

**MARTINS POND ASSESSMENT STUDY
FINAL REPORT**

Submitted to

**THE DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
THE TOWN OF NORTH READING
and
THE MARTINS POND ASSOCIATION**



**by
MERRIMACK COLLEGE
and
MALCOLM PIRNIE ENGINEERS**

This Project was made possible in part by a grant from the Lake and Pond Grant Program administered by the Massachusetts Department of Environmental Management.

January 2003

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PREFACE

Martins Pond is a 92-acre pond in the Town of North Reading, Massachusetts with a primary inlet, the Skug River, and a primary outlet, Martins Brook. In the fall of 1992, a group of local citizens formed the Martins Pond Association (MPA). The association formed the following long-term goals:

1. Protect the delicate environmental balance of Martins Pond through careful, long term management and education.
2. Establish the MPA as a politically and economically viable group.
3. Enhance the recreational and social value of Martins Pond and its facilities.

The association has been involved in many education and pond enhancing activities to increase the recreational and social value of the pond. In addition, the pond's swimming and playground area has been completely upgraded and in 1998 a "Turtle Trail" was completed which is a walking trail that describes the history of Martins Pond. The MPA received a match grant from the Massachusetts Department of Environmental Management (MDEM) to build the trail.

Unfortunately, despite the efforts of the MPA, the Pond has been experiencing problems with several different issues that are not only reducing recreational enjoyment, but also may be endangering the long term quality of the pond and its tributary area. These problems include the following:

- A lack of public swimming and boating activities due to fear of high bacterial counts in the pond.
- The appearance of high algae conditions in the pond.
- A concern about the increased population of invasive plant species in the pond and in the wetlands at the inlet and outlets to the pond.
- The raising of the pond water surface elevation during low rainfall periods.
- Flooding of the pond, homes and septic systems during large rain events.

In December of 2001, the Town requested assistance from Malcolm Pirnie Engineers for the submittal of a Department of Environmental Management (DEM) Lake and Pond Grant application. The Lake and Pond Grant was sought to perform several assessments of the pond including water quality, aquatic plants, sediments, and fish population. Also, an assessment of surrounding wetlands was proposed including vegetation, soil, bird species and a pilot study for the release of the *Galerucella sp.* beetle to control an invasive plant species, purple loosestrife. Finally, an assessment of the hydraulic conditions of the pond, including the Skug River and Martins Brook was proposed. In April 2002, North Reading was awarded the Lake and Pond Grant from DEM.

In the fall of 2001 a partnership was formed between the Martins Pond Association and the Environmental Science Program at Merrimack College to assist with biological control of purple loosestrife. Once the DEM Lake and Pond Grant was approved, Merrimack College offered to assist with the grant assessment work and a project team was formed to complete the grant scope of work. The team included the Town of North Reading, the Martins Pond Association, Merrimack College and Malcolm Pirnie Engineers.

This report describes the results of the Martins Pond DEM Lakes and Pond Grant assessment. Recommendations are provided for each section of the report and describe how the Town of North Reading and the MPA should proceed to continue the progress made in this study. Merrimack College has agreed to continue their environmental analysis of the pond through the year 2004 as part of their partnership with the Town and the MPA. Also, given that Martins Pond and Martins Brook are the only waters in North Reading listed on the state's 303(d) list of impaired waters, these water bodies should be

a priority for pollution reduction as part of the Town's Storm Water Program. Since these water bodies are also identified as major areas of concern in the Town's Flood Hazard Mitigation Plan, continued investigation of the Martins Brook watershed area for potential flood reduction and mitigation should also be a priority for the Town's Storm Water Program.

1.0 The Martins Pond - Merrimack College Partnership

Working Together to Investigate Our Local Environment



1.1 Overview

The Martins Pond / Merrimack College Partnership (MPMCP) began in the fall of 2001. It is a partnership between the Martins Pond Association, the Town of North Reading and the Environmental Science Program at Merrimack College. The Martins Pond Association (<http://www.martinspond.org/index.htm>) contacted Dr. Jon Lyon to see if Merrimack College would be interested in working with Martins Pond on the biological control of purple loosestrife (*Lythrum salicaria*). Dr. Lyon agreed and integrated Martins Pond into his *Environmental Management* course at Merrimack in the spring semester 2002. The class investigated several aspects of the ecology and water quality in Martins Pond, its surrounding wetlands and the Pond's watershed. The semester ended with a presentation of their results at the North Reading Town Hall in April 2002. The results presentation was also carried on the local cable access channel.

The MPMCP continued through the summer and fall of 2002 and is planned to continue through 2004. From the perspective of Merrimack College, the primary objectives of the partnership are:

- To conduct thorough environmental analyses of Martins Pond and the Martins Pond Watershed;
- To link research with the management goals outlined by the Martins Pond Association, the Town of North Reading and state regulatory agencies;
- To integrate Merrimack College students into the entire process, including data collection and analysis, working with the Association, coordinating with environmental consultants working with Martins Pond, proposing management solutions and working with local and state regulatory agencies.

This report is the final summary report for Merrimack College's involvement in watershed, wetland and pond assessments as they relate to the 2002 DEM Lakes and Ponds Program Grant for Martins Pond in North Reading, MA. The summary provided by Dr. Jon Lyon, is based on work conducted based on the grant cycle ending 31 December 2002.

Contributions to the report were made by several individuals including Stephanie Ackroyd (Water Quality Assessment), Mike Rock (Wetland Assessment and Beetle Release), Tracy Eastman (Pond Assessment) and Dr. Larry Kelts (Bird and Fish Surveys). Christina Han also assisted on the total phosphorus analysis and interpretation. The report also benefited from the comments of several reviewers including Stephanie Ackroyd, Chuck Hardesty and L. Soucie.

Summary of Recommendations

Loosestrife and Wetland Assessment Recommendations

- Develop a program to monitor purple loosestrife in the Martins Brook wetland for the next 2-3 years to assess changes in purple loosestrife density, cover, biomass and herbivory attributed to *Galerucella sp.* beetles.
- In addition, wetland vegetation assessments should continue to monitor changes in the abundance and frequency of native wetland species, to determine if their cover increased as purple loosestrife begins to diminish.
- Monitoring of *Galerucella sp.* beetle's herbivory patterns should be implemented to track the migration of the beetles to other areas of the wetland. Tracking the migration will also add valuable information for any subsequent releases that may occur.
- Immediate assessment of beetle populations in late spring 2003 at the onset of emergence from the dormant stage. This needs to be done to ensure that the previous population was able to produce a viable offspring which can continue the cycle in the fall of 2003.
- A second release may be necessary to supplement the existing population and to ensure the existence of a healthy population of beetles in the wetland.
- Patience is needed; the beetles need time to do their job. It should be noted that noticeable results may not be seen for several years. Project leaders must remain focused on controlling purple loosestrife and determined to guide the project to its end. Purple loosestrife first has to be stopped from spreading before it can be controlled.

Martins Pond Assessment Recommendations

- Re-sample the macrophyte vegetation in 2003 to assess any temporal changes in macrophyte distribution and abundance.
- Any exotic plant control measures should be conducted on a pilot-study basis rather than pond-wide. Any plant control measures should be conducted on a small-scale to ensure the results of control measures, both intended and unintended, match management goals.
- High turbidity is currently limiting the extent of aquatic plant growth. Efforts to reduce any of the components of turbidity (tannins, algal biomass, total suspended solids) could increase light penetration and result in dramatic increases in the extent of aquatic plant (macrophyte) growth in the littoral zone. Smaller-scale, pilot-studies to reduce turbidity should be conducted and results used to guide pond-wide efforts. There are no quick fixes; all management actions have consequences that need to be monitored and assessed to ensure they match management goals.
- Additional detailed mapping of the ponds sediments, including sediment depths, are needed to address siltation and sedimentation rates in the pond.

Water Quality Recommendations

- Support and continue monitoring water quality (including total P) in Martins Pond and upstream along the Skug River through June 2003. A full year of water quality data is needed to assess seasonal changes in water quality in Martins Pond. Additional sampling sites upstream are also needed to identify the source(s) of high P levels in waters entering Martins Pond.
- Continue monitoring total and fecal coliform levels in Martins Pond and upstream along the Skug River until June 2003. A full year of coliform data is needed to assess seasonal changes in coliform in Martins Pond and the Skug River. Additional sampling sites upstream are also needed to identify the source(s) of high coliform levels in waters entering Martins Pond.
- Support combining water quality data with flow data to develop nutrient budgets for Martins Pond. This approach is needed to facilitate development of TMDL's for the pond. Financial support for this effort is needed to begin the process of addressing water quality concerns in Martins Pond and the Martins Pond watershed.
- Conduct a sediment study along Martins Brook from Martins Pond outlet past Route 62 to assess sediment composition and chemistry prior to any potential stream channel modifications.
- Develop a water quality monitoring network from members of the Martins Pond Association to track the newly installed water level gauges in and around Martins Pond, Skug River and Martins Brook.
- Link water quality monitoring with water quality efforts in the Ipswich River watershed. Understanding and addressing the linkages between the Martins Pond watershed, Martins Pond, Martins Brook and the Ipswich River is required, especially in the formation of TMDL's for Martins Pond.
- Swimming in Martins Pond is not advised – especially after rainfall events. Total and fecal coliform spike after rain events and residents around the pond should be fully aware of the potential health risks of swimming under these poor water conditions.

1.2 Introduction

The following is the final summary report for Merrimack College's involvement in watershed, wetland and pond assessments as they relate to the 2002 DEM Lakes and Ponds Program Grant for Martins Pond in North Reading, MA. The summary is based on work conducted based on the grant cycle ending 31 December 2002. This part of the report is divided into four sections:

- I. Biological Control of Purple Loosestrife (Section 1.3)
- II. Wetlands Assessment (Section 1.4)
- III. Martins Pond Assessment (Section 1.5)
- IV. Water Quality Assessment (Section 1.6)

The main objectives, methods, results and recommendations for each section are described below.

1.3 Biological Control of Purple Loosestrife

Merrimack College worked with the *Martins Pond Association* and the *Association of Massachusetts Wetland Scientists* (AMWS) to develop a biocontrol program for purple loosestrife (*Lythrum salicaria*) consisting of propagation and release of the *Galerucella sp.* beetles and long term field monitoring of the beetles at three release sites. Purple loosestrife is an aggressive invader of North American wetlands, lakes and rivers, often affecting the biodiversity of an area. Loosestrife displaces native plants, eliminating food and shelter for wildlife and other species. Martins Pond has been permitted as a release site for the beetles.

Merrimack College reared *Galerucella sp.* beetles in their greenhouse in Mendel Hall. The beetles were released in June 2002 (see Figure 1 for release site locations). The following work was conducted for the loosestrife project:

- Merrimack College propagated *Galerucella sp.* beetles until their release in June
- Merrimack College initiated a loosestrife monitoring program to assess the level of impact of the beetles in the first (and subsequent) years of their release
- Merrimack College established permanent transects at three (3) beetle release sites along Martins Brook and 33-1 m² sampling quadrats were used to assess loosestrife density, *Galerucella sp.* damage and overall vegetation composition (see photograph below)

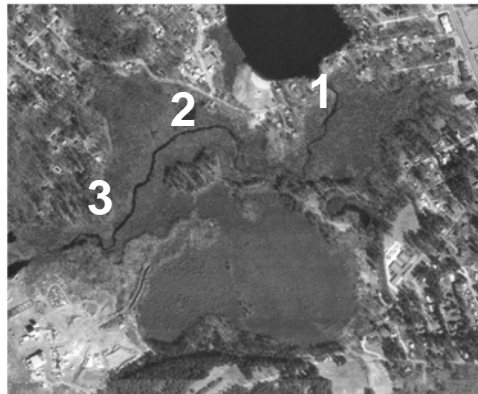


Figure 1. Aerial photograph (orthophotograph) of southern Martins Pond and Martins Brook showing the three beetle release sites.

