The Martins Pond Assessment and Remediation Project

Diagnostic/Feasibility Study
Final Report

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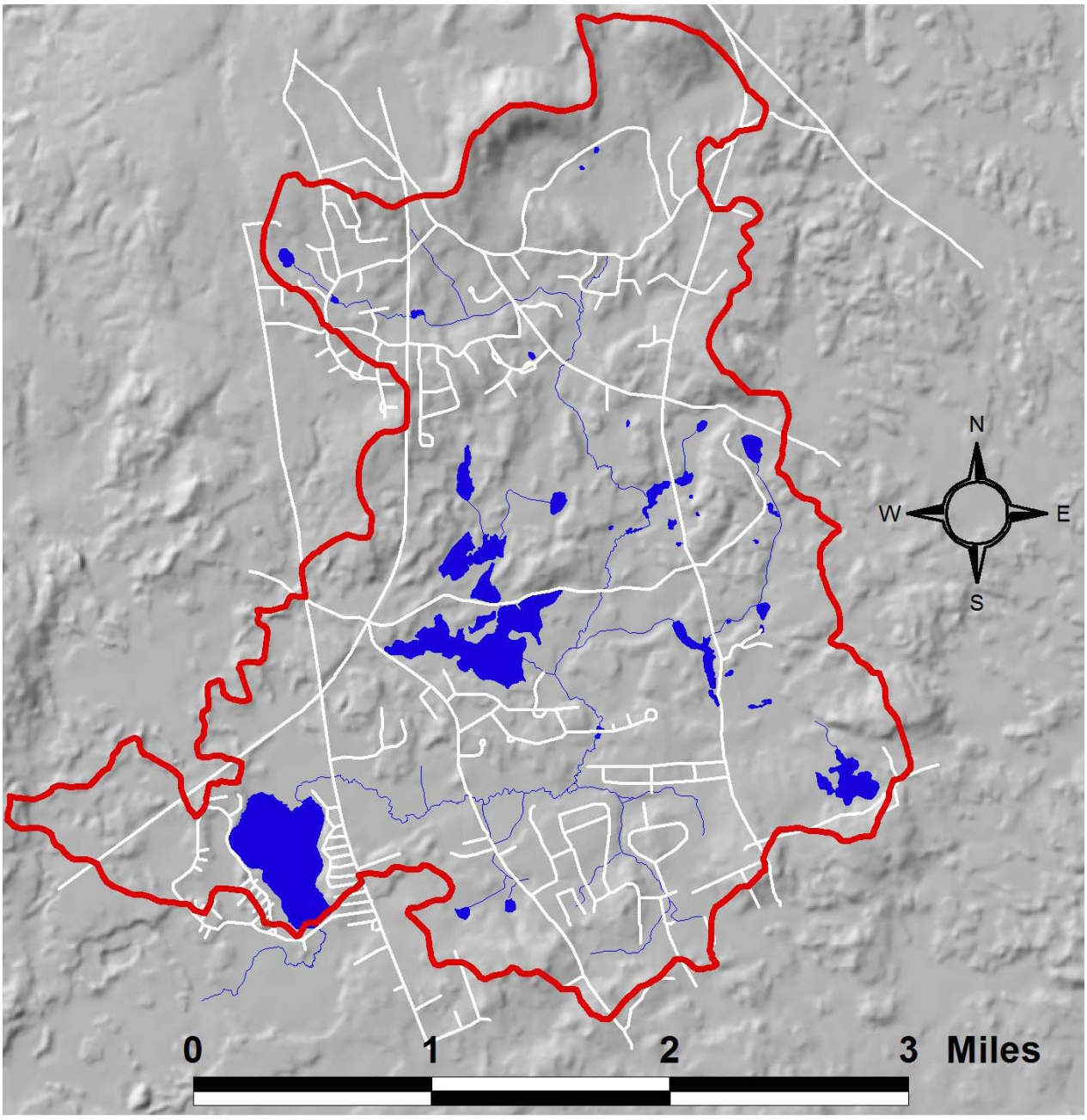
The Martins Pond Watershed



Shaded Relief Map of the Martins Pond Watershed.

