sampled in 1998 (Metcalf & Eddy for Town of Amesbury). This would facilitate comparison of storm flows entering the lake via the river, and those from the residential area storm drains. Two events would be sufficient; such an effort would cost approximately $1,000.

In addition, as noted below in Recommendation 7, if stormwater treatment devices are installed, sampling of the subject storm drain before implementation would aid in evaluating its effectiveness later on.

4.1.4 Data Management

In past years, the Lake Attitash Association has entered its monitoring data into tables. As part of this study, CDM has entered all the past and present years' data into a single spreadsheet. The spreadsheet is in EXCEL format, and can easily be converted to another spreadsheet (such as Lotus) or a database program, such as Access or other.

It is recommended that the Town and Lake Attitash Association continue to keep the data in electronic files, to aid comparison of trends and statistics. The database should include, in addition to the date, parameter, and value, the person collecting the sample, the laboratory that conducted the analysis, the detection limit, and any comments. Lastly, all original laboratory analytical reports should be kept on file.

4.2 Lake Attitash Watershed

The ultimate goal of the Lake Attitash watershed management program is to improve water quality in the lake; and specifically, to slow or reverse the eutrophication process.

To meet this goal, the recommendations must:

(1) prevent additional phosphorus loads from new sources (e.g., future development),
(2) control the generation of phosphorus from existing sources, and
(3) provide treatment of flows to reduce phosphorus loading to the lake.

The use of both source controls and treatment controls will be important to achieve the community's goals, and in particular to achieve them faster than if only one approach were used. Source controls can be time-consuming to implement as a retrofit at existing sites (whether agriculture or residential) and may not be completely effective at removing all phosphorus. Due to permanent alterations in the natural terrain and vegetation that have already occurred and are irreversible, it is not always possible in such situations to achieve the high level of phosphorus control that would be required of new development. To complement source controls, treatment controls can be used. Treatment controls typically involve a capital expense, but can be very effective. This combined approach is consistent with the recently-issued state Generic Environmental Impact Report - Eutrophication and Aquatic Plant Management in Massachusetts (November 1998), which states:

> "Integrated management uses the best elements of a variety of lake management techniques to enhance the effectiveness of treatment and minimizing unwanted impacts over the long-term."

The following pages present the recommendations for Phase 1 and 2. These recommendations are comprehensive, and address each of the potential contamination sources described in Section 3:

- To address the existing agricultural and unknown sources in the Back River subbasin, which accounts for 47% of the annual load, the recommendations include mitigating the known existing sources with BMPs; continued monitoring and investigations to identify additional sources and opportunities for control; and using a curtain filter/barrier at the Back River inlet, along with weed harvesting within the barrier, to "pretreat" the flow before it enters the lake.

- Recommendations that control the Southwest inlet and direct runoff areas, which are dominated by denser residential development, include increasing the use of residential BMPs through education, and the piloting of stormwater treatment devices that will effectively reduce stormwater loadings.

- Throughout the watershed, reduce potential impact of future development on the lake by additional recommended measures such as land acquisition, improve local development controls (as needed) and maintain protected lands status.

- On a longer term basis, following the implementation of the source and treatment measures which will reduce the loadings to the lake, other in-lake and watershed actions should be evaluated in the context of the changes in lake quality. These include in-lake controls (dredging; phosphorus inactivation, aeration), wetlands restoration, and possibly, boating restrictions, if lake sediment is determined a significant source of phosphorus.

To implement the recommendations, CDM advises three phases:

Phase 1 = years 1 to 4 (1999 to 2002)
Phase 2 = reevaluation (2003)
Phase 3 = years 5+ (2003+)

In Phase 1, projects to reduce existing sources of phosphorus to the lake will be implemented, while additional data is being collected in source investigations and water quality monitoring. Phase 1 requires significant cooperation among various entities and funding for some projects, and thus it is recommended to establish the four year time frame for this phase. A more aggressive schedule may be unattainable, and lead to disappointment. Moreover, the phase approach requires that projects are implemented, and then *their success monitored; and this important monitoring step would not be possible in a shorter time frame.*

Phase 2 consists of a formal re-evaluation. At the end of four years, various improvements will have been made and much more data will be available. A formal re-evaluation of the lake's health, the relative significance of the contamination sources, and the effectiveness of programs will be essential to ensure the program's maximum effectiveness and that the community's goals are met. In particular, at this time the significance of lake sediment to the phosphorus load can be definitively determined, and if sediment is significant after reducing inputs to the lake, in-lake treatments can be considered. Phase 3 then consists of the re-evaluated program from year five out.

The specific recommendations are based on water quality data and the evaluation of potential contamination sources. The recommendations are listed below and detailed on the following pages.

Summary of Recommendations

Recommendation 1: Formalize Coalition for Lake Attitash
Recommendation 2: Implement Curtain Barrier
Recommendation 3: Increase Residential BMPs
Recommendation 4: Implement Agricultural BMPs
Recommendation 5: Address Hobby Farms
Recommendation 6: Continue Monitoring and Conducting Source Investigations
Recommendation 7: Implement Stormwater Treatment Devices as Pilot
Recommendation 8: Land Acquisition
Recommendation 9: Strengthen Controls on New Development
Recommendation 10: Phase 2 Re-evaluation

Recommendation 1: Formalize Coalition for Lake Attitash

Purpose: A Coalition for Lake Attitash will be useful to coordinate activities of various parties, to apply for grants, and to share information re: development issues.

Benefits: With an effective Coalition in place, there will be a greater likelihood of obtaining state grants. Also, the implementation process will be smoother, with less potential for conflict to negatively impact or delay projects to improve the lake.

Suggested Responsibility: All interested entities, such as those listed below.

Actions: Building on and extending the effort of the past few months during this study, the local governments, citizen associations, lake users, and residents should cooperatively form the Coalition for Lake Attitash. The Coalition would essentially be an umbrella organization or committee that would provide a forum for discussion about the lake and its watershed, and coordinate efforts. Ideally, the Coalition would include representatives from:

- Town of Amesbury
- Town of Merrimac
- Town of Newton NH
- Lake Attitash Association
- Agricultural representatives (farm owners and/or USDA-NRCS, MA DFA)
- Lake users
- Amesbury Lakes & Waterways Commission
- Town Conservation Commissions,
- Any other interested groups or individuals

In addition, the following associations/agencies could be considered either for inclusion in the Coalition, or be invited to selected meetings. These agencies can be a source of information or help concerning grants and/or state technical assistance (see Appendix B for further description).

- Merrimack River Watershed Association
- 8 Towns and a Bay
- Merrimack Valley Planning Commission (MVPC)
- Massachusetts Department of Environmental Management (DEM)
- Massachusetts Department of Food and Agriculture (DFA)
- Massachusetts Department of Environmental Protection (DEP)
- Massachusetts EOEA Watershed Initiative Basin Team

The Coalition could be formed without additional funding, if towns or organizations can contribute some time for coordination. It is recommended that the Coalition does not become a financial entity; rather, the Coalition should focus on coordination. For example, the Coalition would be well suited to organize a grant application, gathering support from its members, but the grant itself would be awarded to one or more of the parties for execution.

The selection of a facilitator that is viewed as "neutral" and "fair" by all parties should be considered to help create an atmosphere for productive cooperation.

When: Initial formation by March 1999. It is suggested the Coalition meet on a quarterly basis, with a formal schedule established and distributed to all at the beginning of the year. Additional, special meetings could be scheduled and held as needed.

Recommendation 2: Implement Curtain Barrier

Purpose: The proposed curtain barrier will reduce phosphorus and solids entering Lake Attitash from the Back River. The barrier will provide a reduction in the phosphorus load to the lake, as source controls are being implemented. Also, the barrier will help to ensure phosphorus from the Back River is reduced, regardless of the effectiveness or timing of source controls along the river.

Benefits: A curtain barrier at the mouth of the Back River will "treat" 47% of the annual phosphorus load to Lake Attitash. Assuming a reduction of 70% from the barrier, this would reduce the annual total phosphorus load by 33%.