Loosestrife Results - The average purple loosestrife biomass values for release sites 1, 2, and 3 were 1075.9, 526.0, and 1075.7 g/m² respectively. Purple loosestrife herbivory (damage by beetle feeding) results showed that herbivory was minimal with mean herbivory ranging from 0.1 to 2.1%. Herbivory was centralized near the immediate release sites and decreased further along the transect lines. Around the central release sites, up to 10% of the plants surveyed showed evidence of beetle herbivory. Table 1 summarizes some of the main purple loosestrife characteristics in the Martins Brook wetlands.

Table 1. Summary of purple loosestrife information on the three beetle release sites.

Release Site	Tallest Stem Heights (m)	Number of Flower Spikes per Stem	Percent Herbivory	Biomass (g/m ²)
1	1.92	20.6	2.1	1075.9
2	2.02	27.9	0.3	526.0
3	2.54	19.7	0.1	1075.7

Based on sampling on 33 plots at the 3 release sites, purple loosestrife was found on 89.9% of all plots (relative frequency) and had a mean plot cover value of 29.1%. These values, when compared to the entire wetland species survey, indicate that purple loosestrife has become the most dominant species within the wetland area along Martins Brook. The biomass assay indicates that purple loosestrife is abundant within the wetland. A list of plant species found in the wetland assessment is given in Table 2.

1.4 **Wetlands Assessment** (with contributions from Mike Rock)

Overview

A multi-faceted approach was used to assess the wetland area immediately south of Martins Pond along Martins Brook. This assessment, in part, overlapped with the vegetation assessments described in the loosestrife project (Section 1.3.). The wetland assessment focused on assessing and quantifying wetland vegetation and soils.

Wetland Vegetation and Soils Assessment – A series of three (3) transects were established for both quantifying and monitoring wetland vegetation at the three beetle release sites. Three central reference points were selected along Martins Brook south of Martins Pond (corresponding to the *Galerucella sp.* beetle release sites). From these central points, three transects were established oriented North, South, East, and West. Along each transect, 1 m²-square quadrats were established at 15 m intervals. Within each 1 m² quadrat, every plant species was identified and its percent cover was visually estimated using the Braun-Blanquet method. Soil samples were taken in each plot, using a soil corer. Sample plots were located entirely within the wetland and ceased at the edge of any woody or upland vegetation. Soil samples were analyzed for % organic matter at Merrimack College. Other soil analyses were conducted at the Plant and Soil Analysis Laboratory at UMass-Amherst. The soil results are summarized in Appendix A.

Results

Table 2 summarizes the plant species found in the assessment as well as their mean cover values per plot and their relative frequencies. Purple loosestrife was clearly the dominant plant species in the wetland. Overall, 34 species were found on the 33 plots. There is a pattern of many less abundant species. Thirteen of the 34 species were found only on a single plot.

Table 2. A summary of plant species found in vegetation sampling of the three beetle release sites along Martins Brook. Mean cover values (range from 0-100%) and relative frequency (percentage of plots where each species was found) are shown. Sampling is based on 33, 1m² sample plots.

Latin Name	Common Name	Mean Cover Value	Relative Frequency
<i>Lythrum salicaria</i>	Purple loosestrife	29.12	89.9
<i>Pontederia cordata</i>	Pickeral weed	3.53	30.3
<i>Clethra alnifolia</i>	White alder	2.15	6.1
<i>Rosa multiflora</i>	Multi-flowered rose	1.96	30.3
<i>Lemna sp</i>	Duckweed	1.89	30.3
<i>Acer rubrum</i>	Red maple	1.86	15.2
<i>Myrica gale</i>	Sweet gale	1.82	6.1
<i>Unknown grass</i>	Grass	1.59	15.2
<i>Salix sp</i>	Willow	1.30	12.1
<i>Cephalanthus occidentalis</i>	Buttonbush	0.91	3.0
<i>Nyssa sylvatica</i>	Sour gum	0.61	3.0
<i>Viburnum dentatum</i>	Viburnum	0.61	3.0
<i>Dryopteris sp.</i>	Fern	0.61	3.0
<i>Rorippa palustris</i>	Swamp mustard	0.33	6.1
<i>Lindera benzoin</i>	Spicebush	0.32	6.1
<i>Alnus rugosa</i>	Speckled alder	0.30	3.0
<i>Onoclea sensibilis</i>	Sensitive fern	0.30	3.0
<i>Typha latifolia</i>	Cattail	0.18	18.2
<i>Scutellaria latifolia</i>	Mint	0.11	12.1
<i>Unknown 1</i>	Unknown	0.08	9.1
<i>Sphagnum sp.</i>	Moss	0.08	15.2
<i>Galium palustre</i>	Bedstraw	0.06	9.1
<i>Cardamine sp</i>	Bittercress	0.06	12.1
<i>Thelypteris simulata</i>	Massachusetts fern	0.06	6.1
<i>Cornus sp.</i>	Dogwood	0.06	6.1
<i>Carex sp.</i>	Sedge	0.06	12.1
<i>Unknown 2</i>	Unknown	0.03	3.0
<i>Sagittaria brevirostra</i>	Arrowhead	0.03	3.0
<i>Peltandra virginica</i>	Arrow arum	0.03	3.0
<i>Mentha sp.</i>	Mint	0.03	6.1
<i>Rosa palustris</i>	Swamp rose	0.02	3.0
<i>Cornus sericea</i>	Red osier dogwood	0.02	3.0
<i>Unknown 3</i>	Unknown	0.02	3.0
<i>Bidens connata</i>	Beggar's ticks	0.02	3.0

Results from the vegetation assessment show that all species are not uniformly distributed throughout the wetland, as shown by the relative frequencies of the species identified. Purple loosestrife (*Lythrum salicaria*) had the highest relative frequency, present in 89.9% of the plots. The next highest relative frequencies belong to pickeral weed (*Pontederia cordata*), multi-flowered rose (*Rosa multiflora*), and duckweed (*Lemna sp.*) all appearing in 30.3% of the plots. Cattail (*Typha latifolia*) was next with a

relative frequency of 18.2%. The relative frequencies for other species were much lower and the remaining species only occurred in 1-4 plots throughout the entire study area.

Mean cover value illustrates the average area a species covers in a plot, percent cover was determined for every species in every plot. The mean cover values show that *Lythrum salicaria* dominates most of the area inside the plots with a mean cover value of 29.1%, almost 27 points higher than the next highest species (*Clethra alnifolia*, 2.2). All other species fell somewhere between 0.015 and 1.955%.

Bird Species Assessment – A series of viewing stations were established around Martins Pond. Merrimack teachers and students conducted periodic and regular bird counts from July to October 2002. A preliminary list of bird species found in the area is shown in Table 3.

Table 3. Bird species found around Martins Pond from July to October 2002.

Common name		
Baltimore oriole	Goldfinch	Rock dove
Bank swallow	Great blue heron	Rough-winged swallow
Barn swallow	Herring gull	Song sparrow
Belted kingfisher	House sparrow	Spotted sandpiper
Black-capped chickadee	Mallard duck	Starling
Blue jay	Mourning dove	Swamp sparrow
Canada goose	Northern mockingbird	Tree swallow
Cardinal	Osprey	White-breasted nuthatch
Cat bird	Purple grackle	White-throated sparrow
Cedar waxwing	Red-winged blackbird	Yellow warbler
Chimney swift	Ring-billed gull	
Eastern kingbird	Robin	

Loosestrife and Wetland Assessment Recommendations

- Develop a program to monitor purple loosestrife in the Martins Brook wetland for the next 2-3 years to assess changes in purple loosestrife density, cover, biomass and herbivory attributed to *Galerucella sp.* beetles.
- In addition, wetland vegetation assessments should continue to monitor changes in the abundance and frequency of native wetland species, to determine if their cover increased as purple loosestrife begins to diminish.
- Monitoring of *Galerucella sp.* beetle's herbivory patterns should be implemented to track the migration of the beetles to other areas of the wetland. Tracking the migration will also add valuable information for any subsequent releases that may occur.
- Immediate assessment of beetle populations in late spring 2003 at the onset of emergence from the dormant stage. This needs to be done to ensure that the previous population was able to produce a viable offspring which can continue the cycle in the fall of 2003.
- A second release may be necessary to supplement the existing population and to ensure the existence of a healthy population of beetles in the wetland.
- Patience is needed; the beetles need time to do their job. It should be noted that noticeable results may not be seen for several years. Project leaders must remain focused on controlling purple loosestrife and determined to guide the project to its end. Purple loosestrife first has to be stopped from spreading before it can be controlled.

1.5 Martins Pond Assessment (with contributions from Tracy Eastman)

Overview

There has been extensive research into the key biotic and abiotic factors that influence the composition and diversity of aquatic macrophyte communities in freshwater lakes and ponds (Barko and Smart 1986; Carpenter 1988; Engel and Nichols 1994; Scheffer 1998). In Massachusetts, high densities of aquatic macrophytes are typically limited to depths less than ten feet and to lakes and ponds where organic rich sediments are found (Mattson et al., 1998). Shallow eutrophic lakes and ponds are vulnerable to natural and human-induced changes both within the lakes and within their watersheds. In urban areas, these lakes face additional and often intense human pressures, including recreation, surface runoff, and progressive urbanization. This research project is focused on an intensive survey of aquatic macrophytes in a shallow, eutrophic pond. The research effort is divided into four interconnected lines of investigation; these are complementary components of a comprehensive effort to assess and characterize aquatic macrophyte communities in the pond:

- Assessment and characterization of plant species and plant community composition, structure and diversity
- Assessment and characterization of the influence of non-native macrophyte species on native macrophyte species and littoral communities
- Mapping and spatial analysis of macrophyte community composition and structure using a Geographical Information System (GIS)
- Mapping and spatial analysis of sediment characteristics using GIS

Martins Pond is classified as Class B water in the Commonwealth of Massachusetts. These waters are designated as a habitat for aquatic life, and for primary and secondary contact recreation. Martins Pond is currently suffering from several environmental insults and is listed as an impaired water body under section 303(d) of the Clean Water Act, in part, because of *noxious aquatic plants* and *exotic species*. Fanwort (*Cabomba caroliniana*) is one of the plants of most concern in the pond. Martins Pond is shallow with an average depth of approximately 1.1 m and a maximum depth of 2.8 m. Martins Pond is connected to several other ponds within the watershed by the Skug River, and is encircled by urban housing and development.

Methods

Vegetation sampling of native and non-native aquatic macrophytes was conducted using an extensive series of 33 transects that covered the entire pond. Transects were spaced at regular intervals and extended perpendicularly from the shoreline to the center of the lake and traversed the littoral zone (where aquatic macrophytes grow) into the limnetic zone (area without aquatic macrophytes). Sampling was done at plots located along transects at each 0.5 m depth class where applicable. To assess macrophyte composition and distribution, the rake sampling method of Deppe and Lathrop (1992; 1993) was used. Plants recovered from the rake were assigned an abundance rating ranging from 0 (not present) to 5 (very abundant). Pond-wide macrophyte composition sampling was done in July and August to correspond with peak biomass levels of macrophytes. A total of 161 sample plots were assessed along the 33 transects. Each plot was recorded with a global positioning system (GPS) receiver and entered into ArcView Geographic Information System (GIS) software to map the plots as well as to analyze the overall distribution and abundance of macrophytes.

Results

A total of 131 out of the 161 sample plots had macrophytes present. A total of 22 macrophyte species were identified in the study. A summary of the species found and their total cover and relative frequency are shown in Table 4. Fanwort (*Cabomba caroliniana*) had the highest total cover in the pond and had the second highest relative frequency, indicating it was both abundant and widely dispersed. Fourteen of the 22 species (64%) had a total cover ≤ 8 and a relative frequency less than 8%. These results indicate a relatively high proportion of species with rare occurrence in the pond.

Table 4. A summary of the total cover and relative frequency for macrophyte species found in Martins Pond. This summary is based on results from 131 sample plots along 33 transects. Total cover refers to the sum of cover of each species (maximum value would be 655) and relative frequency refers to the percent of the 131 sample plots in which each of the macrophyte species was found.