EXECUTIVE SUMMARY

Martins Pond (segment MA92038-2004) is a Great Pond in the Commonwealth of Massachusetts and covers some 92 acres. It is a Class B water body meaning that it is designated for supporting aquatic life and recreational uses. Martins Pond is listed under the Massachusetts Year 2004 Integrated List of Waters (303d list) as an impaired water body due to **turbidity**, **noxious aquatic plants**, **exotic species** and **metals**. Turbidity levels are such that the Pond does not meet minimum clarity for swimming, and a local beach that offered swimming at one time, has been closed since 1988. Being on the 303d list, Martins Pond is classified as a *Category 5 Water*, which means it requires a TMDL. The Martins Pond watershed is located within the 155 mi^2 Ipswich River watershed (MA01102000). The northern portion of the watershed is in Essex County and the southern portion in Middlesex County. The total watershed area is 4927 acres

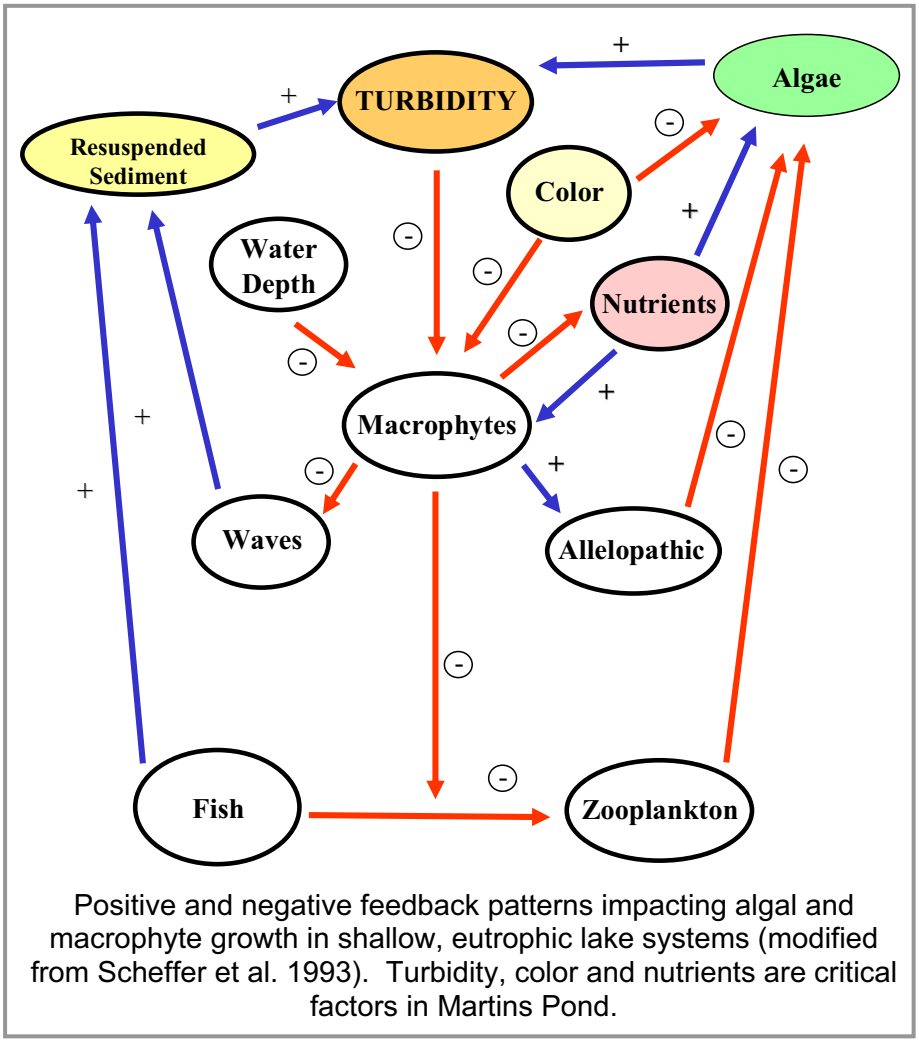
In late 2004, the General Court of the Commonwealth directed the Department of Environmental Protection (DEP) through Chapter 352 of the Acts and Resolves of 2004, Section 78, to expend funds toward the assessment and remediation of Martins Pond. The Town of North Reading agreed to use the funds received from DEP specifically for the purpose of water quality problem identification and mitigation. The Town was given the charge of continuing water quality assessment work conducted on Martins Pond towards the goal of completing a new Diagnostic/Feasibility Study for Martins Pond and an assessment of potential non-point source pollution in the Martins Pond Watershed.