Suggested Responsibility: The Coalition for Lake Attitash should discuss this project and determine the most appropriate "owner." The location of the curtain would be within the Town of Merrimac. However, no officials from the Town of Merrimac local government have participated, to date, in this study; thus, it cannot be assumed that the Town of Merrimac would have an interest in this project. Due to the presence of the beach, it is possible that the Merrimac Board of Health may be interested, since the project would probably also reduce coliform bacteria originating in the Back River.

Alternately, DEM may be a possible candidate. DEM has an interest in the health of lakes throughout the Commonwealth, particularly those with recreational facilities. The presence of a state boat ramp at the lake may be adequate reason for DEM to become involved. It is recommended that the Coalition explore this possibility, as well as discussions with the Town of Merrimac.

Actions: The proposed curtain barrier is modeled after a pilot curtain barrier that was installed at Wachusett Reservoir in 1998. The curtain consists of black polyethylene that is suspended from the water surface by floats, and anchored at the lake bottom by weights. The curtain has small openings cut in the plastic. The openings allow fish movement and flow through. Although the curtain's openings allow flow to move directly through and it is not a contained area, the curtain is effective by modifying circulation patterns from the river into the lake.

Monitoring conducted by the Metropolitan District Commission (MDC) Division of Watershed Management showed that the barrier removed 78% of total suspended solids (TSS) (MDC did not monitor phosphorus). The removal of particulate phosphorus should be similar to this, but removal of dissolved phosphorus (Soluble reactive) may not be as high. MDC also noted significant algal growth on curtains. Based on this success, MDC is now planning to pilot a filter curtain at another brook. The curtain filter functions by changing circulation, as the curtain barrier does, but also functions as a filter, since the curtain filter does not contain large openings but water must flow through the material's very fine pores that essentially filter the water. Disadvantages of the curtain filter are its higher cost, and the lack of fish passage. More information on the barrier curtain and filter curtain is contained in Appendix C.

Steps in implementing a curtain barrier are:

1. Coalition for Lake Attitash to determine project owner; project owner accepts responsibility.
2. Obtain funding for design, any permitting, and construction. Design cost could range from zero, if town engineering staff are available, to $5,000 to $10,000 for a consultant. Materials cost is estimated at $10,000 to $15,000 for a curtain barrier, and somewhat higher if a curtain filter type is selected.
3. Develop design, including selecting exact location for placement.
4. Obtain permits.
5. Install.
6. Conduct visual and water quality monitoring.
7. Contract for weed harvesting during late summer.

When: The barrier should be installed in spring. Due to funds required, it is probably unlikely to implement by Spring 1999; thus, the target installation date is Spring 2000.

Recommendation 3: Increase Residential BMPs

Purpose: Increasing the use of Best Management Practices, or BMPs, by individual residents in their yards could reduce the phosphorus entering Lake Attitash from residential areas. The purpose of an organized outreach program is to educate residents about improvements they can make and offer incentives for them to do so.

Benefits: This recommendation targets residential areas, which are estimated to contribute approximately 58% of the annual phosphorus load. While individual BMPs cannot eliminate the contribution of phosphorus from developed areas, it could reduce the loads, at a low cost. Given the past outreach programs by the Lake Attitash Association and response, there is a high likelihood that this could be effective.

Suggested Responsibility: The Lake Attitash Association is in an ideal position to conduct this program, with its excellent organization of volunteers. The Towns of Amesbury and Merrimac could provide support, such as copying and printing of the audit checklist and any educational materials that could be passed out during the audits, and providing a location for the landscaping workshop.

Actions: The basic BMPs for residential areas that address phosphorus loads include:

- Eliminating bare soils
- Using no fertilizer or no-phosphorus fertilizer on lawns and plants
- Keeping vegetated buffers along the shoreline and bank (e.g., avoiding lawns, paved areas from extending all the way to the water's edge)
- Discharging gutter downspouts, driveway runoff, sump pumps to gravel dry wells or leaching areas, or vegetated areas (where they can tolerate the flows without erosion)
- Reducing paved areas in favor of vegetated areas (but using pavement to reduce eroding, bare soils)
- Selecting plants and landscaping materials that tolerate natural conditions without need for fertilizers
- Keeping lawns at a higher grass height to improve pollutant attenuation

To encourage homeowners to implement such measures, a program of voluntary home audits is recommended, focused on the neighborhoods immediately surrounding the lake. The audit consists of a brief (30-60 minute) walk of the property, with suggestions for improvements. Typically, there is a checklist that is filled out, so the homeowner is left with a written copy of the suggestions and ideas. The following specific actions are recommended:

1. Solicit volunteers to form home and yard audit teams. (These teams could be called by an upbeat name, such as "Yard Helpers" or "Team Attitash".) Obtain/provide training for the teams, possibly by participating in similar audits

being conducted by another watershed group. (Portland, ME Water District staff have conducted this type of audit, for example.)

2. Announce the availability of the team for certain dates in May and June (when many people are working in their yards).

3. Conduct audits for residents that have requested them. If response is slow, the teams could walk door to door to solicit interest. However, audits should be purely voluntary on behalf of homeowners.

4. To complement the audits, the Lake Attitash Association could sponsor a landscaping workshop, again timed to coincide with gardening activity. Local landscape centers and landscape architects would probably be interested in giving short lectures on relevant topics, such as:

   - Replacing lawn with vegetated buffers
   - Selecting plants for vegetated buffers
   - Selecting plants to thrive in poor soils
   - Ground covers to reduce soil erosion

5. In some locations, contests for the most lake-friendly yard have been held to promote and recognize homeowners' efforts. Again, local landscape centers and landscape designers would likely be interested in helping, through judging or offering prizes. Massachusetts Audubon, North Shore center has sponsored this type of workshop in the past.

6. Formation of a Youth Conservation Corps similar to that in China Lake, Maine could be considered. The Conservation Corps could conduct revegetation and drainage improvement projects.

Various technical references are available that provide helpful recommendations and specifics. The Nashua River Watershed Association is conducting a project of "gardening BMPs" which may be particularly useful here.

When: Spring 1999 for summer 1999 season

Recommendation 4: Implement Agricultural BMPs

Purpose: Water quality data suggests the Sargent farm area as a source of excessive nitrogen; data also show high levels of phosphorus may be originating above site 21 (located at Bear Hill Road), in the middle to upper Back River watershed. These may or may not be related to agriculture; however, Best Management Practices (BMPs) will reduce the potential of phosphorus, nitrogen, bacteria and other pollutants from leaving agriculture sites and entering the river and lake.

Benefits: BMPs at agriculture sites could address 24% of the annual phosphorus load, as estimated by the model. Agricultural BMPs will also be beneficial in reducing bacteria and other possible pathogens present in agricultural drainage, and thus reducing health risk in the Town of Amesbury drinking water supply.

Suggested Responsibility: Implementation of BMPs at agricultural sites are the responsibility of individual owners. The U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) is the federal agency charged with providing technical assistance and grants/loans to individual farm owners to enable them to implement BMPs. The NRCS is not a regulatory agency; thus, the participation of farm owners is purely voluntary. It is hoped that the Massachusetts DFA also will play a role in the Lake Attitash watershed, providing technical and financial support as available.

Actions: As discussed in Section 3, there are two large agriculture sites in the Lake Attitash watershed. Suggested actions are organized by site, below. In addition, there is a separate recommendation (Recommendation 5) to address the smaller farms that may be in the watershed.

<u>1. Sargent Farm</u>

- The Sargent family is currently working with the NRCS to develop BMPs, including a Nutrient Management Plan.
- CDM recommends, based on a site visit with the cooperation of the Sargents, that the Sargents and NRCS give consideration to the following:

- Develop an impervious or low permeability compost pad (such as the prototype USDA compost facility in Beltsville, Maryland). Note that the idea of an impervious or low permeability pad is to reduce the migration of compost constituents into groundwater; however, by doing this, the surface drainage is increased. A low permeability pad would only be an aid to water quality if it is graded and pitched to collect surface runoff to a basin or other treatment device.