Scientific Name	Common Name	Total Cover Value	Relative Frequency
<i>Eloдея nautili</i>	Eloдея	0.25	0.85
<i>Potamogeton amplifolius</i>	Big-leaf pondweed	0.25	0.85
<i>Stuckenia pectinatus</i>	Sago pondweed	0.25	0.85
<i>Typha sp</i>	Cattail	0.25	0.85
<i>Najas minor</i>	Slender naiad	0.50	0.85
<i>Lemna sp</i>	Duckweed	0.50	0.85
<i>Scirpus sp</i>	Bullrush	0.50	0.85
<i>Nuphar variegatua</i>	Yellow water lily	2.50	2.545
<i>Pontederia cordata</i>	Pickeral weed	3.50	6.78
<i>Potamogeton epihydrus</i>	Ribbonleaf pondweed	3.75	4.24
<i>Utricularia purpurea</i>	Purple bladderwort	5.25	11.02
<i>Nitella</i>	Stonewort	5.25	9.32
<i>Utricularia vulgaris</i>	Common bladderwort	6.00	8.47
<i>Eloдея canadensis</i>	Eloдея	8.00	7.27
<i>Najas flexilis</i>	Slender water nymph	17.50	17.80
<i>Filamentous algae</i>	Algae	19.25	29.66
<i>Brasenia shreberi</i>	Water shield	21.25	19.49
<i>Utricularia intermedia</i>	Flatleaf bladderwort	25.00	27.97
<i>Ceratophyllum demersum</i>	Coontail	30.75	34.75
<i>Nymphaea odorata</i>	White water lily	46.75	27.12
<i>Moss (Musci)</i>	Water moss	61.50	60.17
<i>Cabomba caroliniana</i>	Fanwort	82.75	57.63

Distribution of Fanwort – To assess the distribution of fanwort (*Cabomba caroliniana*) in Martins Pond, both the distribution of fanwort with depth as well as patterns of spatial distribution across the pond. Were assessed. Figure 2 shows the distribution of fanwort with depth. Fanwort is found at virtually all depths throughout the littoral zone with a peak of abundance near 1.2 m. Fanwort abundance follows a somewhat normal, bell-shaped distribution with depth.

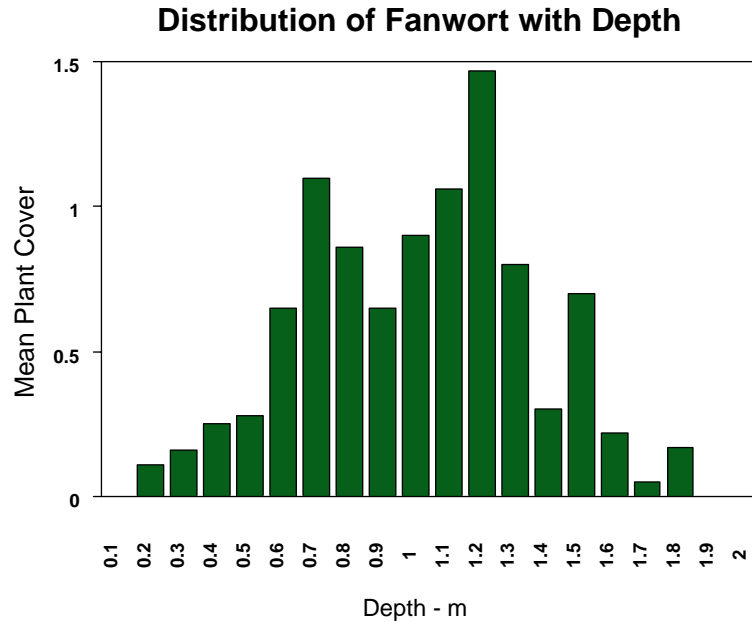


Figure 2. The above bar chart illustrates the distribution of fanwort (*Cabomba caroliniana*) with depth. The figure is based on sampling conducted on the 112 sample plots that had fanwort (out of 161 total plots). The distribution of fanwort is somewhat normally distributed and exhibited the highest cover at 1.2 m. This pattern illustrates the extent that fanwort has occupied the littoral zone. There was no fanwort found in the white region in the middle of the pond (limnetic zone)

In addition to distribution with depth, we also analyzed the spatial distribution of fanwort using the Spatial Analyst feature of ArcView. The results of that analysis are shown in Figure 3. It is apparent that fanwort is distributed throughout the littoral zone in Martins Pond with higher densities in the northern end of the pond.

Figure 3. Distribution of fanwort (*Cabomba caroliniana*) in Martins Pond. Darker areas represent zones of higher fanwort density.

An Ordination of Sampling Plots in Martins Pond - An ordination is a multivariate technique that arranges plots (sampling sites) along axes on the basis species presence and abundance. Figure 4 below is a 2-D summary constructed using *Detrended Correspondence Analysis* (DCA)*. The DCA plot is based on species abundance in sampling plots and is used to assess dominant patterns of variation in macrophyte community composition. Each point (triangle) on Figure 4 represents a sampling plot in Martins Pond. Analysis of the ordination indicates no strong separation or grouping between plots. This pattern may indicate the lack of any distinct macrophyte community types within the pond. These preliminary results indicate that macrophyte species may be acting more individually in the pond.

* DCA was run using PC-ORD (McCune and Mefford 1995).

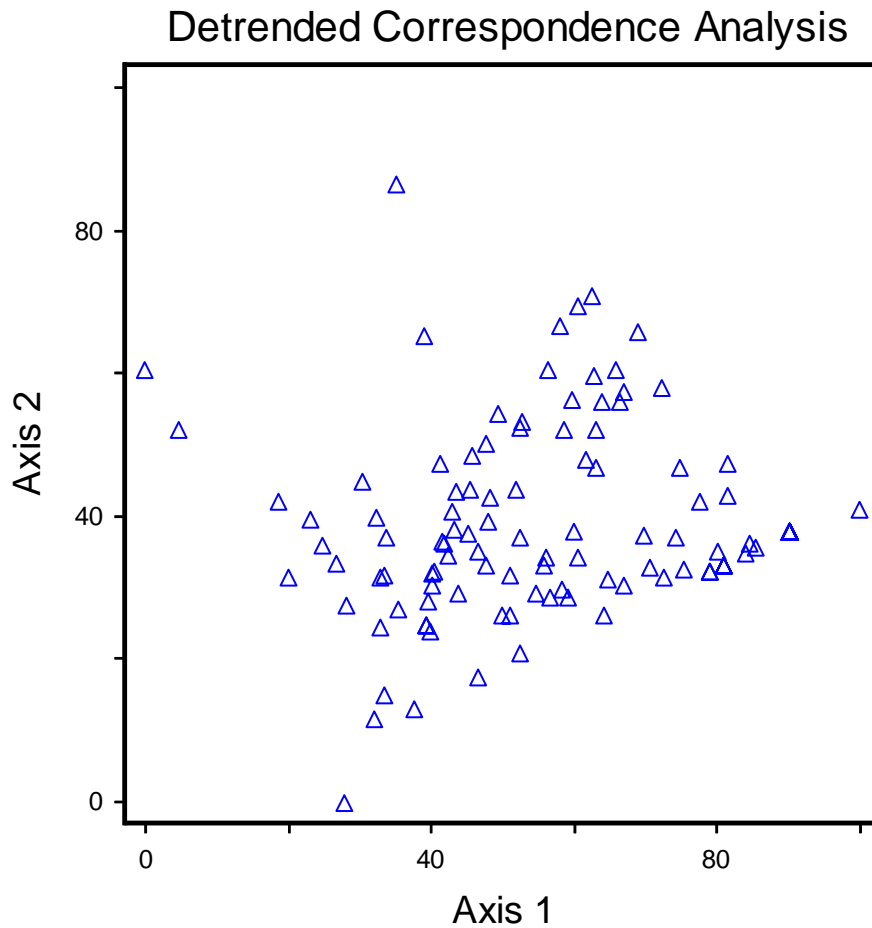


Figure 4. An ordination (DCA) of macrophyte sample plots on Martins Pond. No distinct macrophyte communities are evident, indicating a gradual transition between macrophyte associations in the pond. Each triangle represents a single sample plot (161 sample plots are shown).

Sediments - The nature of bottom sediments can influence both the turbidity of water through re-suspension of sediments as well as the growth of submerged macrophytes. The composition of macrophyte communities and the spatial distribution of individual species have been correlated to the sediment organic matter (OM) content (Macan 1977; Barko and Smart 1983). To understand how bottom sediments vary within Martins Pond, a total of 21 sediment samples were collected from sites around the pond. Samples consisted of approximately the upper 5 to 10 cm of surficial sediment. Sediments were transported under ice and stored at 4°C in sealed polypropylene containers. Sediment moisture and density were measured gravimetrically by drying known volumes at 110°C and then combusting them in a muffle furnace at 450°C to estimate the total organic matter (%OM) from loss of mass on ignition. The results of the sediment analysis are provided in Appendix B.

Table 5 below is a comparison of sediment characteristics found in the 1985 Martins Pond Diagnostic Feasibility Study and the 2002 sampling. Please note that the 1985 and 2002 results may not be entirely comparable due to differences in sediment analyses between the two studies.

Table 5. A comparison of sediment characteristics in Martins Pond.

Parameter	1985 sample mg/l	2002 mean mg/l	2002 sample range mg/l		
pH	6.3	5.5	5.0 - 6.1		
% Organic Matter		25.4	1.3 - 39.6		
Total P	222.0				
Extractable P		5	3.0 - 8.0		
Nitrate – N	42.2	8.9	7.0 – 13.0		
Ammonium – N	26.1	9.1	1.0 – 27.0		
Potassium		41.6	28 - 76		
Calcium		1088.8	261 - 1386		
Magnesium		92.0	28 - 137		
Aluminum		42.5	14 - 62		
Boron		0.3	0.1 – 0.5		
Manganese	190.0	42.4	9.9 – 270.0		
				RCS-1*	RCS-2*
Zinc	41.0	7.0	2.4 – 11.1	2500	2500
Copper	12.0	0.7	0.4 – 1.3		
Iron	8800	44.6	9.6 – 133.0		
Lead	< 4.0	33.3	1 - 59	300	600
Cadmium	< 0.3	0.2	0.0 – 0.3	30	80
Nickel	3.8	0.9	0.1 – 1.4	300	700
Chromium	6.4	0.2	0.0 – 0.3	1000	2500

*Based on DEP 310 CMR 40.0975(6)(a) and 310 CMR 40.0975(6)(b)

For the purpose of determining whether a notification obligation exists under 310 CMR 40.0315, measured concentrations of any oil or hazardous material listed at 310 CMR 40.1600 shall be compared to the Reportable Concentration value in the reporting category that best characterizes the current use of the site under evaluation, as described below:

Reporting Category RCS-1. Reporting category RCS-1 shall be applied to all soil samples obtained:

1. at or within 500 feet of a residential dwelling, a residentially-zoned property, school, playground, recreational area or park;
2. or within the geographic boundaries of a groundwater resource area categorized as RCGW-1 in 310 CMR 40.0362(1)(a).

Reporting Category RCS-2. Reporting category RCS-2 shall be applied to all soil samples that are not obtained from category RCS-1 areas.

Updated Water Depth Mapping – As part of the vegetation sampling, we used a GPS system to locate each sampling point and record water depth. Using spatial analysis techniques in ArcView GIS, we will be able to create an updated water depth map of Martins Pond. The 1985 water depth map is shown below in Figure 5. An updated water depth map will be available in spring 2003.

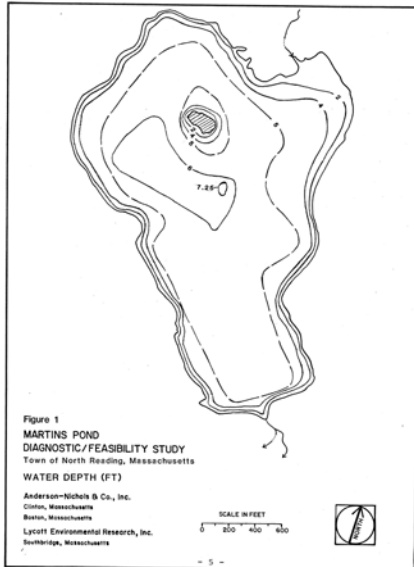


Figure 5. Bathymetry in Martins Pond in 1985 (from Martins Pond Diagnostic/Feasibility Study Report 1985).