The water quality of Martins Pond and the Skug River, have been the focus of study since at least the 1970s. Federal, State and Town agencies, private groups and concerned citizens have all been involved in assessing water quality, proposing remediation measures, and in some instances, implementing management practices. The large number of studies on Martins Pond conducted to date, reflect the hydraulic, hydrologic and nutrient dynamic complexity in the pond and its watershed. One main goal of this report was to synthesize the information from previous reports and integrate it with the work conducted in the most recent time frame (2005-2006) and draw some broad conclusions about the nature of this watershed. A summary of the major findings and recommendations of this report are given below.

Turbidity and Light Attenuation

Light is arguably the most important limiting factor regulating macrophyte and algae growth in Martins Pond. One of the most critical aspects of the current study is the impact of the relatively high water color levels in Martins Pond (and in the Skug River, its tributaries and several other ponds in the watershed) on light attenuation through the water column. Color alone, at median levels found in Martin Pond, can reduce available light by $1/3^{rd}$ at depths of only 0.4 m. Light attenuation is further exacerbated by the relatively high turbidity levels observed in the pond. Combined, these factors are effectively limiting macrophyte growth, the extent of the littoral zone and the spatial and temporal scale of algal blooms. In addition, low water clarity is creating conditions unfavorable for swimming.

A summary of the interconnections and feedbacks between turbidity, color, nutrients and other critical components of shallow eutrophic lakes (such as Martins Pond) are shown in the figure below. Management efforts that alter turbidity, nutrients, macrophyte or other components shown in the Figure, will have repercussions on the entire system. For example, any significant reductions in turbidity will likely result in increased macrophyte growth, expansion of the littoral zone and increased susceptibility to algal blooms. Such a result might ultimately be counter to the objective of improving the recreational potential of Martins Pond.



Positive and negative feedback patterns impacting algal and macrophyte growth in shallow, eutrophic lake systems (modified from Scheffer et al. 1993). Turbidity, color and nutrients are critical factors in Martins Pond.

Nutrient Dynamics

Martins Pond should be considered somewhat atypical with respect to the physical, abiotic and biotic conditions found in this geographic region of New England. The median parameter values for Martins Pond (including color, turbidity, conductivity, total P, chlorophyll-a, sulfate and chloride), exceeded the median parameter values published by several regional studies, save for Secchi depth which was lower than the regional medians. While eutrophication has been at the

historical center of all the previous and most recent diagnostic work conducted in and around Martins Pond, these other parameters provide critical context for evaluating current conditions and in formulating management options to improve water quality.

Martins Pond can be considered highly eutrophic and it exhibits very high levels of phosphorus. The mean yearly total P concentrations (0.040 mg/L in 2003, 0.069 mg/L in 2004 and 0.052 mg/L in 2005-06) clearly put Martins Pond in the eutrophic category. NPSLAKE modeling predicts Martins Pond should have a concentration of 0.029 mg/L/. Given that only 12.5% of all lakes and ponds in the North Eastern Coastal Zone ecoregion are classified as eutrophic based on total P and other Trophic Status Classification Index (TSI) criteria, Martins Pond should be considered among the most eutrophic surface waters in the ecoregion. In addition, the loading of P entering (and leaving) Martins Pond has essentially doubled over the past two decades. This is reflected in both the overall watershed loadings (327 kg/year in 1985 and 657 kg/yr in 2005-06) as well as the increase in mean concentration of total P. Watershed sources of P are clearly the most important inputs representing 89.7% of the total P inputs, while septic system inflows represent some 7.4% of P inputs.

Watershed inflow accounts for only 58.3% of the total N budget for Martins Pond. The source of the other N inputs remains unknown, but it is likely a combination of septic tank inflows, atmospheric deposition, shoreline property run-off (including fertilizers), stormwater conveyance, wetland inputs, nitrogen fixation in the water and sediments, decomposition occurring at lake and pond bottom sediments and inputs from groundwater.