- Collect drainage from the compost piles in a new detention basin or other device designed for performance standards aimed at reducing nitrogen and phosphorus levels. If it is located in a low area (with shallow groundwater), the

Recommendation 5: Address Hobby Farms

Purpose:

In the upper watershed, there are some smaller-scale, less well-known sites with animals and livestock. These include horse farms/riding stables, and individual residences with a few animals, be it horses, cows, sheep, etc. Note that such sites are not categorized by USDA as agriculture, and thus they are typically not addressed by the existing programs.

Based on water quality data collected in 1998, there can be high phosphorus levels originating from the upper watershed. While additional data will be developed (see Recommendation 6), it is reasonable to suspect these hobby farm sites as possible contributors of phosphorus. Little information is available concerning this type of site; in other words, there is no map or central database that would list all of these animal locations. There have been occasions in other watersheds in which a relatively small site caused significant water quality impact if animals are being allowed to access streams (for drinking or crossing between fields), or if manure storage/disposal is handled poorly. Thus, the purpose of this recommendation is to encourage the use of BMPs at small-scale and hobby farms.

Benefits:

Applying low-cost, practical BMPs will reduce phosphorus and other pollutants loads from each hobby farm site.

Suggested Responsibility:

It is recommended that the Towns (especially Newton NH and Merrimac) take a lead role in this effort. Either the Conservation Commissions, due to their authority over wetlands and waterways impacts, or the Boards of Health, due to their historical involvement in tracking livestock. It is further suggested that the Towns approach DFA about obtaining technical assistance on the project.

Actions:

The biggest potential water quality problems with small scale sites are:

- Animals have access to wade in streams/ponds, allows direct contact with water
- Animal wastes/manure from barns are stockpiled in wet areas or near streams, so runoff can easily reach stream
- Concentrated animal pens are located close to wetlands or streams, so runoff can easily reach stream
- Wastes are left in grazing fields and are carried via drainage to a stream

Methods to prevent such problems include:

- Properly locating manure storage areas
- Providing buffers between grazing areas/pens and wetlands/streams
- Fencing to block direct access to streams

To encourage the hobby farmers to make any appropriate changes, the following steps are recommended:

1. Based on local knowledge, any Board of Health records, etc., identify a list of hobby farms and stables.

2. Contact DFA and NRCS concerning any available public education materials relevant to this type of site. These materials are also available through the Massachusetts Audubon North Shore Office, and have recently been developed for distribution in the Ipswitch River watershed.

3. Send a letter, with any available materials on BMPs attached, to each owner. The letter should state the overall goal of protecting the environment and water quality; outline general methods to prevent water quality impacts (or reference enclosed materials); and give a contact name for more information.

4. If adequate time is available from staff or Committee member, conduct visits to the farms as a follow-up to the letter.

When: 1999-2002

Recommendation 6: Continue Monitoring and Conducting Source Investigations

Purpose: The purpose of continued monitoring and source investigations is to improve the knowledge, documentation, and understanding of possible phosphorus (and coliform) sources.

Benefits: As specific sources are identified, and more information is understood about currently identified sources, the actions to address them can be focused to be more effective.

Suggested Responsibility: Prior to 1998, the Lake Attitash Association had taken primary responsibility for monitoring and source investigations. In 1998, the Town of Amesbury received a grant. With the grant, the Town of Amesbury provided technical assistance, analytical services, and funded the 1998 monitoring laboratory fees, while the sample collection was again conducted by the Association. It is recommended that the Association continue to lead the monitoring efforts; however, it is further recommended that the monitoring program be reviewed by the Coalition, and that any parties interested in participating are allowed to do so.

It is suggested that the Coalition take the lead role in continued source investigations, so that there is a respresentative group involved in this sensitive area.

Actions: The recommended water quality monitoring program is presented in Section 4.1. As noted, additional samples are recommended to compliment the Lake Attitash Association's past efforts. Additional funding will be needed to support the laboratory costs.

Targeted source investigations are recommended as follows:

1. <u>Sewer Leak</u> - Several individuals have expressed concern over the presence of a sewer line in a wetland are close to Lake Attitash, and the potential for a leak to introduce contamination into the lake. The sewer is part of the Town of Merrimac sewer system. It is recommended that the Town of Merrimac conduct an inspection of this sewer to determine if there are any breaks or leaks. Sewer inspections can be conducted either by television inspection, dye test, or by nightsticking. Nightsticking involves checking the flows during the middle of the night; at that time, there should be little flow. If there is significant flow, this means that groundwater or surface water is entering the pipe through leaky joints or cracks. During the day, the same cracks could result in sewage leaking out. If there are any leaks, the Town of Merrimac is responsible to fix them.

2. <u>Upper Back River</u> - As noted in this report, elevated phosphorus concentrations were observed originating from the upper Back River. Other than the Nicol Farm (described above and in Section 3.4), at which BMPs are already in place, there are no obvious major sources in this area. Thus, it is recommended to conduct additional field investigations to determine if there are any other sites that could be

acting as major phosphorus sources. This could include small scale farms (see above, Recommendation 5), any illegal discharges to the Back River or its wetlands, or any new development which lacks sufficient soil erosion controls or involves extensive clearing of land.

3. Gravel Pits - With assistance of the NRCS or other appropriate entity with soil expertise, determine the potential for former gravel pits to be a source of phosphorus to the Back River. Review of current aerial photographs and conducting a detailed site walk (with permission of the owner or owners) is needed to assess the current condition of the mining areas, the likelihood of highly sedimented runoff, and the presence of any surface drainage (e.g., small or intermittent streams) or groundwater penetrations at the gravel pits. If conditions indicate that the mining areas are contributing sediment, sampling exposed soils for phosphorus concentration may aid in determining the significance of this source.

4. Wetlands Study - As noted in this report, the hydrology of the Back River has been altered significantly by beavers. The role of the flooded lands/wetlands in phosphorus transport and loads to the lake has not been studied, but could be significant if the dammed areas stagnate, deplete oxygen levels, and cause resolubilization of phosphorus from sediment and decaying plant materials. To better understand the wetlands, it is recommended that the Coalition approach the Merrimack River Watershed Association and the EOEA Basin Team for the Merrimack or perhaps a local college to ask them to conduct a study of this system. Such a study would likely provide useful information to other similar situations. Note that the monitoring program recommended above also includes sampling specifically aimed at this question.

5. Southwest Inlet - A field investigation should be conducted of the Southwest Inlet subbasin to determine if there are any major sources. Based on the land use, it appears there could be the possibility of storm drain discharges into the wetlands above the inlet. Also, there are some areas shown on the land use map as agriculture, but site-specific information was not available. These include some fields along Route 110 in Merrimac (behind the strip of residences along the road). Further evaluation of these areas would be useful to determine if there is any active agriculture or whether the land is now fallow fields.

When: 1999-2002

Recommendation 7: Implement Stormwater Treatment Devices as Pilot

Purpose: Stormwater treatment devices treat stormwater runoff before it enters the lake, reducing solids and phosphorus loads in runoff from the drainage area. The use of stormwater treatment devices is practical in the denser residentially developed areas around the lake shore, considering the existence of some of the necessary infrastructure (catch basins and drainage pipes), and some locations of overland flow (especially associated with roads). However, stormwater treatment devices could be expensive, from $5,000 to $25,000, depending upon the size, type, and design. The purpose of implementing such devices as a pilot program is to demonstrate their effectiveness, become familiar with maintenance, and assess costs.

Benefits: Stormwater treatment devices could be used to address perhaps 20% of the annual phosphorus load to the lake, which originates from the denser residentially developed areas around the lake shore. These devices have been studied and documented to remove phosphorus, as well as other pollutants.

Suggested Responsibility: Since these devices are essentially a component of storm drain infrastructure, it is suggested that the Towns of Amesbury and Merrimac be responsible. The exception would be drainage facilities in any privately-owned roads.