Fish – We also assessed the fish populations within Martins Pond. A variety of techniques were used, including seining and rod-and-reel capture, to develop a fish species list for the pond. Table 6 below summarizes the fish species found and a comparison with the fish species identified in the 1985 Martins Pond Diagnostic/Feasibility Study.

Table 6. A summary of fish species found in Martin Pond in 2002 and 1985.

Common name	Scientific name	Found in 1985 Study
Yellow perch (YP)	<i>Perca flavescens</i>	X
Chain pickerel	<i>Esox americanus</i>	X
Brown bullhead	<i>Ictalurus nebulosa</i>	X
Largemouth bass (LMB)	<i>Micropterus salmoides</i>	X
Pumpkinseed	<i>Lepomis gibbosus</i>	X
Bluegill	<i>Lepomis macrochirus</i>	X
Golden shiners	<i>Notemignus crysoleucas</i>	X
Black crappie (BC)	<i>Pomoxis nigromaculatus</i>	
Swamp darter	<i>Etheostoma fusiforme</i>	

Note: According to the **Freshwater Fish Consumption Advisory List** put out by the Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, in June 2002, Martins Pond has a fish advisory for a mercury hazard. The following fish advisory advice has been given to persons who consume fish from Martins Pond.

P1 (LMB, BC, YP) - Children younger than 12 years, pregnant women, and nursing mothers should not eat any fish (in parenthesis) from this water body.

P3 (LMB, BC, YP) - The general public should limit consumption of affected fish species (in parenthesis) to two meals per month.

Martins Pond Assessment Recommendations

- Re-sample the macrophyte vegetation in 2003 to assess any temporal changes in macrophyte distribution and abundance.
- Any exotic plant control measures should be conducted on a pilot-study basis rather than pond-wide. Any plant control measures should be conducted on a small-scale to ensure the results of control measures, both intended and unintended, match management goals.
- High turbidity is currently limiting the extent of aquatic plant growth. Efforts to reduce any of the components of turbidity (tannins, algal biomass, total suspended solids) could increase light penetration and result in dramatic increases in the extent of aquatic plant (macrophyte) growth in the littoral zone. Smaller-scale, pilot-studies to reduce turbidity should be conducted and results used to guide pond-wide efforts. There are no quick fixes; all management actions have consequences that need to be monitored and assessed to ensure they match management goals.
- Additional detailed mapping of the ponds sediments, including sediment depths, are needed to address siltation and sedimentation rates in the pond.

1.6 Water Quality Assessment (with contributions from Stephanie Ackroyd)

Overview

Water clarity is a primary regulator of biological and ecological functions in aquatic systems. There are two major types of biotic effects resulting from the reduction of light penetrating the water column: decreased photosynthesis leading to reduced productivity in the system; and the impairment of organisms with visual ability (Davies-Colley and Smith, 2001). There are potentially several components that can contribute to turbidity in a freshwater system. These components include algae, suspended and re-suspended sediments and dissolved organic compounds. Figure 6 illustrates some of the major components of turbidity and feed-back relationships between components. This is the main model we have used to assess the components of turbidity in Martins Pond.

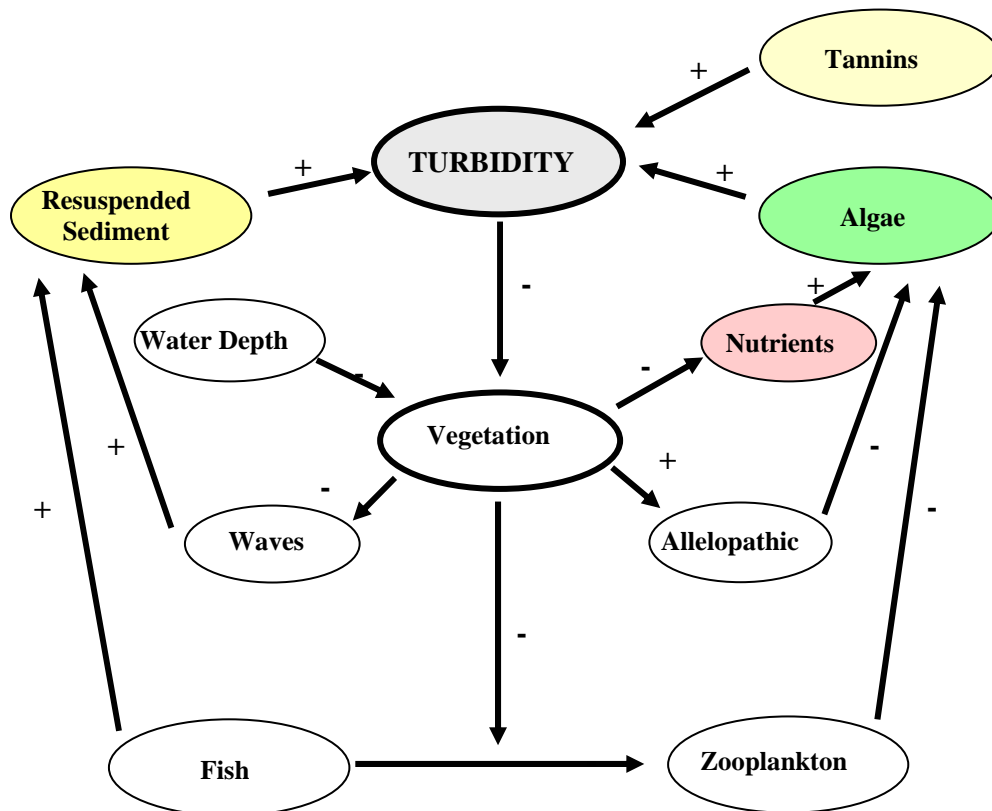


Figure 6. This is an illustration of the major components of turbidity in shallow, eutrophic pond systems (after Scheffer et al. 1993). The main feed-back loops are shown as either (+) or (-). The current study is focused primarily on the contributions of algae (chlorophyll-a), tannic acids and total suspended sediments. We have also been monitoring total phosphorus and total and fecal coliform levels. The parameters investigated in the current study are highlighted with gray backgrounds.

High turbidity also can severely impact human recreation and fishability of waters due to lack of visibility. Turbidity issues exist at the Martins Pond study site in North Reading, MA. High turbidity levels have lead to a swimming ban in the pond and Martins Pond is listed as an impaired water body under section 303(d) of the Clean Water Act because of high turbidity (as well as noxious aquatic plants, exotic species and metals). Martins Pond is located in a semi-urban watershed, is easily accessible, and provides an excellent opportunity to assess water quality. In the current study, we are trying to assess the components that are contributing to turbidity in Martins Pond both spatially and temporally.

Martins Pond (segment MA92038_2002) is within the Ipswich River watershed. The pond is classified a *Category 5 Water*. This means it is considered impaired or threatened for one or more uses and requires a TMDL. The pond was last assessed in April 1997. The pollutants requiring TMDL's are:

- Turbidity
- Metals
- Noxious Aquatic Plants
- Exotic Species

Methods

Standard Operating Procedures (SOP) and Quality Control Procedures were used in the water quality assessment and followed those provided by the *Massachusetts Water Watch Partnership* (MWWP). All persons involved in water quality assessments used the MWWP SOP's in the field and were trained in proper use of all water sampling equipment and in the calibration and maintenance of that equipment. All training was overseen by Dr. Jon Lyon. Several publications guided our water quality sampling including SOPs published by the MWWP, the *Massachusetts Volunteer Monitor's Guidebook to Quality Assurance Project Plans (2001)*, EPA's *Volunteer Monitor's Guide to Quality Assurance Project Plans (1996)* and *Surveying a Lake Watershed: Guidance for Community Volunteers in Massachusetts (2001)*.

A formal Quality Assurance Project Plan (QAPP) has not been completed for Martins Pond. However, SOPs were followed and all Merrimack College water sampling equipment was properly calibrated and the accuracy and precision of sample data were tested. The use of the *Environmental Analysis Laboratory* at Merrimack College provided a strong quantitative component to the sampling and analysis components of the study. The SOPs and equipment specifications used in the water quality sampling are provided in Appendix C.

Martins Pond is a shallow, 92-acre pond with a major inlet, the Skug River, and a major outlet, Martins Brook. We conducted periodic and regular water quality sampling at the inlet, outlet and at 3 locations within Martins Pond. The following parameters were assessed:

<u>Parameter</u>	<u>Sampling/Analysis Equipment Used</u>
• Chlorophyll a (algal biomass)	Hach DR4000 spectrophotometer
• Temperature	Thermometer
• Dissolved Oxygen	YSI 58 DO meter
• Biological Oxygen Demand	YSI 5905 BOD probe
• Turbidity	Hach 2100A turbidimeter, secchi disk
• Conductivity	SensION5 conductivity meter
• Total Suspended Solids	Filtration (GFC Filtration)
• pH	Corning pH meter
• Light penetration	LiCor LI-250 aquatic light meter
<i>The following parameters were analyzed at Severn Trent Laboratories in Westfield, MA.</i>	
• Total P	EPA Method 365.4
• Chloride	EPA Method 300
• Alkalinity	SM 2320 B

Total coliform and fecal coliform tests were conducted at the Town of Andover, MA, Department of Public Works, Water Treatment Plant (Massachusetts Laboratory Certification M-MA005).

Storm Event Sampling – We conducted two storm event samples on 9/25 to 9/26 and 10/15 to 10/17. Samples were collected from the Skug River at Route 28, inlet, boat ramp, pumping station, beach and outlet..

Sampling Locations – Are shown on the Figure 7 below.

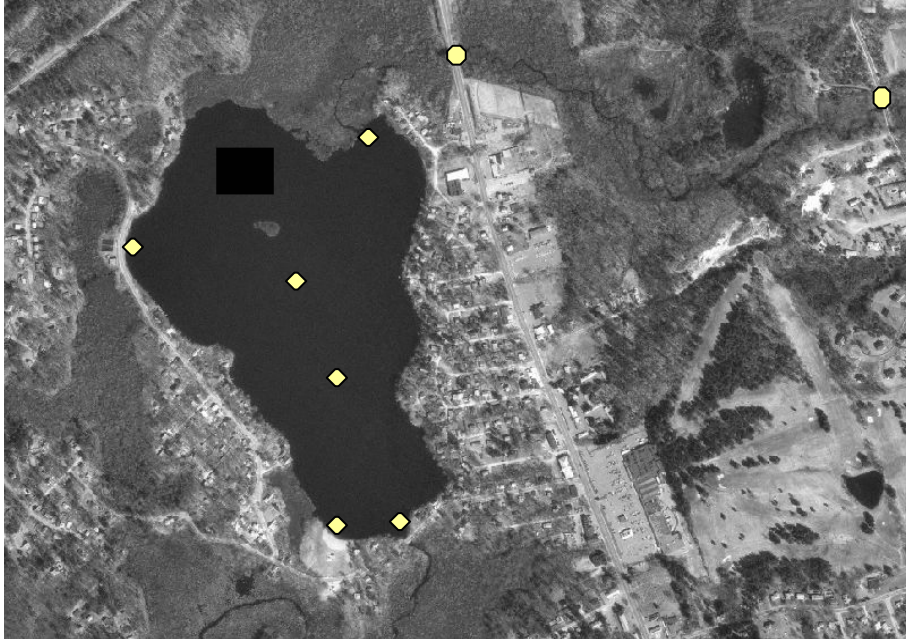


Figure 7. The major water quality sampling locations studied in Martins Pond and along the Skug River are shown. In some cases on some dates, more sampling locations were sampled.