Given the eutrophic conditions, nutrient dynamics are complex in Martin Pond, especially in relation to nitrogen versus phosphorus limitation. The results of this study suggest that the pond may be nitrogen limited in some seasons, phosphorus limited in others, and perhaps some combination of the two at certain times of year. During most of the winter and spring, the N:P ratios were all well over 30:1 (in some cases an order of magnitude higher) indicating the potential for P limitation in Martins Pond. However, during the summer and early fall sampling dates (June through September), the N:P ratios were less than 16:1, indicating the potential for N limitation. Thus, based on the N:P ratios observed in the current study, it appears that Martins Pond may be shifting from P limiting conditions to N limiting conditions over the course of the year. The observed seasonal patterns of total P and total N concentrations also reflect complex seasonal dynamic of P and N sources and sinks. Similar seasonal patterns in N:P ratios have been observed in other shallow, eutrophic systems and complicate efforts to manage nutrient dynamics in Martins Pond.

Any efforts to control and reduce nutrient inputs need to have a strong watershed-based component. Martins Pond is thus challenged with a classic non-point source pollution problem. An integrated suite of BMPs will need to be implemented watershed-wide to reduce the watershed influx of nutrients into Martins Pond. Examples of BMPs to achieve nutrient reductions include fertilizer controls, landscaping management, controlling pet wastes, septic system maintenance and stormwater conveyance alterations. Implementation of BMPs should begin with the subwatersheds exhibiting the highest loadings of nutrients. The Towns of North Reading, Andover and North Andover will have to coordinate their efforts to maximize efficiency and effectiveness.

Swimming Potential

Martins Pond is a Class B water meaning that it is designated as a habitat for aquatic life, and wildlife, and for primary and secondary contact recreation. One long-term management objective since the Town Beach was closed in 1988 was to have the Pond once again meet the water quality standards to allow swimming. Given the high turbidity and color in Martins Pond, achieving water quality standards for swimming will need to balance the goal of improving turbidity to the point where swimming is allowed, but not to the point where light is no longer limiting in the pond. Improvements in water clarity will be positively correlated with macrophyte growth, littoral zone extension and algal productivity. These conditions could result in eutrophication processes becoming even more accelerated than current levels.

It is also recommended that there be continued monitoring of fecal coliform bacteria levels to document effectiveness of bacteria source reduction activities including treatment of stormwater discharges, any sewering activities around Martins Pond and the Phase II community stormwater management programs. Subwatersheds A and D in the current study has been problematic since the 1970s in terms of fecal coliform bacteria levels and below-standard water quality. They should be the focus of any initial remediation efforts. Other subwatersheds that require attention are F, E and I. In addition, in Martins Pond, fecal coliform levels and *E. coli* have been shown to exceed water quality standards during storm events and this issue will need to be addressed in any bacterial reduction management planning.

In order to be able to resume swimming in Martin Pond in the short-term, one option that the Town of North Reading should consider implementing is the use of a barrier curtain during the summer swimming season could achieve the clarity requirements of Massachusetts Department of Public Health. The barrier could be temporarily installed each season. This would allow contact recreation in the pond and be a solution to the complex and inherent problem of high natural turbidity and water clarity issues in this stained pond and allow for treatment of bacteria within the confines of the barrier curtain. Such a barrier could result in producing Secchi depths greater than the 4 ft minimum standard. This represents a relatively low cost and immediate solution to the lack of contact recreation in the pond.

Septic Conversion to Sewering

Since the diagnostic work in the 1970s, there has been evidence that septic systems are a likely contributor to both fecal coliform levels and nutrient loading (particularly N and to a lesser extent P) into Martins Pond, other surface waters and into the Skug River and its tributaries. Converting wastewater disposal from septics to sewering should be part of a long-term management plan to reduce bacterial contamination and help reverse the trend of increasing eutrophication in Martins Pond by reducing N and P inflows.

While not the only solution to the eutrophication problems of Martins Pond, sewering is an essential step on the road to ensuring the long-term recreational use potential of the pond and

part of a broader watershed plan to begin reductions in sources of nutrient loadings to the pond. Sewering will not dramatically decrease P inputs because the main sources are watershed loadings (89.7%), but sewering would decrease P inflows. More significantly, sewering could reduce N inputs into the pond; internal N loadings represent 41.7% of the total N budget of Martins Pond. Thus, sewering should be one part of a multi-pronged program to decrease N and P inflows. In addition, bacterial contamination, particularly during storm events, needs to be addressed if contact recreation and swimming are going to be long-term use options for Martins Pond. Thus, it is highly recommended that the Town of North Reading and all Martins Pond stakeholders set a timeline for the development of a feasible and effective sewering program.