Actions: The following specific actions are recommended:

1. Pursue grants, particularly s. 319 funds from DEP.
2. Using the storm sampling data and supporting information developed for the Town of Amesbury, identify 3 to 5 storm drains for piloting.
3. Select and design appropriate treatment devices, either using Town engineering resources or consultants.
4. Obtain permits such as Orders of Conditions.
5. When funding is obtained, construct.
6. Following construction, monitor effectiveness via storm sampling.
7. Maintain, including regular removal of collected solids.

When: 1999 (planning) 2000-2003 (construction)

Recommendation 8: Land Acquisition

Purpose: Acquiring lands for permanent protection can help water quality in several ways. First, protecting these lands prevents any increase in phosphorus load that could result from development of those lands. Second, the protected lands provide natural stormwater treatment via vegetated buffers.

Benefits: A land acquisition program in the Lake Attitash watershed would benefit water quality over the long-term. Land acquisition may have ancillary benefits to the community, such as open space preservation and recreation/conservation opportunities.

Responsibility: Town planners of the three towns with assistance of Coalition for Lake Attitash and regional/state agencies (see list under Recommendation 1).

Actions:

1. Pursue grants/loans for land acquisition. (See Section 4.4.2 for information)
2. Develop criteria to select sites. Criteria could include factors such as (1) proximity to lake, (2) proximity to tributary or wetland, (3) stream or wetlands on site, (4) soil type, (5) vulnerability to development, (6) current condition (e.g., healthy forest, logged area, disturbed site, etc).
3. Using the criteria, identify the top priority parcels in each town.
4. Determine the appropriate form of ownership - direct purchase or conservation easement and estimate cost.
5. Maintain list of parcels, in order of priority, listing parcel information, desired purchase type, owner name and address, and cost.
6. As funds become available, implement the top priority purchase:
   - Where appropriate, approach owner to negotiate terms.
   - Purchasing entity (whether town or other) should obtain legal advice concerning acquisition procedures.
   - Execute purchase.

When: Ongoing

Recommendation 9: Strengthen Controls on New Development

Purpose: Strengthening local land use controls on new development will help reduce the potential increase in phosphorus load that could result from development.

Benefits: Land use controls can be used so that new development is designed and constructed to reduce the increase in phosphorus load. As approximately 73% of the watershed is undeveloped, these controls could provide a significant benefit to the long-term future loads to the lake.

Suggested Responsibility: Town planners of the three towns with assistance of Coalition for Lake Attitash and regional/state agencies (see list under Recommendation 1)

Actions:

1. Through the Coalition, identify opportunities for improvement in each town's zoning code, subdivision regulations, site plan review procedures, and conservation regulations (if any). A goal to strive towards is no net increase in phosphorus from a site, with long-term monitoring to ensure any stormwater treatment facilities function as designed.

   An example of a possible opportunity is to develop a Watershed Overlay District for each town. This could be used to establish stormwater standards, or to require naturally vegetated buffers to be maintained. Other innovative zoning techniques that may be applicable in a Watershed Overlay District are Transfer of Development Rights and cluster development.

2. Where such opportunities exist, support Town efforts to make improvements.
3. Ensure that Amesbury and Merrimac Conservation Commissions have adequate information concerning the Massachusetts Stormwater Management Policy. Provide a copy of the policy to the Newton NH Conservation Commission; although not applicable, it contains useful reference information.
4. Also, work to maintain protected lands status (e.g., Chapter 61/Land Use).
5. Interested parties should continue their efforts to monitor proposals for new developments in the watershed, and offer productive comments during public reviews and other appropriate occasions.

When: 1999 (planning) 2000-2001 (implementation)

Recommendation 10: Phase 2 Re-evaluation

Purpose: As described in the beginning of Section 4, it is wise to plan on a Phase 2 re-evaluation to assess the effectiveness of measures to date; current state of the lake; and the need for next level of controls.

Benefits: The benefits of conducting the formal Phase 2 Re-evaluation are that it: (1) provides a milestone at a realistic time frame to see if the lake is improving; and (2) allows readjustment of improvement measures if progress is inadequate.

Suggested Responsibility: All. The Coalition should take the lead in conducting the re-evaluation, but steps should be taken to ensure the process is well publicized and the public have opportunity to participate.

Actions: The re-evaluation could be conducted by the Coalition, with assistance of outside experts (via state agencies or consultants) as needed. The key steps will be:

- Conduct a detailed evaluation of the water quality data that will be collected 1999-2003.
- Using this new data, update the nutrient budget to the lake. Assess the additional information (e.g., wetlands study, etc.) to evaluate and update the ranking of sources. Specifically, look at the significance of lake sediment.
- Evaluate the effectiveness of controls that will have been implemented by that time, especially agricultural BMPs and residential stormwater devices.
- Consider additional, more aggressive long-term measures:
  - Boating restrictions
  - In-lake controls: dredging, phosphorous inactivation (such as with an alum treatment), hypolymnetic aeration
  - Wetlands restoration

When: end of 2003

4.3 Tuxbury Pond and Powwow River

Many of the recommendations outlined above will be beneficial to the watersheds of Tuxbury Pond and the Powwow River, as well as to Lake Attitash. These include:

- Recommendation 1: Formalize Coalition for Lake Attitash
  This coalition could become a model to be followed in the future by parties interested in Tuxbury Pond and the Powwow River.

- Recommendation 3: Increase Residential BMPs
  These recommendations each involve outreach to residential areas concerning simple best management practices. This outreach could also be implemented in portions of the Tuxbury Pond and Powwow River watershed.

- Recommendation 6: Continue Monitoring and Conducting Source Investigations
  The recommended monitoring program, presented in Section 4.1 above, includes continued monitoring of the Powwow River above and below Tuxbury Pond, and in the pond itself.

- Recommendation 8: Land Acquisition
  A land acquisition program could be expanded to include the Tuxbury Pond and Powwow River watershed, especially focused on riparian lands.

- Recommendation 9: Strengthen Controls on New Development
  Any improvements in the Town of Amesbury land use regulations will also aid protection within the Tuxbury Pond and Powwow River watersheds.

One of the challenges with the Tuxbury Pond and Powwow River watershed is its size, and the various state and local jurisdictions within which it falls. Initial steps towards developing a specific watershed program for Tuxbury Pond and Powwow River could include:

1. Gathering all available data about the watershed, such as land use maps, zoning maps and regulations, water quality data, etc. This will require traveling to state, regional, and local government agency offices in the New Hampshire portion of the Powwow River watershed, and pulling together these data.

2. Reviewing water quality data and determining existing problems.

4.4 Implementation

4.4.1 Schedule and Budget Considerations

One of the first steps of the coalition, or for the individual parties who take on responsibilities for implementation of some of these recommendations, will be to establish a detailed schedule and budget for those activities. The program outlined above is based on a five year cycle, with implementation occurring beginning in 1999 for four years. This will be followed by a reevaluation step, and then implementation of any additional measures (such as in-lake treatments, dredging, etc.) that are determined in the reevaluation.

Within the initial four year implementation period, there will need to be individual schedules for each recommendation, including target dates for key milestones. The towns and volunteer groups will need to focus on one or two things each year, so that things get done. In addition, funding requirements will play into when each recommendation is implemented. Thus, it is important to plan things out, so both volunteer and staff efforts, and costs, are spread over time.

In terms of overall cost, many of the recommendations can probably be done at a modest cost (or no cost) using volunteers and existing town resources. In some cases, there may be a desire for assistance from professionals, such as graphic artists or consultants. There may also be some printing costs.

These low-cost recommendations include Recommendation 1: Formalize Coalition for Lake Attitash; Recommendation 3: Increase Residential BMPs; Recommendation 5: Address Hobby Farms; and Recommendation 9: Strengthen Controls on New Development.