Sampling Dates

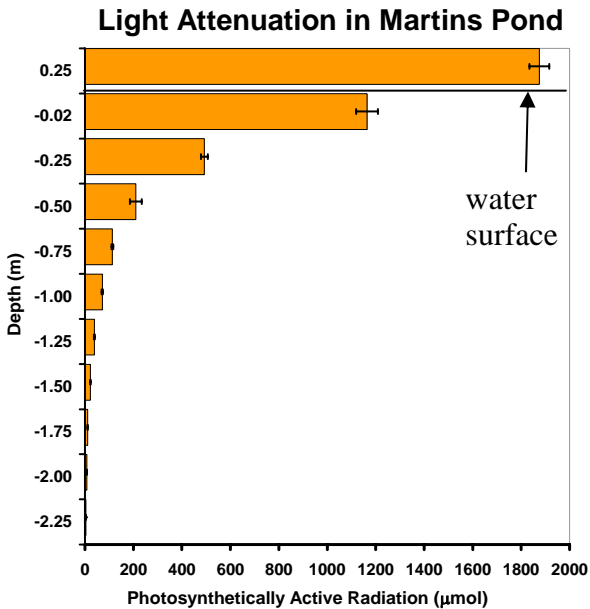
The following are the fourteen (14) dates* when water quality was monitored on Martins Pond:

- 30 May 2002
- 13 June 2002
- 27 June 2002
- 11 July 2002
- 23 July 2002
- 12 August 2002
- 29 August 2002
- 12 September 2002
- 26 September 2002
- 17 October 2002
- 31 October 2002
- 14 November 2002
- 5 December 2002
- 18 December 2002

*note: continued sampling is planned until 1 June 2003

Results

Figure 8 below shows light attenuation in Martins Pond on July 11, 2002. Light (photosynthetically active radiation) was measured at 0.25 m depth intervals.



The euphotic depth (the depth that light are below 1% of the surface light) of the pond is approximately 1.5 m. Solid orange bars represent means with standard errors. High turbidity has resulted in dramatic light attenuation profile. This corresponds to the secchi depth readings in the pond with at mean of 1.05 m (3.44 ft). Any secchi depths less than 4 ft (1.2 m) are considered problematic in Massachusetts lakes and ponds.

Figure 8. Light attenuation in Martins Pond.

Components of Turbidity

Figure 9 provides a summary figure showing the seasonal contributions of the three major components of turbidity: algal biomass; total suspended solids; and tannins. There appears to be a relatively constant 'background' level of total suspended solids (TSS) throughout the summer and fall. Tannins showed a steady decrease over the course of the summer and appear to be increasing again at the end of the year. Algal biomass exhibited more fluctuation, spiking in mid-July and again in late-August. Algal biomass levels indicate eutrophic conditions in the pond (Shaw et al. 2002).

Components of Turbidity

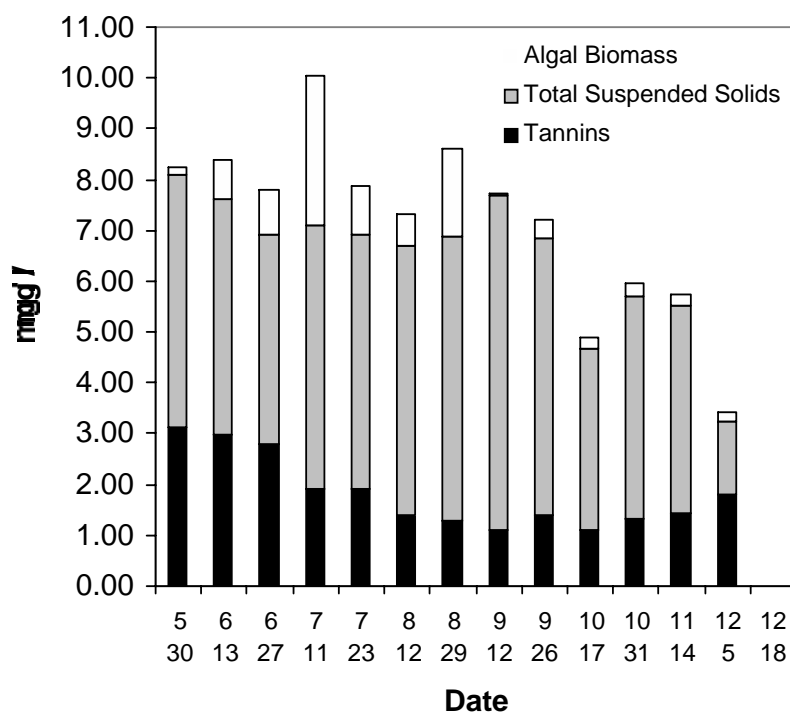


Figure 9. A summary of the components of turbidity in Martins Pond in the summer and fall of 2002. The stacked bar graph shows three major components of turbidity: tannins (black); total suspended solids (gray) and algal biomass (stippled) in Martins Pond. Means are shown for each sampling date.

Chlorophyll-a and Algal Biomass

Based on a review of nutrient data for lakes and ponds in New England, ENSR (2000) reports that the median chlorophyll-a value for ponds and lakes in the North Eastern Coastal zone was 4.1 $\mu\text{g/l}$. That translates to 0.275 mg/l of algal biomass. The mean algal biomass level in Martins Pond during the 2002 sampling period was 0.711 mg/l (range 0.03 – 2.94) indicating that Martins Pond has relatively high algal concentrations, for at least parts of the year.

Tannins

The pattern of tannin concentrations in Martins Pond shows a steady decline over the summer and increasing tannin concentrations at the end of the year. The inclusion of tannins in this study was important because tannins are a major factor influencing turbidity in Martins Pond. Mitigating the influence of tannins will be difficult because the source is primarily leaves from vegetation around the pond, in the wetland complex north of the pond and from the watershed.

Total Suspended Solids

Total suspended solids (TSS) levels were somewhat constant over the study period with declines associated with ice cover. Relatively high TSS levels were expected due to the shallow nature of Martins Pond and the soft sediments underlying much of the pond that are prone to resuspension due to wind and wave action, the latter the result of wind and recreational boat activity.

Total Phosphorus (P)

Total phosphorus (Total P) levels in Martins Pond should be interpreted based on two considerations: (1) changes in total P levels since the 1985 feasibility study; and (2) relative to typical concentrations expected in lakes in the region. Martins Pond is located in the North Eastern Coastal Zone Ecoregion of New England. Griffith et al. (1994) indicate that within this ecoregion, typical total P is at concentrations between 15-19 ug/l, based on spring/fall concentrations. The phosphorus ecoregion map of Rohm et al., (1995) suggests that typical lake concentrations between 30 and 50 ug/l, based on summer concentrations. The ENSR (2000) nutrient data summary review, reports a median total P concentration of 14.4 ug/l in the ecoregion. In addition, the ENSR report suggests a criteria of 9.9 ug/l to protect water quality. Martins Pond clearly exceeds all of these criteria and exhibits remarkably high total P levels, as is shown in Figure 10.

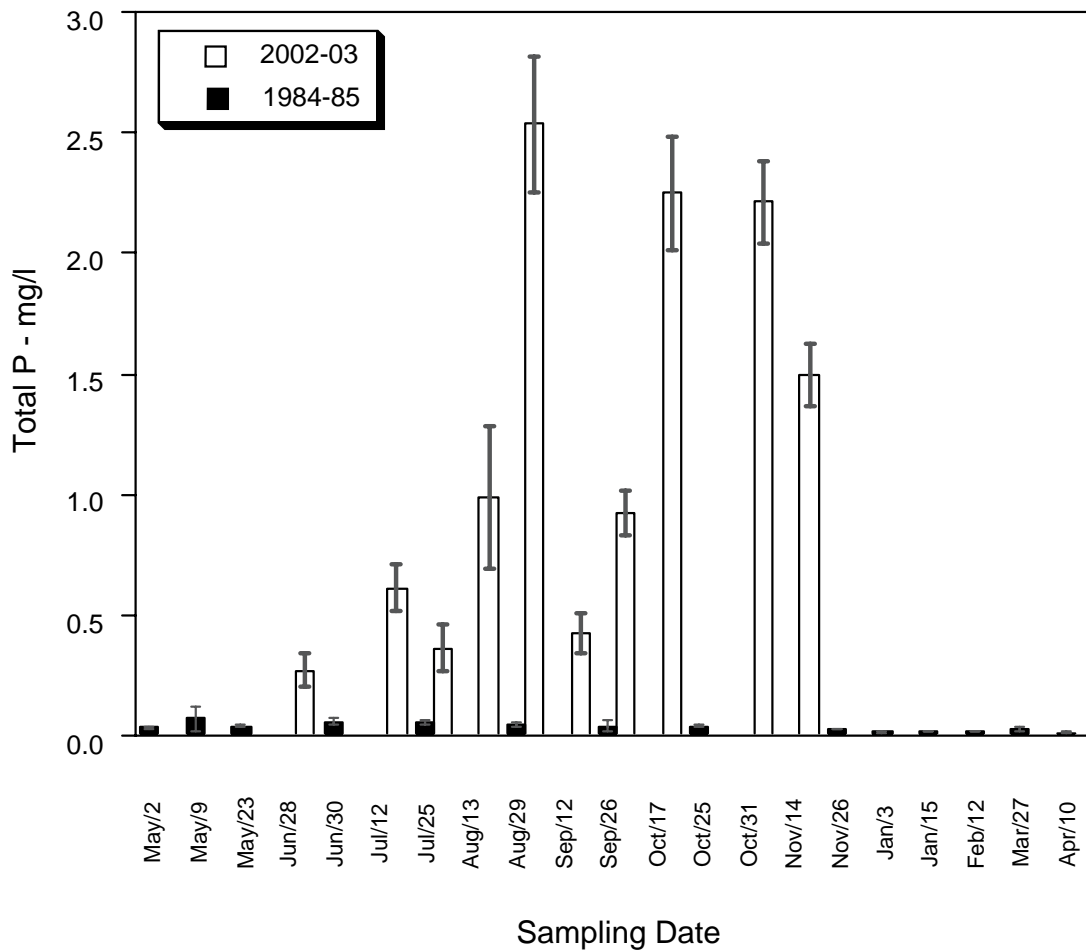


Figure 10. A comparison of total P values from the 1984-85 sampling period and the 2002 Lakes and Ponds Grant study. The P levels in Martins Pond are clearly significantly and dramatically higher in 2002 than in 1984-85. Means and standard errors are shown for each sampling date.

We also analyzed total P patterns from upstream along the Skug River at Central Street and Route 28 in North Reading and from the inlet, pumping station, beach and outlet. Figure 11 is a summary of the pattern of Total P at the six sampling sites during the study period. The P levels observed in different areas of Martin's Pond and Skug River were not expected. Interestingly, total P showed very similar levels and seasonal patterns at the six sampling sites. Two peaks in total P were observed at all sites: one

peak in late August and another peak in mid-October. In addition to the high total P values, there were high level of total P in the Skug River prior to entry into Martins Pond. Furthermore, the area around Martins Pond does not appear to be adding additional P into the pond system. Total P levels in the Skug River, inlet and outlet were very similar and show synchronized temporal peaks. It was hypothesized that since the flushing rate in this pond is about 18 days, P would flow through the Skug Rive and into and out of the pond over that period. However, P levels were surprisingly similar in the Skug River and in Martins Pond. If septic systems around the pond were sources of P, one would expect increased concentrations of P in the pond. Yet, the level of P was basically uniform in all areas of the pond. The contention that beaver activity north of the Pond between the wetland and Route 28 is contributing to high P levels in the pond was also not strongly supported by the results. P levels are uniform upstream and downstream from the area. Another contention is that geese are responsible for high P levels in the pond. This is not supported by the results in that geese activity would have to have been somewhat evenly distributed in the area to account for uniform P levels in all sampling areas. Further studies are recommended, and sampling should be conducted further up Skug River until the source of P is identified. The source of P must have emerged relatively recently since the data from the 1984-85 study of Martin's Pond showed substantially lower P levels than at present.