Watershed-Based Management Planning

The Martins Pond watershed is clearly a complex system that is influenced by a host of natural forces and numerous anthropogenic influences both currently as well as in the near and more distant past. The watershed has experienced a legacy of repeatedly altered land use and altered hydrology, including extensive human land use alteration, conversion and manipulation as well as beaver dam construction. As such, it is not surprising that the water quality dynamics of surface and groundwater, and the hydrology of Martins Pond and its watershed are complex. Surface water quality improvements in Martins Pond thus should be viewed from a watershed perspective. Solutions for continued water quality improvement and restoration of ecological integrity of Martins Pond are needed and an integrated program of watershed management and in-pond restoration procedures will need to be pursued.

Watershed-based management planning will be essential and the most complex management goal to achieve. Water quality in Martins Pond is heavily influenced by watershed-based non-point source pollution as evidenced by high watershed loadings of TSS (91.2%), P (89.7%) and N (58.3%). Therefore, effective management plans need effectively address the source of impairment and a comprehensive watershed approach will be needed to begin to address existing water quality issues in Martins Pond.

One aspect of a comprehensive watershed-based management plan is the development and implementation of a concerted shoreline restoration effort along the shores of Martins Pond. In particular, there are opportunities to reduce sedimentation and runoff by re-directing runoff into BMPs and/or infiltration areas at several locations around Martins Pond. This could then be expanded to other properties in the watershed adjacent to ponds, rivers and/or streams. In addition, a focus on maintenance and remediation of stormwater outfalls immediately adjacent to Martins Pond and along all river and stream channels in the entire watershed is recommended. We recommend implementing a 100 ft buffer rule, whereby all outfalls within 100 ft of surface waters be retrofitted with basic swales and/or detention basins to limit impact of stormwater on surface water resources in the watershed (see Section 10). In addition, a stream bank survey of the Skug River and its tributaries is recommended to identify other potential sources of water quality impairment and ecological degradation such as soil erosion, stream bank degradation and residential intrusions.

Nuisance Macrophyte Species Control (Fanwort)

Fanwort (*Cabomba caroliniana*) is the major nuisance macrophyte species of concern in Martins Pond. Mechanical harvesting was used in 2005 to control fanwort and harvesting remains an option in the future, but should be used very judiciously. Following mechanical harvesting in 2005, there was a dramatic decrease in both the extent and abundance of fanwort in Martins Pond relative to the pre-harvest conditions. The percent occurrence of fanwort on all sample points in 2006, the year after mechanical harvesting, was only 6.5%, compared to 38.9% in 2005, suggesting that harvesting was successful in reducing the overall level of occurrence of fanwort in Martins Pond.

However, the abundance of fanwort in the non-harvested area also showed dramatic decreases despite not being harvested. This suggests that fanwort abundance may have been in a decline cycle despite the harvesting effort. Variability in species abundance of both fanwort and other species was clearly evident over the past 40 years, regardless of any harvesting or mechanical management activities.

The 2006 macrophyte post-harvest survey results showed decreases in all three measures of diversity. It is hard to decipher the relative contribution of harvesting to these declines, but clearly harvesting did not have any positive impact on the abundance and distribution of aquatic plant diversity in Martins Pond. The reduction in species richness is particularly of interest and needs to be monitored closely if any additional harvesting activities are proposed. Fanwort control must be balanced with full consideration of the ecological integrity of the native aquatic plant communities in Martins Pond.

Thus, no additional harvesting should occur without conducting a pre-harvesting survey to determine if fanwort abundance and distribution warrant control efforts. A crucial consideration in any future management effort should be to maintain the aquatic plant diversity in Martins Pond, especially in a system with a high proportion of uncommon species, complex and in many cases non-overlapping spatial distributions of species and a system with inherently high levels of temporal variability in species diversity and abundance. Limited mechanical harvesting for maintenance of boat channels and/or high use recreational is a viable management option, but only on a very limited basis and preceded by a quantitative survey of both the composition and spatial extent of existing macrophyte species. Post-harvesting impacts must also be monitored before any new harvesting is considered.