Several recommendations involve more significant capital costs. These are listed below along with preliminary cost estimates for some components, based on best judgement:

<u>Recommendation 2: Implement Curtain Barrier</u>

Costs: Materials, $10,000 to $15,000
Design/Permitting, $5,000 to $10,000 or Town staff
Labor to install, $3,500 or volunteers

<u>Recommendation 4: Implement Agricultural BMPs</u>

Costs: Unknown; various BMPs currently under consideration and design

<u>Recommendation 7: Implement Stormwater Treatment Devices as Pilot</u>

Costs: Construction, range from $5,000 to $20,000 per treatment system
Maintenance, undetermined
Design/permitting, undetermined, depends upon scope of investigation

<u>Recommendation 8: Land Acquisition</u>

Costs: Land acquisition programs often are conducted by identifying and ranking parcels, and then purchasing the parcels as funds allow. Clearly, a land acquisition program in the Lake Attitash watershed could require significant funds. Conservation easements are another approach to acquisitions that can reduce the required funds while achieving a similar goal.

Recommendation 10: Phase 2 Re-evaluation
Costs: Consultant, $20,000 to $40,000, depending upon scope, available data, etc.

The monitoring program also has a cost. CDM has recommended an ideal program, and a reduced program if funds are limited. The monitoring costs are estimated at $2,000 to $8,900 per year.
Once the Coalition is formed, it will be necessary to determine the priorities and schedule, and along with this, assess the required funds.

4.4.2 Possible Funding Sources

CDM has compiled a list of possible funding sources for various aspects of the watershed management program. These are described below by category: Land Acquisition, Greenways/Recreation/Land Use Planning, Water Quality/Watershed, and Education. Lastly, sources of technical assistance are listed.

Land Acquisition

- **Massachusetts Self-Help Program.** This program provides funds to municipalities for acquiring land for conservation. The program provides a matching grant for 52 - 70% of the total project cost; maximum grant amount is $500,000. Projects that are successful typically protect water resources, include rare or endangered species habitat, link to other protected open space, or contain historic or archaeological resources, and include participation with other governmental or private non-profit agencies. The application process begins in the spring with an application deadline in early summer. Contact the Division of Conservation Services at 617-727-1552 x 292.

- **Massachusetts Urban Self-Help Program.** This program provides funds to municipalities for acquiring land, or for development of park and recreation land facilities. The program provides a matching grant for 52 - 70% of the total project cost; maximum grant amount is $500,000. Cooperation with other governmental and nonprofit agencies is encouraged. Only municipalities with a park, playground, or recreational commission are eligible. The application process begins in the spring with an application deadline in early summer. Contact the Division of Conservation Services at (617) 727-1552 x 544.

Greenways/ Recreation/Land Use Planning

The following programs are administered through the Massachusetts Department of Environmental Management (MA DEM):

- **Greenways and Trails Demonstration Grants Program.** The DEM provides grants of $1,000 to $3,000 to municipalities and non-profits to support innovative projects that advance the creation and promotion of greenway and trail networks in Massachusetts. Applications are due in fall/winter each year. Call (413) 586-8706 for more information.

- **Forest Stewardship Program.** This program provides incentives for sound forest management on private lands. Landowners, with the assistance of DEM foresters, develop a forest stewardship plan for their property, which makes them eligible for federal cost-sharing dollars to help carry out the plan. Most grants range from $3,000 to $5,000. Call (413) 256-1201 for more information.

- **Acquisition and Development Funds for Statewide Trails.** This program offers grants to acquire long-distance trail corridors as greenways linking public and nonprofit conservation land and to incorporate long-distance trails into local open space planning. Contact DEM at (617) 727-3180.

Water Quality/ Watershed Management

- **Riverways, Adopt-a-Stream Program.** This program provides small grants from $1,000 to $5,000 for implementation of nonpoint source prevention projects. Contact Riverways at (617) 727-1614.

- **Rivers Protection Act Grants.** This program will provide funding for watershed projects specific to rivers. Funding is for materials only and will be available annually for the next five years (1999-2004). Application process is expected to open January 1999. Contact the MA Department of Food and Agriculture at (617) 727-3018

- **Lake and Pond Grant Program.** This program provides grants for comprehensive, integrated approaches to lake management, protection, and restoration. Municipalities are eligible; co-application with Lake and Pond Associations and Watershed Associations is encouraged. A maximum grant of $10,000 is available on a 50/50 cost sharing basis. Annual application deadline is in November or December. Contact the DEM, Office of Water Resources, at (617) 727-3267 x 524.

- **State Revolving Fund.** This fund supports water pollution abatement projects, and especially watershed management projects with substantial water quality and public health benefits. Typical projects include new wastewater treatment facilities as well as nonpoint source pollution abatement efforts. Contact the DEP at (617) 292-5749.

- **Section 319 Nonpoint Source Competitive Grants Program.** This program funds projects which implement measures that address the prevention, control, and abatement of nonpoint source pollution. A maximum grant of $150,000 is available; a 40% non-federal match is required. Annual RFR announcement is in March. Contact the DEP at (617) 292-5901.

- **Watershed Initiative/Planning for Growth: Communities Connected by Water Grant Program.** New grant program (1998). A joint submittal under the two grant programs is required. Two contracts are awarded which provide up to$150,000 for watershed protection and up to $100,000 for growth planning. The awards require a 100% and 25% match respectively. Contact the Executive Office of Environmental Affairs at (617) 727-9800 x227.

- **Watershed Initiative: Comprehensive and Capacity Building Grants.** These grants are administered over a two year period to help develop organizational strength for groups/partnerships working on watershed stewardship. Watershed organizations and Regional Planning Agencies are eligible. Comprehensive grants range up to $120,000; capacity building grants range up to $50,000. Contact the Executive Office of Environmental Affairs at (617) 727-9800 x227.

Education

- **Gulf of Maine Council for the Marine Environment.** Recently funded a fecal coliform study in the Ipswich River Watershed. Contact Coastal Zone Management at (617) 727-9530 x401.

- **Massachusetts Environmental Trust.** This program has ten grant categories including water quality, general grants, and mini-grants. The match varies with each program and ranges between $20,000 and $200,000. Contact the MA Environmental Trust at (617) 727-0249 for more information or visit their website at: www.agmconnect.org/maenvtr1.html.

Support/Technical Assistance

Land Acquisition

- Essex County Greenbelt Association (978) 768-7241, www.shore.net/~ecgaTrustees of Reservations (978) 921-1944, www.ttor.orgTrust for Public Lands, New England Regional Office (617) 367-6200MA Department of Food and Agriculture, APR Program (617) 727-3018
- Massachusetts Audubon, North Shore Office: Land Protection Team (978) 927-1122

Water Quality/ Watershed Management

- Massachusetts Department of Fisheries Wildlife and Environmental Law Enforcement, Riverways Program at (617) 727-1614, http://www.magnet.state.ma.us/
- Massachusetts Water Watch Partnership, (413) 545-2842, http://riga.fnr.umass.edu/tei/Mwwpage/
- Merrimack River Watershed Council, (978) 681-5777
- Massachusetts Watershed Coalition, (978) 534-0379, www.ma.ultranet.com/~mwc
- Mass Bays Programs- Local Governance Committees, (617) 727-9530 x 402

Education

- Massachusetts Audubon, North Shore Office (978) 927-1122
- Merrimack River Watershed Council, (978) 681-5777

Appendix A

References

Aerial photographs of portion of watershed. Town of Amesbury Engineering Office. April 13, 1988.

U.S. EPA. Handbook: Septage Treatment and Disposal. October 1984.

U.S. EPA. Guide to Septage Treatment and Disposal. September 1994.

Michael Giggey and Karl Brantner. Characterization of Septage for Design of Waste Treatment Facilities.

Ronald A. Jager. Status Report on the Water Environment Federation's Septage Handling Manual of Practice.

