

Section 4 – Surface Water Quality Assessment

Figure 14 shows the ten (10) major subwatersheds delineated for the current study and the surface water quality sampling sites (♦) for this project. The bold-faced sites represent samples that are as close as possible to being the outlets for the entire subwatershed. It was impossible to exactly locate all sample sites at the exact outlet to do private property, logistical considerations and safety concerns.

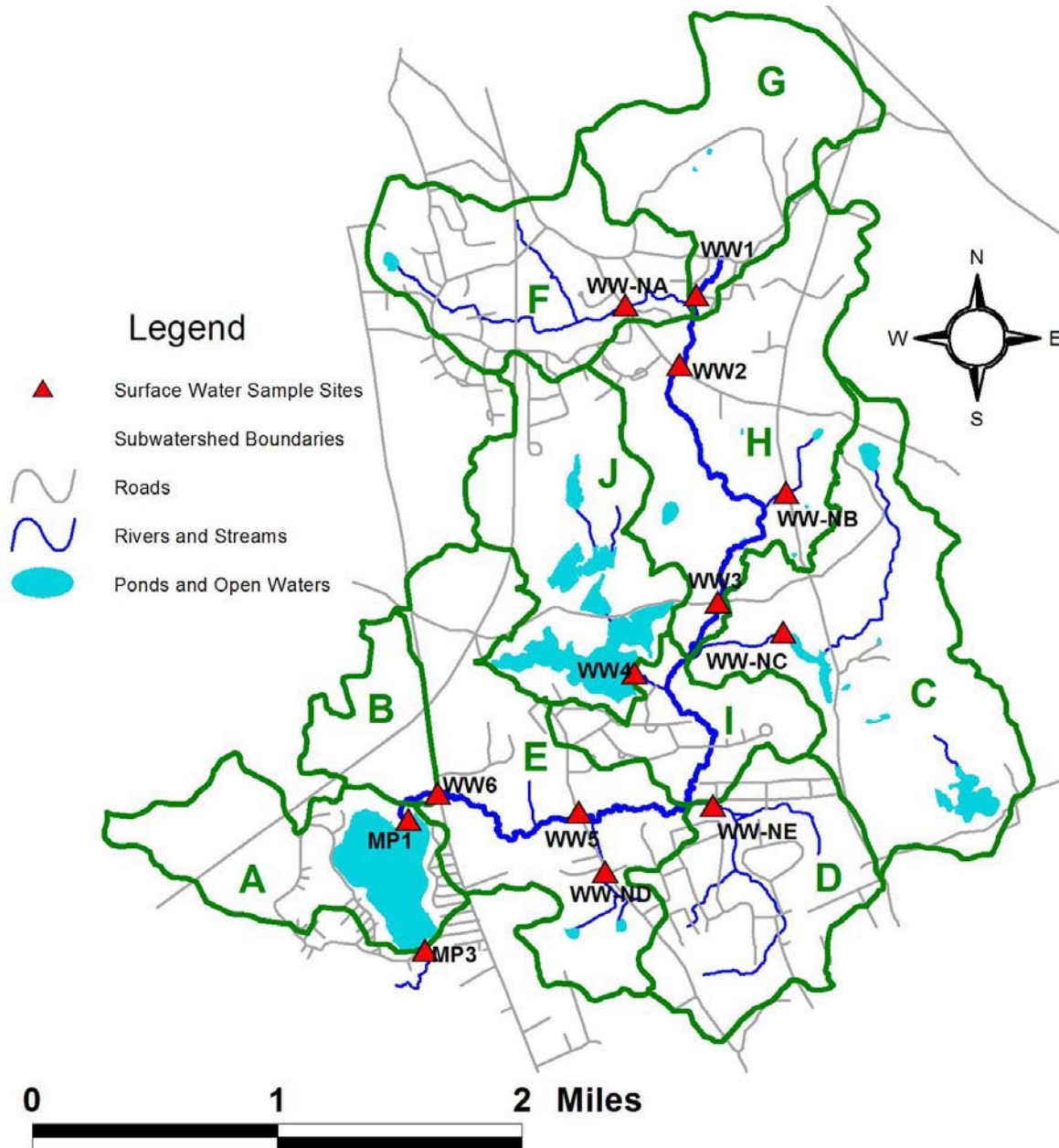


Figure 14. Martins Pond watershed map showing the locations of surface water quality monitoring/sampling sites relative to the 10 major subwatersheds delineated and assessed in this study.