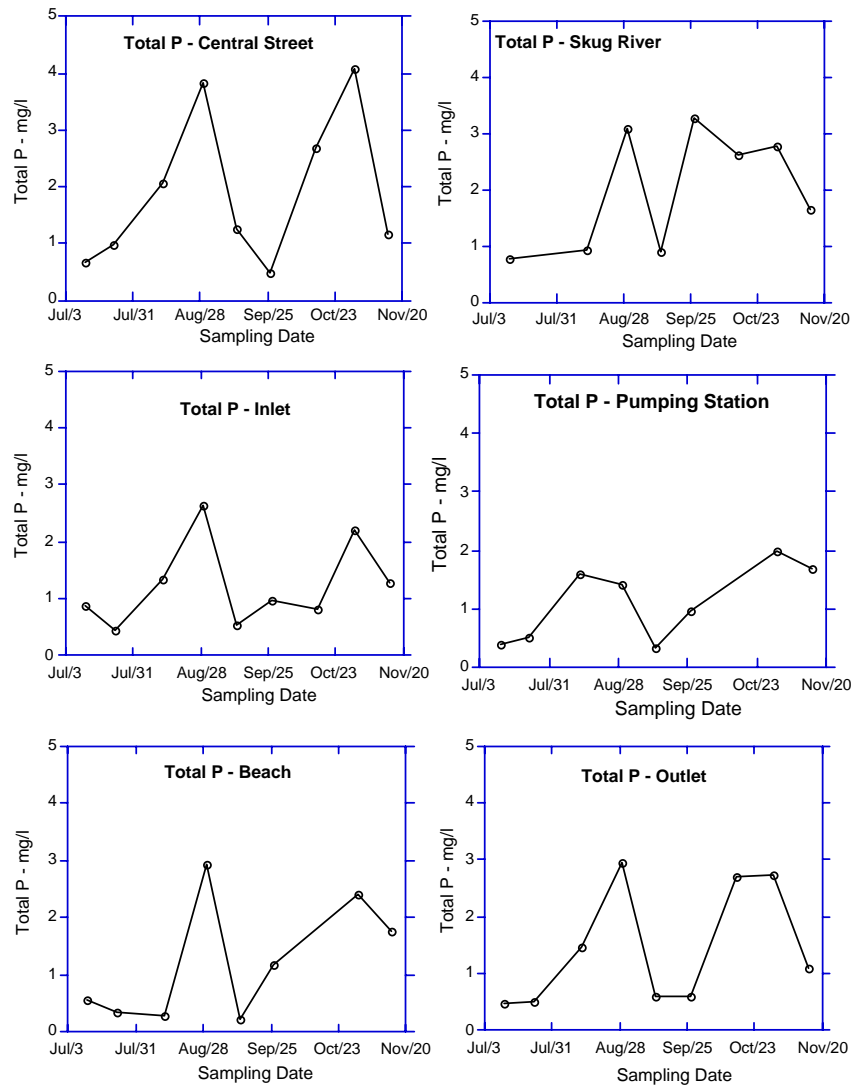


Figure 11. A comparison of total P in water samples at six sample locations during the 2002 study period. Total P showed very similar levels and seasonal patterns at the six sampling sites. Two peaks in total P were observed at all sites - one peak in late August and another peak in mid-October.

Trophic Status of Martins Pond

Martins Pond is located in North Eastern Coastal Zone Ecoregion in New England. The ENSR study (ENSR 2000) developed eco-regional based criteria for classifying water bodies in New England. Based on that study, a Trophic Status Classification Index (TSI) was established based on water quality variables. The TSI is presented below in Table 7.

Table 7. A Trophic Status Classification based on water quality variables (after ENSR 2000). Martins Pond values represent mean values during the 2002 study period. It is evident that Martins Pond is a highly eutrophic system.

Variable	Oligotrophic	Mesotrophic	Eutrophic	Martins Pond
Total P (ug/l)	< 10	10 - 24	> 24	1260
Chlorophyll a (ug/l)	< 1.5	1.5 – 7.2	> 7.2	10.6
Secchi Depth (m)	> 6	2 - 6	< 2	1.09

It should be noted that the Carlson trophic state analysis (Carlson, 1977) is not appropriate for Martins Pond because it has a high quantity of aquatic macrophytes and the turbidity in the Pond cannot be attributed primarily to algal biomass.

Other Water Quality Parameters - Appendix D contains a summary of all the water quality data collected during the study period.

Total Maximum Daily Load - TMDL

Once a waterbody is identified as impaired, the Department of Environmental Protection (DEP) is required by the Federal Clean Water Act to essentially develop a "pollution budget" designed to restore the health of the impaired waterbody. The process of developing this budget, generally referred to as a Total Maximum Daily Load (TMDL), includes identifying the causes (types of pollutant) and source(s) (where the pollutants come from) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and developing a plan to meet that goal. (<http://www.state.ma.us/dep/brp/wm/tmdls.htm>)

It is recommended that water sampling be supported and continue in Martins Pond and upstream along the Skug River in 2003. In addition, water sampling should be linked with flow information to model inputs of total P and other nutrients into Martins Pond in an effort to develop a TMDL for Martins Pond and the Martins Pond watershed.

Coliform Levels

Surface-water quality standards for primary contact recreation use in Massachusetts are as follows for fecal coliform: *geometric mean < 200 colonies/100 ml in any representative set of samples and <10% of samples > 400 colonies/100 ml. Standards met in >90% of measurements for all samples or dry- and wet-weather guidances met support primary contact recreation use.*

In April 2001, the Department of Public Health issued new beach monitoring requirements for public and semi public beaches in Massachusetts.

Under 105 CMR Section 445 (445.031): Indicator Organisms

(B) For fresh water, the indicator organisms shall be *E. Coli* or *Enterococci*

(1) No single *E. Coli* sample shall exceed 235 colonies per 100 ml. and the geometric mean of the most recent five *E. Coli* samples within the same bathing season shall not exceed 126 colonies per 100 ml; or

(2) No single *Enterococci* sample shall exceed 61 colonies per 100 ml. and the geometric mean of the most recent five (5) *Enterococci* samples within the same bathing season shall not exceed 33 colonies per 100 ml.

Total and fecal coliform levels were monitored during the study period. An overall summary of twice-monthly coliform sampling results are summarized in Figure 12. These are dry-weather, base flow coliform levels and do not reflect storm events.

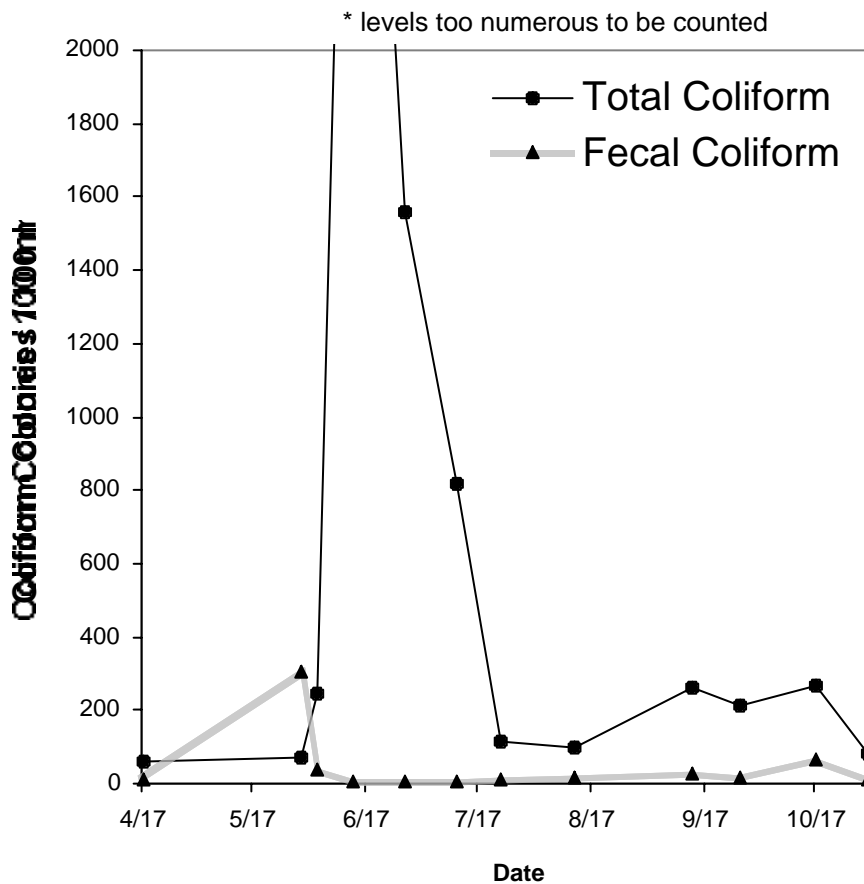


Figure 12. A comparison of total and fecal coliform levels in Martins Pond during the study period. A peak of total coliform occurred in mid-June.

Storm event sampling for coliform was also conducted. The results from the October 15th to 17th storm event are summarized by sample location in Figure 13. Unfortunately, maximum coliform levels could not be specifically identified on some samples collected on 10/16 pm. Despite the measurement issues, total coliform clearly spiked during the rainfall event. However, total coliform levels were highest in the north end of Martins Pond indicating coliform entry into the pond is influenced by the Skug River inflow as well as conditions in the north end of the pond. Additional storm event sampling is needed to confirm this pattern. Furthermore, future sampling should be conducted upstream along the Skug River to pinpoint the source of high coliform levels in the Skug during rainfall events.

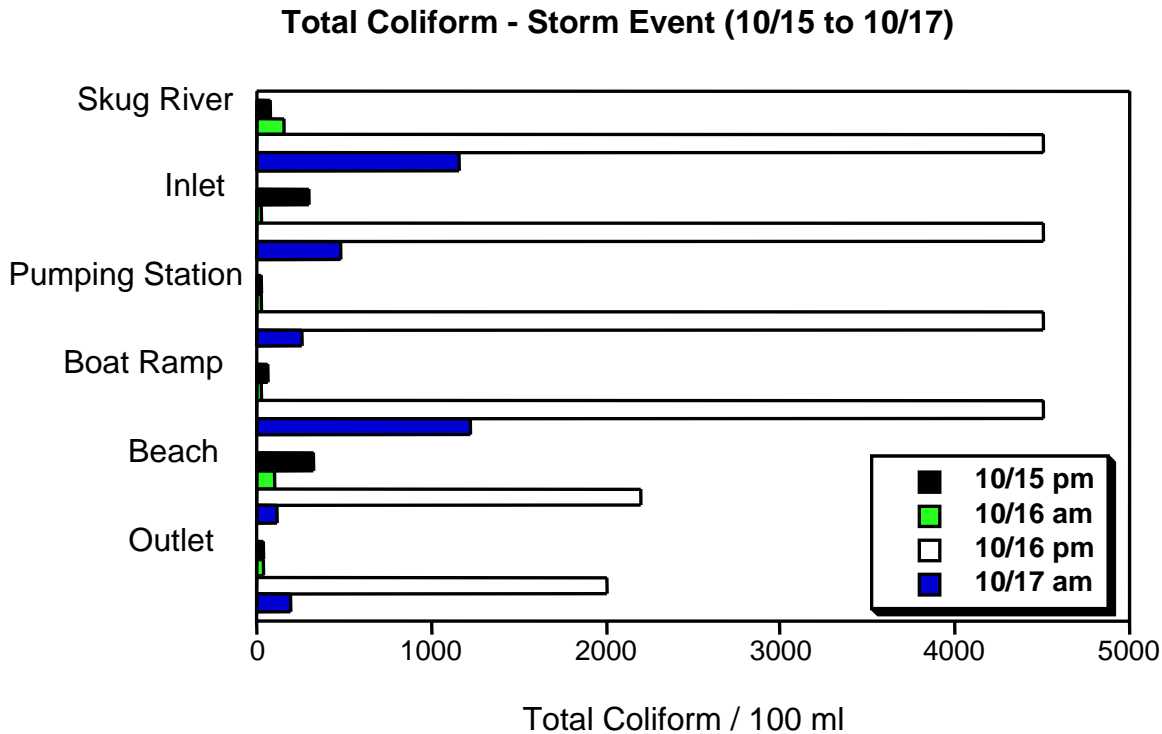


Figure 13. A comparison of total coliform levels during a storm event in October 2002. Six locations were sampled at 6:00 pm on 10/15, 6:00 am on 10/16, 6:00 pm on 10/16 and 6:00 am on 10/17/2002. Please note that 10/16 pm samples (*) were at least 4500 (actual coliform values could not be determined). Thus, this is a conservative estimate of coliform levels in the Pond at that time. Total coliform levels exceeded surface water quality standards at all sites during the storm event, but coliform levels were highest in the Skug River and the northern end of Martins Pond.