Sanjay Jeer, Megan Lewis, Stuart Mech, Jon Witten, and Michelle Zimet, American Planning Association. Nonpoint Source Pollution: A Handbook for Local Governments, 1997. -- *explains lake hydrology, models, and nonpoint sources; contains a model water resource protection ordinance and a water quality checklist for reviewing development plans.*

Mark D. Mattson, Paul J. Godfrey, Regina A. Barletta, and Allison Aiello, Water Resources Research Center at U. Mass. Amherst, for DEP and DEM, Eutrophication and Aquatic Plant Management in Massachusetts -- Draft Generic Environmental Impact Report, February 1997 issued for public review November 1998.

North American Lakes Management Society for USEPA. The Lake and Reservoir Restoration Guidance Manual, Second Edition. USEPA, Office of Water August 1990 (EPA-440/4-90-006).

University of New Hampshire Cooperative Extension "Motorized Boating on Lakes: What are the Environmental Impacts?" -- *includes list of simple things boaters can do*

Kenneth J. Wagner. "Assessing Impacts of Motorized Watercraft on Lakes; Issues and Perceptions."

Robert G. Wetzel. Limnology. Harcourt Brace College Publishers, pp. 293-294. 1983.

David O. Wright and Kenneth J. Wagner. "Power Boats on Shallow Lakes: A brief summary of literature and experience on Lake Mohegan (NY)" Lake Line 11(4) December 1991.

Appendix B

Contacts

1. Participants

- Town of Amesbury

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  978/388-8121
  ted@amesbury.greennet.net

  Rob Demarus - Town Engineer
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  Nick Cracknell - Town Planner
  978/388-8110

  Lakes and Waterways Commission
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  mcbrien@massed.net

- Lake Attitash Association

  Bill Stazik
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  A. Tod Campbell
  978/388-7888
  atcampbell@lucent.com

  http://www.seacoast.com/~chaski/LAA

- Massachusetts Department of Environmental Management (DEM)
  (Provided grant for this project)
  Steve Asen
  617/727-3180

- Town of Newton, NH
  Steven Cushing - Selectman

- USDA Natural Resource Conservation Service (NRCS)
  319 Littleton Road
  Suite 205
  Westford 01886

  Dan Lenthall (Westford) 978/692-1904, fax 392-1305
  Ron Thompson (in another division) 508/829-6628

- Jason Sargent
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  Merrimac MA 01860

- USDA Cooperative Extension Service at UMass Amherst
  Martin Vanderkamp
  413/545 5731
  (compost expert)

- Nicol Farm
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  Newton NH 03858

2. Others

- Merrimac Power & Light
  Linda Soucy
  978/346-8311

- Department of Environmental Protection
  Northeast Regional Office (NERO)
  Wilmington, MA
  978/661-7600

  DEP Main INFO Line 800/462-0444

- Massachusetts Department of Food and Agriculture (DFA)
  Brad Mitchell
  617/727-3018

- New Hampshire Department of Environmental Services (DES)
  Steve Landry
  re: alum treatments in NH ponds
  603/271-2969

- Eight Towns & A Bay
  Vicky Boundy
  978/374-0519
  vboundy@aol.com
  re: regional watershed projects, funding sources, grant application assistance

- Massachusetts EOEA Watershed Initiative
  Merrimack River Basin Team
  William Dunn - EOEA Team Leader
  508/767-2799

3. Relevant Web Sites

- EPA Clean Lakes Program
  http://www.epa.gov./OWOW/lakes/lakes.html
  includes publications list and links to oganizations

- Farm*A*Syst
  Farm*A*Syst includes self-assessments leading to voluntary actions to prevent pollution... designed for individual landowners to use.
  www.wisc.edu/farmasyst/

- Small Watershed Program Assessment and Inventory Reports, NRCS (Located under Watershed and River Basin Planning and Installation Public Law 83-566 PL566)
  may include special funding source for local organizations and states to plan and install watershed-based probjects on private lands.
  http://www.ftw.nrcs.usda.gov/pl566/pl566.html

- State of the Land, NRCS
  http://www/nhq.nrcs.usda.gov/land

Appendix C

Barrier and Filter Curtain Information

Barrier Curtain

The only known barrier curtain in the area is installed at Wachusett Reservoir. The project manager is Vincent Vignaly at Metropolitan District Commission, Division of Watershed Management (508) 792-7423. The engineering consultant is ENSR.

Filter Curtain

Gunderboom Inc. has developed a curtain fabric for use in blocking pollutant transport in aquatic situations. Gunderboom has approximately a dozen installations at swimming beaches. The cost of the filter fabric is approximately $100 per linear foot, for 5 to 10 feet deep. The fabric is estimated to have a useful life of about 5 years.

Manufacturers' information is attached. The manufacturer's representative is:

Eco-Boom Marine Control
31 Cedar Lane N
Glen Head NY 11545
Attn. Raymond Bauer
(516) 384-3711

Other parties that have information or experience include Bill Clark at The Massachusetts Bays Program, 617/451-2770. Also, a filter curtain was proposed in Barrett Pond in Leominster; it is not known if it was installed.

NARRATIVE DESCRIPTION OF THE SYSTEM.

The *GUNDERBOOM* is a full water depth curtain of special material that is suspended from flotation billets on the surface of the water. The boom is secured to the bottom of the lake, river or ocean water bed floor in a variety of different ways. This depends on the application and the physical characteristics of the bottom material. The boom material itself is the unique aspect of the boom. The material allows relatively large volumes of water to pass through 5 to 40 GPM per square foot yet will "filter" out particulates above 30-100 microns. This is accomplished while maintaining a high strength factor, which is normally important due to the tidal or current loads placed on the boom. The boom material also is UV resistant and non bio-fouling, both important aspects to any in water installation.

PRINCIPAL USES OF THE GUNDERBOOM

1) GU*NDERBOOM* - SDCS Stormwater Discharges Control System
Up to 15,000,000 Gallons Per Day (GPD). Best management practice (BMP) to meet NPDES Permit Regulations.

This adaptation of the boom has proven quite successful and was the focus of a Study Grant recently awarded by the U.S. EPA to *Ecoboom* the company which undertook this project on Long Island, New York. The nature of the material provides for a filtering of stormwater discharges, with the removal of particulate material and containment of floating debris, trash and - potentially - petroleum contamination. The boom system encircles the outfall in a size and configuration that allows adequate flow capabilities to accommodate the anticipated maximum flow. Testing to date shows the control of fecal coliform. Studies by Nassau* and Mamaroneck** Health Departments conclude that; we are stopping particulates the coliform "ride" on.

*Sea Cliff Beach Study 1990
**Mamaroneck Beach Study 1993

GUNDERBOOM - BPS Beach Protection System

2) The first boom system used for Bathing Beach Protection was developed at the Sea Cliff Community Bathing Beach in New York during the summer of 1990. This was one of the collateral benefit installations that was experienced with and proved to be remarkably successful. Many of the beaches on Long Island have been closed during the summer season due to high bacteria counts from sewage discharge and floating debris in the form of hospital waste. The *GUNDERBOOM*, in a configuration suitable for a beach application, was installed to provide a 100 meter by 50 meter swimming area. The boom was completely successful in eliminating floating debris, provided swimming water that was noticeably clearer than the outside

water and, again, as a collateral benefit, reduced the fecal coliform bacteria count dramatically. As part of the project, Nassau County Health Department conducted numerous tests during the summer and concluded that the water inside the boom has levels of bacteria that were within the range safe for bathing, while the bacteria levels outside and at the surrounding beaches were high enough to require closure. The boom added additional protection in the form of a safety barrier, keeping out watercraft and, of course, excluded jelly fish and other potentially hazardous or aggressive fish.

3) To protect shellfish, shrimp farms, marine habitats etc., from particulate pollution and from bacteria that "ride" on particulates. Gunderboom *(PCS) Particulate Control System* is fabricated from durable, high strength materials which have been tested and proven to inhibit biological organism growth and resist deterioration from ultraviolet radiation. The components of the boom consist of a main body which is fabricated using a special and proprietary combination of polyester & polypropylene materials; a floatation system that maintains the boom in a vertical position in the water column, providing "freeboard" to prevent floating materials from overtopping the boom; a ballast system to provide a secure bond to the seafloor/basin or river bottom, also assisting in the maintenance of a vertical position; and, an anchoring system which is used to hold the Gunderboom in a secure position.