Purple Loosestrife Control

Biological control of purple loosestrife (*Lythrum salicaria*) along Martins Brook has been marginally successful to date. *Galerucella* release sites 2 and 3 have shown some signs of success but not any widespread or sustained impact. One key factor likely limiting the success of the biocontrol project is that the surface water level at the release sites has exceeded the critical threshold in 2003, 2005 and 2006. This is likely correlated to the extreme reduction in

reduced beetle herbivory noted in this study. The concerns surrounding surface water elevations in the Martins Brook wetland complex south of Martins Pond and influenced by flow restrictions further downstream. Given these important constraints, any future beetle releases should be in more elevated portions of the Martins Brook release site. There is micro-topographical variation in the wetlands and release sites should be shifted to areas of higher elevation to help avoid the negative impacts of high seasonal water levels. Given that it is typical that it often takes 4-7 years out to begin to see results in biological control projects, additional raising and releasing of beetles is recommended at all 3 release sites. Beetle herbivory still has potential at the release sites if high water levels can be worked around. Thus it is recommended that beetles be released again in 2007 and that the monitoring and release program continue at least through 2010.

Project Partner Acknowledgments

The core partners on this project were the Town of North Reading, the Martins Pond Association, Malcolm Pirnie Inc. and the Department of Biology at Merrimack College. However, several additional local and State agencies, organizations and concerned citizens have made important contributions to this project. The content of this study thus represents the efforts, work and contributions of numerous people and groups. The following list highlights some of the individual project contributors and their contributions to the project.

- Kim Honetschlager, GIS Coordinator in North Reading, provided valuable and detailed GIS data from North Reading for the project.
- David Hanlon, Director of Public Works in North Reading, assisted in several components of the project, and supported and offered the assistance of his staff in all aspects of the project, including excavation labor.
- Mary Trudeau, North Reading Conservation Commission Agent, was instrumental in reviewing and guiding the implementation of the fanwort harvesting and ground water well monitoring portions of the project.
- Larry Soucie, Martins Pond Reclamation Study Committee member has been an invaluable assistant in the use and application of the SWMM modeling effort.
- Janet Nicosia, Co-Chair of the Martins Pond Reclamation Study Committee and Martins Pond Association has been a critical component of linking and making accessible the scientific-based work with the broader community, outreach and education, and in coordinating volunteers and in oversight of all aspects of the project.
- Paul Cameron, Martins Pond Reclamation Study Committee member, for weekly field inspections of beaver activity areas, water level gauge readings, and coordination of culvert cleaning and beaver management implementation.
- Harvey Card, Martins Pond Association volunteer created the design for the retrofit of the dock system, working with James Decola, Building Inspector.
- Denise Conry, P.E., North Reading Waste Water Stormwater Advisory Committee member, for assistance and coordination in outreach and education campaign.
- Dr. Peter Kerr at the Environmental Analysis Laboratory at UMass-Amherst, has assisted in the development and quality control of Merrimack College's analysis of surface water chemistry.
- Al Carifio, Chief Chemist at the Andover Water Treatment Plant, has graciously helped the project by conducting fecal coliform and *E. coli* analyses.
- Kathleen Legere, currently a graduate student at UNH, assisted in collecting and analyzing valuable field data, GPS mapping and in setting up the SWMM modeling effort.
- Mike Soraghan, North Reading Town Engineer provided essential guidance in the development and implementation of all aspects of the project, specifically developing the specifications for the aquatic weed harvesting contractor bid documents and contract, Mass Waterways Chapter 91 license application submittal, and field inspections of stormwater conveyance systems and outfalls and road culverts.
- Brian Wood, North Reading Parks & Recreation Director provided project oversight, labor, excavation, plantings, survey and design for the handicapped accessible dock system.
- James Decola, North Reading Building Inspector oversaw the retrofit and ADA compliance issues for the ADA dock system.
- Dr. Oscar Pancorbo, Division and Station Director of the Senator William X. Wall Experiment Station along with Jean Tang and Ron Stoner from the Station, have offered their services to conduct the extensive laboratory work in bacterial source tracking for this project