Water Quality Recommendations

- Support and continue monitoring water quality (including total P) in Martins Pond and upstream along the Skug River through June 2003. A full year of water quality data is needed to assess seasonal changes in water quality in Martins Pond. Additional sampling sites upstream are also needed to identify the source(s) of high P levels in waters entering Martins Pond.
- Continue monitoring total and fecal coliform levels in Martins Pond and upstream along the Skug River until June 2003. A full year of coliform data is needed to assess seasonal changes in coliform in Martins Pond and the Skug River. Additional sampling sites upstream are also needed to identify the source(s) of high coliform levels in waters entering Martins Pond.
- Support combining water quality data with flow data to develop nutrient budgets for Martins Pond. This approach is needed to facilitate development of TMDL's for the pond. Financial support for this effort is needed to begin the process of addressing water quality concerns in Martins Pond and the Martins Pond watershed.
- Conduct a sediment study along Martins Brook from Martins Pond outlet past Route 62 to assess sediment composition and chemistry prior to any potential stream channel modifications.
- Develop a water quality monitoring network from members of the Martins Pond Association to track the newly installed water level gauges in and around Martins Pond, Skug River and Martins Brook.
- Link water quality monitoring with water quality efforts in the Ipswich River watershed. Understanding and addressing the linkages between the Martins Pond watershed, Martins Pond, Martins Brook and the Ipswich River is required, especially in the formation of TMDL's for Martins Pond.
- Swimming in Martins Pond is not advised – especially after rainfall events. Total and fecal coliform spike after rain events and residents around the pond should be fully aware of the potential health risks of swimming under these poor water conditions.

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2. Martins Pond Hydraulic Assessment

2.1 Introduction

The objective of the hydraulic assessment portion of the Martins Pond study is to help clarify the cause of major and minor flooding problems adjacent to Martins Pond and also to develop recommendations concerning the establishment of a normal pond elevation. The hydraulic assessment included the review of available hydraulic information, field surveys, and the hydraulic analysis of information and data collected. Based on the assessment results, recommendations are provided in this report, in cooperation with the Town of North Reading and the Martins Pond Association, for proceeding with measures that will help mitigate problems associated with minor and major flooding and for the creation of a normal pond elevation.

2.2 History of Flooding

Flooding damage in the Martins Pond Area of North Reading has been a recurring problem for many years. Records of major flood occurrences are documented for 1938, 1948, 1954, 1958, 1962, 1968, 1987, and more recently in October 1996, June 1998, and March 2001. As shown in Figure 14, during major flood events homes become flooded and portions of Burroughs Road and Lakeside Boulevard become inundated with floodwaters and are closed for safety reasons. These roads serve as the only legal access to approximately 100 residences and also the Town's Lakeside Water Treatment Plant. In addition, members of the Martins Pond Association have recently noticed a rise in the normal level of Martins Pond caused by restrictions or obstructions in the ponds outlet, Martins Brook. This increase in the normal pond elevation causes a reduction in the pond water storage capacity and in the Martins Brook watershed, which can increase a flood events depth and duration. Flooding of the homes adjacent to the pond can also cause the backup and overflow of septic systems, causing the pollution of Martins Pond, Martins Brook and ultimately the Ipswich River.

2.3 Existing Watershed and Hydraulic Conditions

The Martins Brook watershed, which includes the Skug River, Martins Pond and Martins Brook, is shown in Figure 15 and is a total of 14.93 square miles or 9,555 acres. The watershed includes the Towns of Andover, North Reading, North Andover, and Wilmington. The watershed is located in the western section of the Ipswich River Basin and flows to the Ipswich River through the Skug River, Martins Pond, and Martins Brook.

Because of the many wetlands and areas of low elevation in the Skug River tributary area, peak inflow into Martins Pond during a rainstorm should normally be reduced and delayed. However, because of constraints in the Skug River causing water to back up, these low elevation areas are artificially filled with water during low rainfall conditions. This causes the delay in peak inflow to be reduced and the peak flow to increase during a rainstorm. Also, during larger storm events, the peak flow entering the pond from the Skug River is larger than the capacity of Martins Brook, causing the elevation of the pond to rise. In times of flooding, the low elevation areas upstream of Route 62, Martins Pond, and the low elevation areas along the Skug River act as one large interconnected storage reservoir.

The following table was presented in the 1985 Town of North Reading Supplemental Report and shows the water surface area of Martins Pond and the water surface area of the interconnected watershed areas at

different water surface elevations. This table demonstrates the large water storage that is availability in the watershed.

Water Surface Elevation	Water Surface Area Martins Pond Acres	Water Surface Area Total Interconnected Acres
72	98	129
74	101	213
76	110	310
78	121	390
80	135	470

As indicated, the water surface elevation in Martins Pond and in the watershed makes a substantial difference in the amount of available water storage to help delay or reduce the impact to flooding in the Martins Pond area. However, this water storage is being reduced by flow constrictions in the Skug River and Martins Brook that artificially causes water levels to rise above normal elevations. As shown in Figure 16, there are several flow constraint locations along Martins Brook and one on the Skug River that have been identified in the watershed that are causing hydraulic problems. The following is a description of each location.

1. Martins Brook Weir Boards at Route 62: This structure is located in the Town of Wilmington just downstream of Route 62. There are two concrete structures with a top of concrete elevation of 73.5. Between the concrete structures are two 5-foot wide openings where boards are installed that act as weirs. Each board is approximately 8-inches deep and three boards can be installed at each location. The top of weir board elevation is approximately 72.7 and the bottom is approximately elevation 70.7.
2. Martins Brook Route 62 Culvert: This culvert is located in the Town of Wilmington and passes beneath Route 62. The culvert has two different cross sectional areas. The downstream portion appears to be two old stone rectangular culverts, one 4-foot wide and the other 3-foot wide, having a total flow area of approximately 30 square feet. The upstream portion is a concrete box culvert that is 11-foot wide and has a total flow area of approximately 68 square feet. The transition area between these two culverts is not only a flow constraint but is a location that often becomes blocked with debris causing flow backup. The entrance to the culvert has a large head wall and the elevation of the road above is much higher than the top of the culvert. Therefore, during high flow periods if the capacity of the culvert is exceeded, the flow is unable to bypass around the culvert and flow is able to back- up considerably.
3. Martins Brook Culvert at Benevento Sand and Gravel: This culvert is located in the Town of Wilmington on the Benevento Sand and Gravel property. This culvert is a 6-foot diameter concrete pipe that passes beneath a gravel road. This culvert is at a bend in the brook and its entrance and exit are partially blocked by brush, stone, and concrete blocks. Also, this culvert is pitched in the wrong direction and has about a 1-foot elevation drop between its exit and entrance locations. The elevation of the road above is only about one foot higher than the crown of the pipe.
4. Martins Brook between Benevento Sand and Gravel and Martins Pond. Beaver activity and a beaver dam in this portion of the brook has caused flow to back-up within the last several years.

5. Narrowing of the channel south of Burroughs Road: Recent aerial photography of Martins Brook shows that approximately 1500 feet of Martins Brook appears to be narrowing from either sediment deposition or wetland plant encroachment.
6. Skug River between Martins Pond and Route 28: This area of the river has flow backing up even during low rainfall periods. The cause of this back up is not known but is likely caused by a beaver dam, given the beaver activity in the Martins Pond area.

The above indicated flow constraints are contributing to the back up of flow during low rainfall periods and periods of high rainfall.

2.4 Land Survey and Gauge Locations

In order to set river and brook gauge stations and to analyze current water levels, a topographic survey of locations along Martins Brook and one location along the Skug River was performed. To provide for consistency, the survey datum used was the same as used for the 2001 FEMA study. A total of eight level gauges will be installed at the locations shown on Figure 17. By installing permanent gauge stations, a historical record of seasonal water surface elevations can be recorded which will provide a consist set of water level data. The gauges will help with determining any changes to normal water surface elevations, current brook or river flow rates, and the triggering of required action to remove obstructions or to lower the weirs at Route 62. Also, the gauges can be used to monitor water surface elevations in response to larger storms, to help calibrate existing hydraulic models, and to monitor the hydraulic improvement of any changes made to Martins Brook or the Skug River.

2.5 Coordination with the Town of Wilmington

The portion of Martins Brook located in the Town of Wilmington includes the weir location downstream of the Route 62 culvert. The Town of Wilmington maintains the weir boards, which are installed to help artificially maintain the water surface elevation of the wetlands adjacent to the Brook where the Town draws water from a shallow well field. During the summer months and during other extended dry periods, the Ipswich River watershed begins to dry-up and down stream of the weir location also becomes dry. For this reason, the Town of Wilmington maintains the weirs to prevent the upstream wetlands from drying and possibly affecting their well fields. During the fall when rain begins to increase, the Town lowers the weirs by removing one or two boards and then reinstalls the boards in the summer.

The installation and removal of the boards is a concern of the Martins Pond Association because the boards do cause an obstruction to flow during lower rain events and keeps the elevation of Martins Brook and the wetlands upstream of the weir artificially higher than normal. However, the weirs only impact the hydraulic grade line during low rainfall periods and only impacts flooding by the amount of water storage that is lost due to the raising of the water surface elevation in the watershed. In addition, the artificial raising of the water surface elevation during low rainfall periods also affects the wetland areas, making them wetter than normal.

A meeting was held between the Town of North Reading and the Town of Wilmington to discuss the weir boards and the gauges that will be installed along Martins Brook. The Town of Wilmington confirmed that the weirs are lowered during the fall and rose in the summer to maintain a water surface elevation upstream of the weirs to protect the wetlands from drying. The Town indicated that they would be willing to agree to a standard operating procedure for the removal and installation of the weirs provided it was based sound hydraulic data. The installation of the water level gauges and the monitoring of the gauges

were thought to be a positive step toward providing sound hydraulic data as a basis for developing a standard removal and installation procedure.

2.6 Existing Hydraulic Analysis

The flooding problems in the Martins Pond area is related to the quantity of flow entering the pond and the capacity and water surface elevation of Martins Brook leaving the pond. Assuming that the quantity of flow entering the pond cannot be controlled, the capacity and water surface elevation of Martins Brook dictates the elevation of Martins Pond during a storm event and determines how fast the raised elevation of Martins Pond will fall after a storm event. Reducing the quantity of flow or further delaying the quantity of flow entering the pond should be reviewed as part of a more extensive hydraulic study of this upstream tributary area. This type of hydraulic review is a long-term program that may provide recommendations for some improvements, but will not be able to eliminate flooding in the Martins Pond area during large storm events. Therefore, in terms of reducing the impact of flooding in the Martins Pond area, the short-term focus should be put on increasing the capacity of Martins Brook and decreasing the abnormally elevated water surface elevations caused by obstructions and constraints in the Brook. In review of existing hydraulic data and based on field visits and measurements, several observations can be made about the hydraulic conditions of the Skug River, Martins Pond and Martins Brook.

Figure 18 shows the calculated water surface elevations of Martins Brook and the Skug River during various flow conditions. The water surface elevations during the 10-year, 50-year and 100-year storm events are based on the 2001 FEMA study data. Based on this information, observations can be made concerning hydraulic conditions in the brook during these larger storm events.