The Gunderboom *(PCS) Particulate Control System* is site specific and, therefore, the detailed specifications are not developed until that information is acquired. The detailed specifications will include:

1) Size & Type of Floatation

2) Main Body Fabric Density & Flow Rate Characteristics

3) Boom Depth

4) Boom Length

5) Boom Ballast Chain

6) Anchoring System

7) Installation & Handling Specifications

The Gunderboom *(PCS) Particulate Control System* will prevent the passage of particles greater than 30 micron in size under normal conditions and will typically be self cleaning when placed in a tidal environment.

The Gunderboom *(PCS) Particulate Control System* is an in-water barrier which excludes or contains floating and suspended particulate matter by deflection and filtration. The product, when installed will create a long term full water column wall which allows water to pass from one side to the other. The typical boom consist of three main components:

1) The Floatation System

2) The Body Curtain

3) The Anchoring System

The product is versatile and has many uses. It has been proven to filter and deflect organisms as small as bacteria, particulates as minute as suspended silts and all petroleum products. The effectiveness of excluding or containing organisms and material can be 100% under certain conditions.

The Gunderboom *(PCS) Particulate Control System* is designed and fabricated for each project and application to meet criteria developed from the technicians' field surveys and site evaluation. These site specific Gunderbooms are unique and represent 10 years of product development in a wide range of climates and applications.

The parameters of consideration for the Gunderboom *(PCS) Particulate Control System* are:

1) Anticipated Water Flow

2) Water Depth & Bottom Contour

3) Type & Density of Particulate

4) Exposure to Elements (Wind, Wave, Current)

5) Site Restrictions as to Length, Access, Navigation

6) Anchor & Securing Considerations

GUNDERBOOM (MLES) MARINE LIFE EXCLUSION SYSTEM

4) The Gunderboom (MLES) is being tested at Orange & Rockland Utilities (ORU) Lovett Generating Station. This is a Court ordered test to settle a lawsuit brought on by Hudson Riverkeepers. By stipulation, ORU must use the "Gunderboom" for two years and achieve BTA to prevent the impingement and entraiment of fish. The regulatory agencies are prepared to declare the Gunderboom Best Technology Available (BTA) for the preservation of marine life (see

316 b draft of the Clean Water Act-CWA- Attached).

The CWA 316 b states that all US power plants must use BTA to protect marine life from impingement and entraiment. Once the MLES becomes BTA at ORU, other power plants will follow.

The MLES is a filter wall, placed in front of cooling water intakes (CWI's). Water passes through the filter wall, while fish and larvae are deflected.

5) Oil Control Boom (OCB)

Used during the Exxon Valdez Oil Spill. The Gunderboom was used successfully to protect marine habitats.

Should be placed on oil tankers at three times their length as an "oil spill ~~prevention~~ Response plan." (Will reduce insurance rates).

Contact persons: Raymond A. Bauer
Principal
(516) 384-3711

Hal Dreyer
Principal
(907) 349-7008

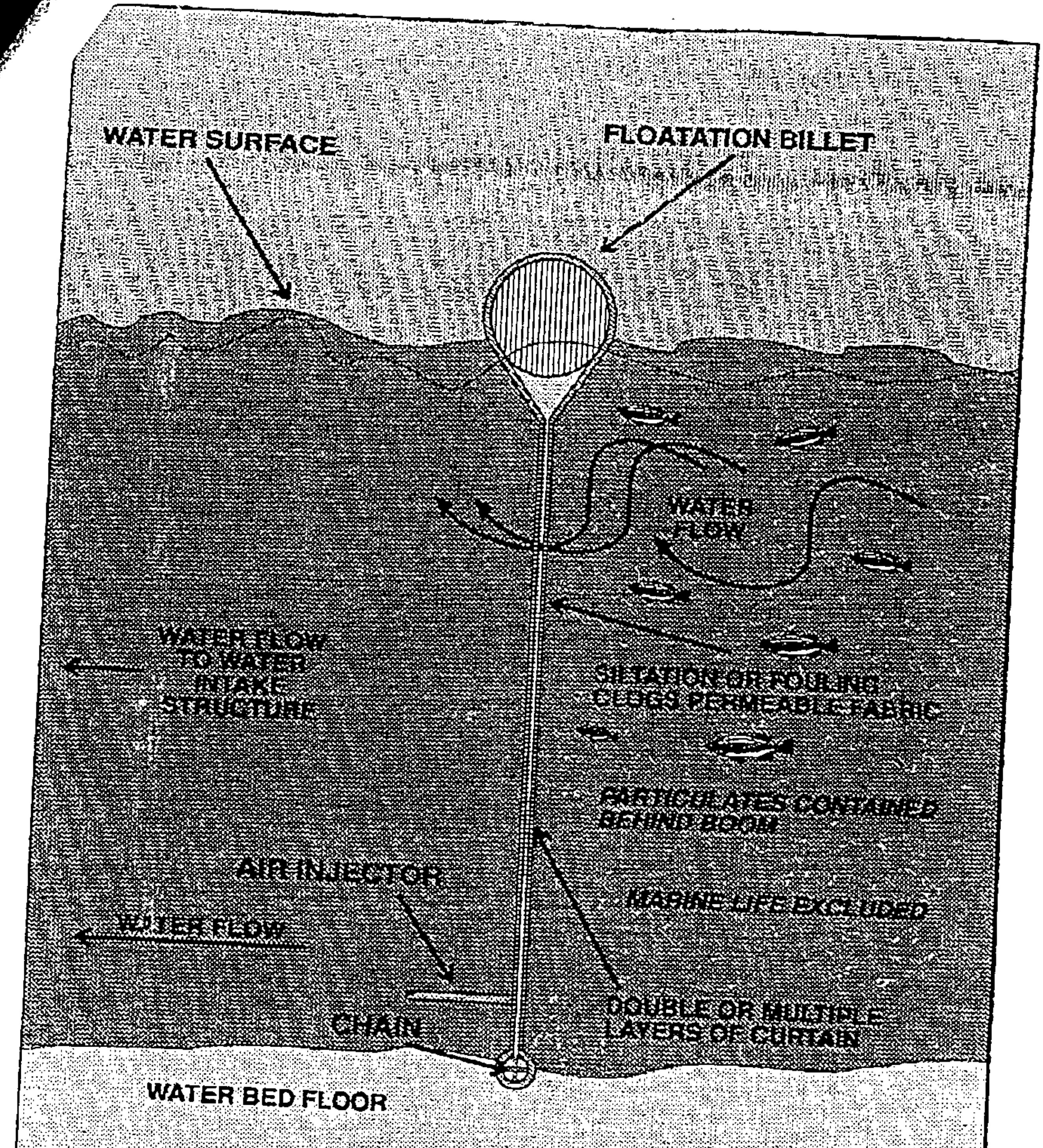
EXHIBIT 14

Goal: *Further illustration of the GPS for containment or exclusion of marine life, or suspended solids.*

Results: *At a bathing beach, marine life, fine solids and suspended particulates are kept out by the GPS. At beaches, most debris enters the water ways via storm water. After a storm, on an incoming tide, all water entering the bathing beach area is filtered, keeping out the pollution.*

On an outgoing tide, floatables, fine solids and suspended particulates on the GPS are flushed off. The result: in tidal situations the GPS is self cleaning and the optional bubbler is unnecessary.

Section of floating boom.



SECTION FLOATING CONTAINMENT BOOM

MULTIPLE LAYER CURTAIN: AIR BUBBLER FOR REMOVAL OF SILT OR OTHER FOULING FROM CURTAIN BY INJECTION OF AIR INTO SPACE BETWEEN LAYERS OF CURTAIN. RISING/EXPANDING AIR CREATES MOVEMENT OF THE FABRIC WHICH SHAKES LOOSE MATERIAL AND AIR BUBBLES PASS THROUGH THE PERMEABLE CURTAIN DISPLACING PARTICLES WHICH CLOG THE PORES IN THE CURTAIN FABRIC.