- Frederick Snell, President, the Trustees, and David Dargie, Warden, from the Andover Village Improvement Society (AVIS), have generously supported and worked with the project in regards to site selection for groundwater monitoring wells on their properties.
- Numerous Martins Pond Association volunteers liberally assisted in the harvesting and preparation of loosestrife for the greenhouse rearing of *Galerucella* beetles, and volunteered to pass out outreach and education flyers and work educational events.
- DEP staff in the Central Region Office, including Dr. Mark Mattson and Arthur Screpetis, were instrumental in overseeing the development of the project QAPP and in providing guidance and technical assistance during the project.
- Tim Smith and Beth Suedmeyer at the Massachusetts Wetland Restoration Program for assisting in the loosestrife biocontrol aspects of the project.
- Merrimack College senior Environmental Science Majors Lauren Berg, Mike Horton, Beth Houghton, Sarah Zazzaro and Maria Lonardo-Roy were involved in field monitoring, laboratory analyses and hydrological modeling.
- Massachusetts State Senator Bruce Tarr for proposing our project for Supplementary Budget FY2005 consideration, attending planning meetings, interfacing initially with the Department of Environmental Protection, and maintaining constant contact throughout the project.

Massachusetts State Representative Bradley Jones Jr. for partnering with Sen. Bruce Tarr in this effort to pass the Supplementary Budget FY2005 through the legislature, attending planning meetings, and remaining in constant contact with the project team.

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The Martins Pond Assessment and Remediation Project

Martins Pond (segment MA92038-2004) is a Great Pond in the Commonwealth of Massachusetts and covers some 92 acres. It is a Class B water body meaning that it is designated for supporting aquatic life and recreational uses. Martins Pond is listed under the Massachusetts Year 2004 Integrated List of Waters (303d list) as an impaired water body due to **turbidity**, **noxious aquatic plants**, **exotic species** and **metals**. Turbidity levels are such that the Pond does not meet minimum clarity for swimming, and a local beach that offered swimming at one time, has been closed since 1988. Being on the 303d list, Martins Pond is classified as a *Category 5 Water*, which means it requires a TMDL.

In late 2004, the General Court of the Commonwealth directed the Department of Environmental Protection (DEP) through Chapter 352 of the Acts and Resolves of 2004, Section 78, to expend $300,000 toward the assessment and remediation of Martins Pond. The Town of North Reading agreed to use the funds received from DEP specifically for the purpose of water quality problem identification and mitigation. The Town was given the charge of continuing water quality assessment work conducted on Martins Pond towards the goal of completing a new Diagnostic/Feasibility Study for Martins Pond and an assessment of potential non-point source pollution in the Martins Pond Watershed.

The primary work outlined in the *Scope of Services* (Appendix A) has been completed. This report describes the over year-long study results of the project and represents the Final Diagnostic/Feasibility Study Report for the project. The recommendations in this study offer suggestions as to how the Town of North Reading, the Martins Pond Association and other stakeholders might build on the work presented in this study and improve the water quality, the ecological integrity and the recreation potential of Martins Pond and the entire Martins Pond watershed. Throughout the report, many section headings are followed by an italicized, parenthetical *Scope of Services* code. This code refers to the specific work called for under the approved Scope of Services (Appendix A).