1. Starting at the weirs downstream of Route 62, there is no increase in water surface elevation caused by the weirs, this is because the brooks water depth is much higher than the top weir elevation. Therefore, during these larger storm events, the weirs do not have an impact on flooding.
2. There is an approximate 1.5-foot increase in the water surface elevation upstream of the Route 62 culvert during a 50 and 100-year storm and a 0.5-foot increase during a 10-year storm. This is due to the limited capacity of the Route 62 culvert and the fact that the flow is unable to bypass the culvert due to the high elevation of the roadway.
3. There is a 1.5-foot increase in the water surface elevation upstream of the Benevento culvert during a 10-year storm event and a .5-foot increase during the 50-year and 100 year storm events. The reason the head loss is less during the larger storm events is because the higher water surface elevation during the 50 and 100 storm events are able to flow over the low elevation roadway above.
4. The section of Martins Brook between the Benevento culvert and the Boroughs Road culvert has a gradual .5 foot elevation increase, which does not indicate any abnormal hydraulic limitations.
5. There is an approximate 2-foot increase in the water surface elevation upstream of the Route 28 culvert during a 10-year storm event and a .5-foot increase during the 50 and 100-year storm events. The reason the head loss is less during the larger storm is because the water surface elevation during the 50 and 100 year storm allows flow to bypass the culvert by rising over the roadway.

Based on review of this information, several recommendations to improve the hydraulic conditions of Martins Brook become apparent.

- The Route 62 culvert should be replaced and increased in size to reduce the increase in water surface elevation caused by its limited capacity to pass flow during storm events. However, before this culvert is increased, a hydraulic analysis should be performed to be sure that the affects of enlarging the culvert does not cause additional flooding problems downstream.
- The Benevento culvert should be replaced and redesigned to lower its invert elevation, increase its capacity, minimize its potential for blockages, and allow for additional flow to bypass over the culvert by lowering the roadway above it.
- The culvert under Route 28 on the Skug River is holding backwater during larger storm events causing storage in upstream low elevation areas. If plans to modify this culvert or any other upstream obstruction ever develop, there hydraulic impact on Martins Pond must be addressed so that additional flooding problems are not pushed downstream.

Figure No. 19 shows water surface elevations in Martins Brook and the Skug River that were measured in November 2002. During the first two weeks in November several water level measurements were taken during a low rainfall period and the average of the readings is show. The water levels measured during this low rainfall period show only a very small change between readings. An additional set of water level readings were taken on November 19, 2002 to see how the water level changed based on a small storm the previous day. Based on this information, the following observations can be made concerning the hydraulic conditions in the brook during lower rainfall periods.

1. The weirs downstream of the Route 62 culvert do artificially raise the upstream water surface elevation during low rainfall periods as demonstrated by the measured raise in water surface elevation at the weirs of 1.1 feet in early November and .7 feet on November 19th.
2. The location of Martins Brook upstream of the Benevento culvert to the Burroughs Road monitoring location is being artificially raised about 1-foot by an obstruction. Given the observation of a beaver dam and beaver activity in this section of the brook, it is likely that the obstruction is being caused by one or more beaver dams. The one known beaver dam was breached in early December 2002 and preliminary monitoring by the Martins Pond Association indicates that the water surface elevation did drop as a result of the dam breach. However, additional monitoring of the water surface elevations will be required to determine if this dam was the sole cause of water surface raising or whether additional problems further downstream need to be investigated.
3. The portion of Martins Brook from the Burroughs Road monitoring location to the Burroughs Road culverts did not show any rise of the water surface when readings were taken in November. However, this portion of the brook has experienced a narrowing of the channel for about a 1500-foot length. Although the narrowing does not indicate that it is causing an artificial increase in the water surface elevation of the brook during low flow conditions, the narrowing of the channel may be causing an increase in the water surface elevation during larger flow conditions due to the channels decreased capacity. Also, the water surface elevation monitoring by the Matins Pond Association after the beaver dam was breached in early December 2002 shows that the narrowing is causing a delay in lowering the water surface in Martins Pond. However, this section of the

brook is not likely causing a severe restriction during very large storm flow conditions because the water surface elevation becomes high enough to flow over the natural banks of the brook.

4. The Skug River location between Martins Pond and Route 28 is being artificially raised approximately .7 feet by an obstruction. Given the beaver activity in the Martins Pond area, it is probable that one or more beaver dams are causing the obstruction. Although obstructions upstream of the pond do hold back flow from Martins Pond, obstructions that hold back flow during dry weather conditions add to the flooding problems by artificially backing water up into low elevation areas. This artificial filling of low elevation areas during dry weather periods means that water storage that would normally be available during a storm event is not available and more flow is routed downstream to Martins Pond and at a faster rate.

Based on review of this information, several recommendations to improve the hydraulic conditions of Martins Brook during low rainfall periods become apparent.

- Although the weirs at Route 62 do not cause a flow restriction during larger storms, they do artificially raise the upstream Martins Brook water surface elevation, which contributes to the more frequent flooding of the upstream wetlands making them wetter than would normally be expected. This contributes to the degradation of the wetlands, turning them into swamps. Also, the artificially high water surface elevation in the wetlands will adversely impact the Galerucella beetles that have been released into the wetlands to control the invasive purple loosestrife. The weirs also contribute to the artificial raising of the Martins Pond water surface, making it higher than would normally be expected during dryer periods. Therefore, an agreement for lowering the weir elevation even during the summer months should be further explored with the Town of Wilmington. We recommend that a compromise position would be to leave the weir elevation with one board removed or at approximately elevation 72.0 during the summer months. This would provide for a lowering of the upstream water surface during low rainfall periods but would also provide the Town of Wilmington protection against drying of the upstream wetland. In the fall an additional board could be removed down to an elevation of approximately 71.4 and a board reinstalled in the summer back to elevation 72.0. The boards are currently removed down to an elevation of approximately 72.0 but a more formal arrangement for board removal and installation needs to be developed as additional gauge readings are taken and provided to the Town of Wilmington.
- Given the greater than 1-foot raising of the water surface likely caused by the one or more beaver dams located between the Benevento culvert and Burroughs Road, it is clear that the cause of this artificial raising of the water surface should be investigated and corrected. Additional water surface elevation monitoring should continue through the winter of 2003 to determine if there is an additional obstruction or beaver dam that needs to be addressed. Because of the wetlands, access into the area is difficult and therefore the any additional obstructions should be investigated during the winter when the wetlands are frozen and access to the brook is possible.
- The narrowing section of the brook between the Burroughs Road monitoring location and the Burroughs Road culvert should be further assessed so a determination can be made as to the extent of narrowing and the cause. Although this narrowing is probably not contributing to flooding during larger rainfall events, it is likely causing the elevation of Martins Pond to be artificially raised during more normal rain events and is likely causing a delay in the lowering of the Ponds water surface elevation after a storm event. Also, if the channel narrowing continues, it may become a larger problem by maintaining the water surface of Martins Pond at an artificially high elevation. Because of the

wetlands, this area of the brook is also very difficult to access. Therefore, this section of the brook should also be further investigated during the winter of 2003 when the wetlands are frozen and access is possible. Once the extent and cause of the narrowing problem is determined, a plan of action should be developed for preventing further narrowing and correcting the narrowing problem.

- The cause of the obstruction between Martins Pond and the Route 28 culvert should be investigated. Given access difficulties to this area, the cause of the obstruction should be investigated in the winter when the wetlands around the river are frozen. Once the extent and cause of the obstruction is determined, a plan of action should be developed for addressing the problem.

2.7 Normal Pond Elevation

The establishment of a normal pond water surface elevation for Martins Pond is a desire for the Martins Pond Association to help gauge if the pond elevation is higher than expected during any given period of time, which would then trigger an investigation of the cause. In an attempt to obtain input from community members knowledgeable about the ponds water surface elevation, a survey was performed by the association asking for estimates of the elevation of the pond for different conditions and seasons. A description of the survey and a table of the results produced by the Martins Pond Association is included in Appendix A. The survey results show that although there is some variation in the results, the median readings do not show a large seasonal fluctuation (74.1 to 74.6). However, by correcting the beaver dams or other obstructions and lowering the weirs at Route 62, there is an opportunity to lower the normal pond elevation range. This lowering of the pond would likely be less than a foot, but could have important benefits to the wetlands surrounding Martins Brook and would add additional water storage volume in the watershed. As shown in the survey, the water elevation at Martins Pond rises sharply during larger storms such as experienced in the spring of 2001. Houses and streets begin to flood at an elevation of around elevation 77.0 but pollution from flooded septic systems occurs at lower elevations. Although a formal survey of the septic systems surrounding the pond has not been performed, the consensus of residents who attended a December 18, 2002 Town Hall meeting indicates that the elevation is likely around 75.5. Therefore, lowering the elevation of the normal pond elevation an additional foot would likely help reduce pollution from septic systems that currently may occur even during relatively smaller 2-year or 5-year storm events. Although the current normal pond elevation range is between elevation 74.1 and 74.6, attempts should be made to reduce this number to improve the health of the surrounding wetlands, reduce the frequency of septic system pollution, and to maximize available water storage in the wetland.

2.8 Recommendation Implementation

The chart below provides a description of how each proposed hydraulic recommendation should be implemented to continue progress toward improving the hydraulic conditions in the Martins Pond area.

Recommendations Implementation Chart Implementation Plan	
<u>Recommendation</u>	<u>Implementation</u>
1. Martins Brook Route62 Weirs	Short-term – The Town should continue to monitor water surface elevations in Martins Brook and develop a more formal arrangement with the Town of Wilmington for the lowering of the weirs. This work can be performed as part of the Town’s storm water program.
2. Martins Brook Benevento Culvert Replacement	Short-term – Benevento Sand and Gravel, Inc. have indicated that they would be willing to replace the culvert. The design of a new culvert could be developed under the Town’s storm water program and provided to Benevento for installation.
3. Martins Brook Beaver Dams	Short-term – The Town should determine the extent of the Beaver Dams or any other obstruction in Martins Brook during the winter of 2003 when access to the wetland areas is possible. This work can be performed as part of the Town’s storm water program.
4. Martins Brook Narrowing	Short –term – The Town should determine the extent of the channel narrowing during the winter of 2003 when access to the wetland area is possible. Based on this assessment, a plan of action should be developed to correct the problem. This work can be performed as part of the Town’s storm water program.
5. Skug River Beaver Dams	Short-term – The Town should determine the extent of the beaver dam problem or any other obstruction in the Skug River during the Winter of 2003 when access to the wetland areas is possible. This work can be performed as part of the Town’s storm water program. Based on the assessment, a plan of action should be developed to correct the problem.
6. Martins Brook Route 62 Culvert Replacement	Long-term – Town of North Reading is working

**Recommendations Implementation Chart
Implementation Plan**

<u>Recommendation</u>	<u>Implementation</u>
	with Massachusetts Highway Dept. (MHD) and the Town of Wilmington for replacement of the culvert and the bridge as part of the MHD bridge replacement program. The hydraulic analysis to determine the required size of the new culvert and any downstream hydraulic impacts will be performed as part of an Army Corps of Engineers hydraulic study or as part of the Town’s Storm water program.
7. Skug River Route 28 Culvert	Long-term – The Town should monitor any plans by MHD for replacement and improvement of this culvert and if plans develop, be sure that a hydraulic assessment on the impact to Martins Pond is completed.
8. Martins Pond Upstream Storm Water Storage in Skug River Watershed	Long-term – The Town should investigate opportunities to further retain or detain storm water in the Skug River watershed. This could be performed as part of the Town’s storm water program.

2.9 References

Charles A. Maguire & Associates. Existing and Proposed Drainage Facilities for the Town of North Reading, Massachusetts: 1971

CE Maguire, Inc. Supplemental report on Drainage for the Town of North Reading, Massachusetts: 1985

Green International Affiliates, Inc. FEMA Study in the Town of North Reading, Massachusetts for the Skug River, Martins Pond and Martins Brook: 2001

Town of North Reading, Massachusetts. Flood Hazard mitigation Plan: 2002