Monitoring Sites

A total of nine (9) primary sites and four (4) supplemental monitoring sites were included in this study. An overview of the monitoring sites is provided in Table 15. The nine primary sites correspond to the 10 subwatersheds delineated for this study. Sampling site WW-5 has been used for the outlet of a combined subwatershed E and I. This was necessary because of limited site access. Thus, all references to WW-5 results in this study refer to a combined subwatershed consisting of catchments E and I.

Table 15. A summary of the surface water quality monitoring/sampling sites used in the current study. The monitoring column refers to years for which water quality data were available.

Site	Subwatershed	Elev - ft	Monitoring
<i>Primary Sites</i>			
*WW-1	G	177	2003-2006
WW-NA	F	164	2005
WW-3	H	90	2003-2006
WW-NC	C	86	2005
WW-4	J	94	2005
WW-5	I	77	2002-2006
WW-NE	D	91	2005
WW-6	E	76	2002-2006
MP-3	A	74	2002-2006
<i>Supplemental Sites</i>			
WW-2	within H	134	2003-2005
*WW-NB	within H	114	2005
WW-ND	within E	79	2005
MP-1	pond inlet	74	2002-2005

* Represent wetland sites

The Scope of Services called for ‘*sampling from an in-lake station, and a minimum of six upstream tributary stations and at least 2 wetland sites.*’ MP-1 and MP-3 represent in-pond stations, WW-1 and WW-NB represent wetland sites and the remaining 9 sampling sites represent upstream tributary stations. Water quality data collected at all these sample sites were also used in combination with flow data to calculate subwatershed loadings.

Elevations of the primary sampling sites are shown in Figure 15. The difference in elevation from the Skug River headwaters to the Martins Pond outlet is some 103 ft.