NOT TO SCALE

RAY BAUER
JULY 96

EXHIBIT 17

TYPE BOOM: BATHING BEACH POLLUTION
BARRIER SCREEN

Goal: *To use a GPS to keep a bathing beach free from pollution, situated on a 20 acre pond near farms.*

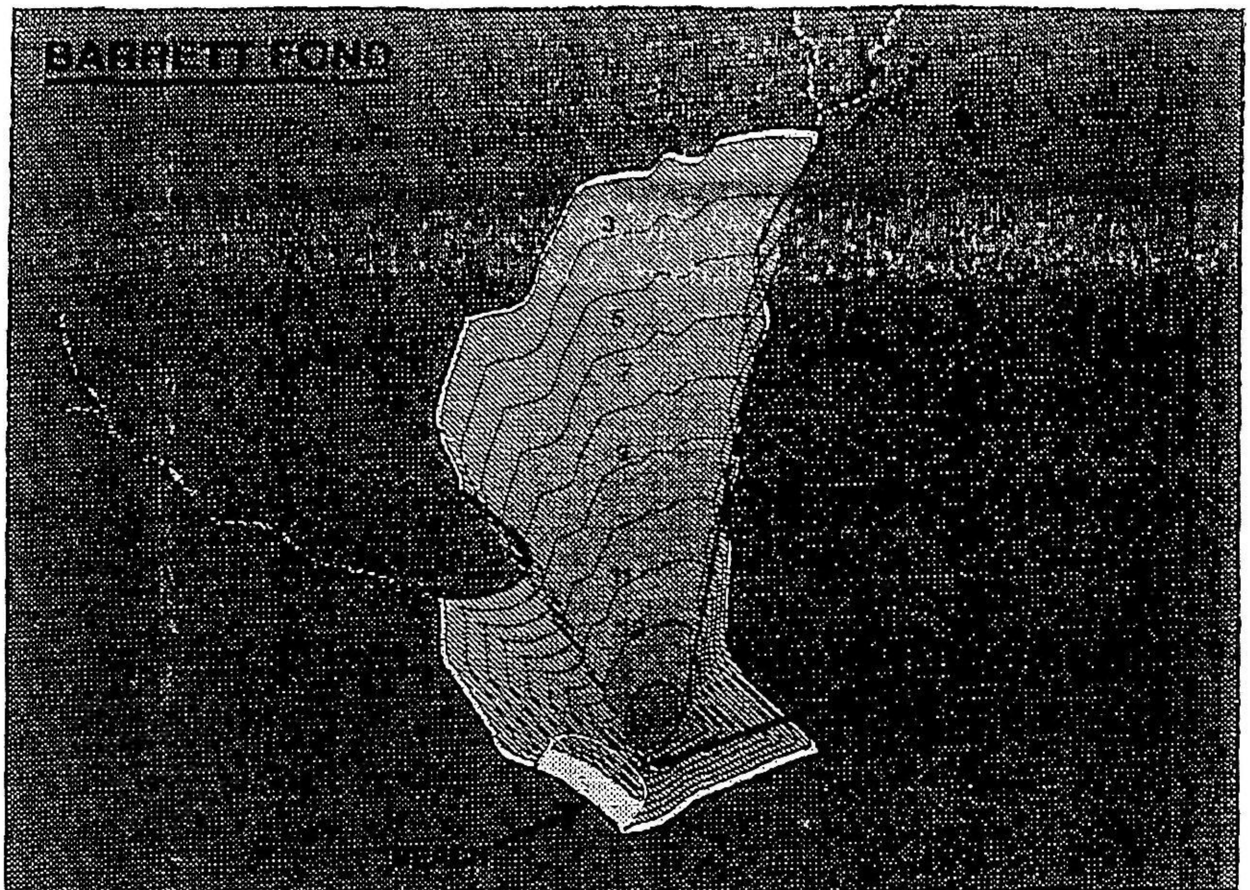
Results: *The town is also seeking grant money for this installation.*

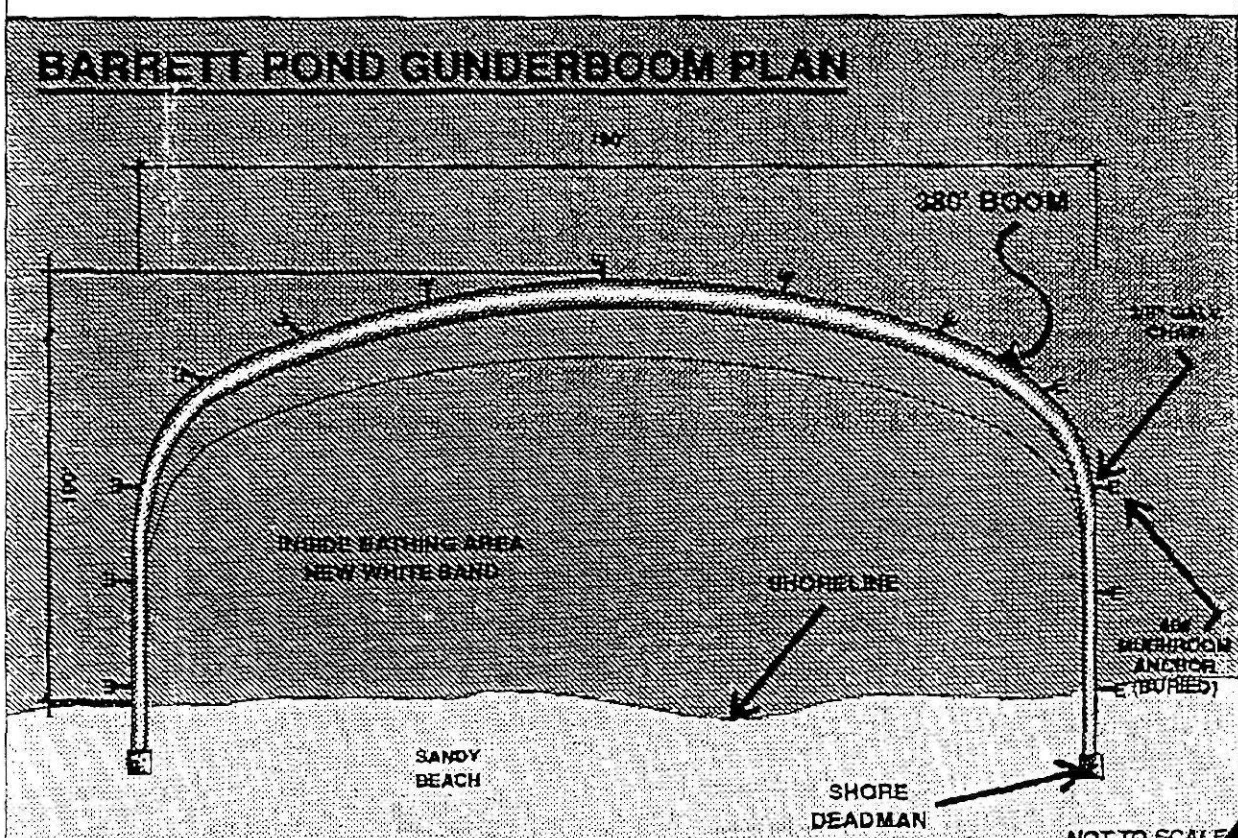
Graphics for Barrett Pond GPS, Leanmister, Massachusetts

Here the source of pollution are farms on the streams feeding the pond. When it rains, farm run off enters the streams polluting the pond.

We were called by the Town to save their endangered bathing beach. This plan will work as most farm pollutants travel as floatables, fine solids, and suspended particulates. These pollutants will be kept out of the bathing area with the GPS.

We also proposed cleaning up the entire pond by Gunderbooming in the polluting two streams. Here the GPS would keep the pollution in, to be rendered harmless over time through biodegration.





GUNDERBOOM PARTICULATE EXCLUSION SYSTEM