PART I. DIAGNOSTIC STUDY

Section 1.0 The Martins Pond Watershed

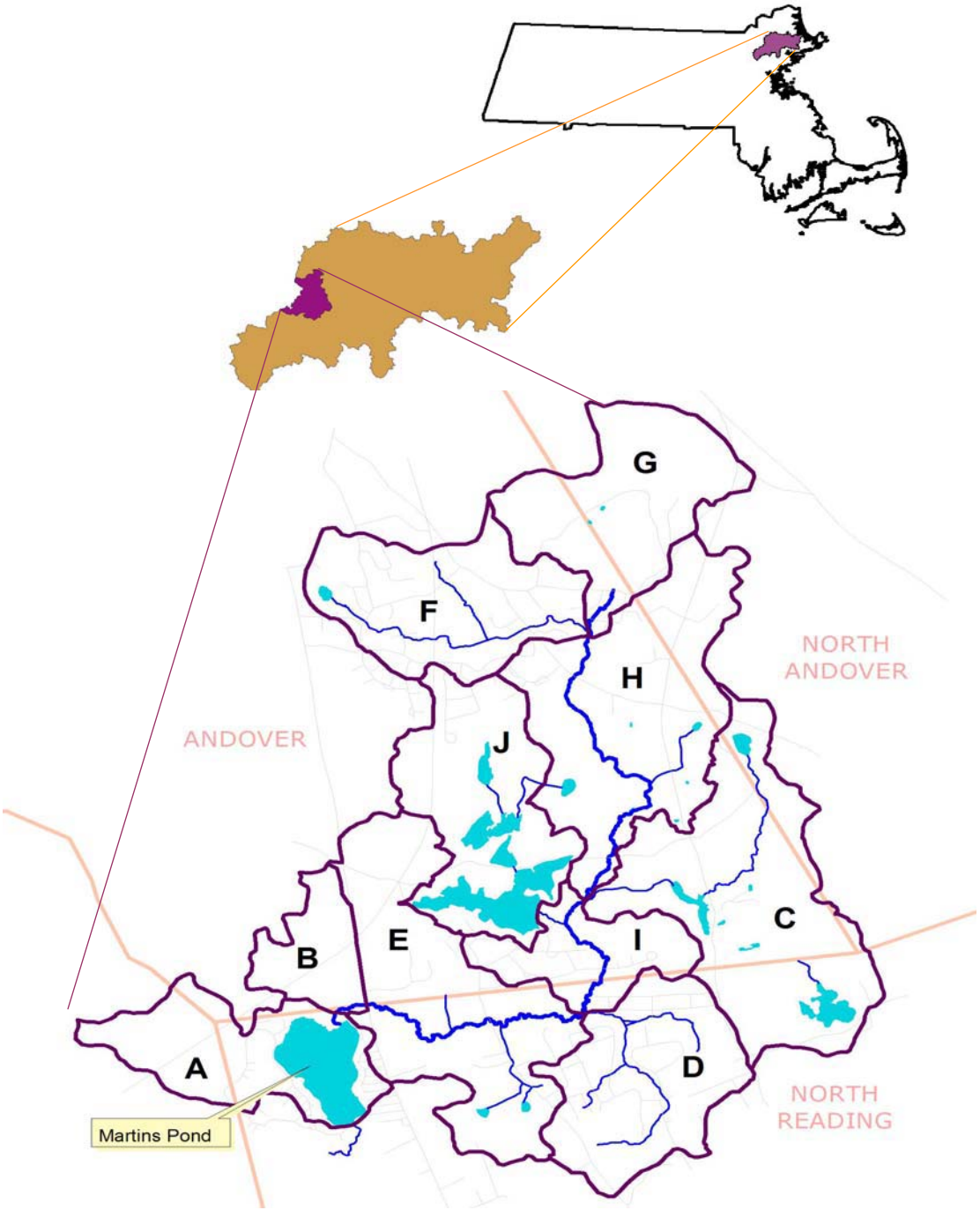

Figure 1. A map showing both the location and area of the Martins Pond watershed relative to the Ipswich River Watershed and the Commonwealth of Massachusetts. Major subwatershed boundaries are also shown (labeled as A through J). The watershed (4927 acres) includes lands in both Essex and Middlesex Counties and is located in EPA Region I.

Figure 1 shows the geographical location and size of Martins Pond and the Martins Pond watershed. Both are located within the 155 mi^2 Ipswich River watershed (MA01102000). The northern portion of the watershed is in Essex County and the southern portion in Middlesex County. The total watershed area calculated for this study, 4927 acres (1994 ha), is slightly higher than previous calculations of 4673 acres (IEP 1977) and slightly less than the 5057 acres presented by Anderson-Nichols and Lycott (1985). However, given the GIS technology available to calculate land areas, it is not surprising that there has been some variance in the determination of area in different decades. More importantly, these differences have no real impact on the interpretation of the study results in the current report. Thus, the 4927 acre figure will be used throughout this report and all watershed-based calculations are based on this value.

The revision of watershed boundaries in the present study reflect more detailed mapping and coincide with the data provided by MassGIS (www.mass.gov/mgis/) and the USGS National Hydrology Dataset (NHD) (nhd.usgs.gov/). The watershed and subwatershed boundaries shown in Figure 1 were revised in 2005 as part of the current study. The watershed includes part of four Towns as noted below:

Town	**Acres**	**% of Total Watershed**
Andover	2865.5	58.2 %
North Andover	577.0	11.7 %
North Reading	1336.5	27.1 %
Wilmington	148.0	3.0 %
Totals	*4927*	*100 %*