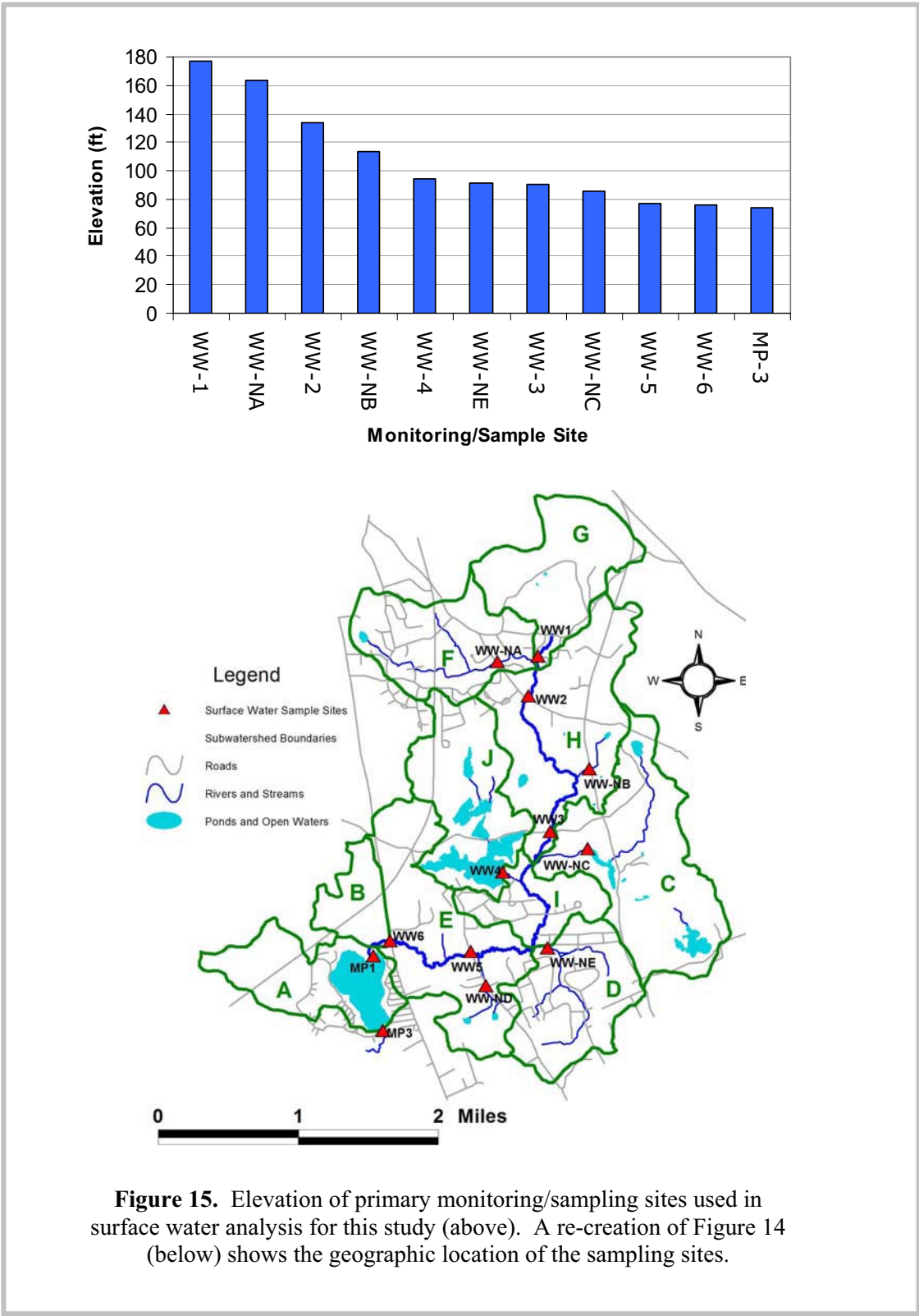


Figure 15. Elevation of primary monitoring/sampling sites used in surface water analysis for this study (above). A re-creation of Figure 14 (below) shows the geographic location of the sampling sites.

Sampling Dates

The Scope of Services called for ‘*bi-monthly (every other month) sampling from an in-lake station, and a minimum of six upstream tributary stations and at least 2 wetland sites.*’ This sampling scheme was achieved in the current study. The dates below on the left represent when surface water samples were collected during the 2005-06 study. Dates below the dotted line show additional sampling that was conducted independently by Merrimack College after March 2006.

Samples Taken

7 March 2005
14 April 2005
10 May 2005
2 June 2005
24 June 2005
13 July 2005
26 July 2005
9 August 2005
23 August 2005
14 September 2005
28 September 2005
14 October 2005
4 November 2005
23 December 2005
14 January 2006
8 February 2006
23 February 2006
21 March 2006

20 April 2006
25 May 2006
7 June 2006
29 June 2006
8 July 2006

4.1 – Quality Assurance Performance Plan - QAPP (Scope of Services 1.b)

A QAPP was developed for the project in late 2004. The QAPP was tentatively approved by the DEP in 2005 and was regularly updated during the 2005-06 study. The QAPP has been submitted along with this report, and is available for review, thus, details as to the methodology and procedures will not be elaborated on in this report. However, a summary of the parameters measured, methods and units is presented in Table 16.

Table 16. A summary of parameters and methods used in the current study.

Parameter	Method Number	Source	Reporting Units	MDL ¹
Temperature, pH, Dissolved Oxygen, Conductivity, Chlorophyll-a	YSI 6920-S Probe	YSI	pH units; DO mg/L; conductivity μ S; chlorophyll-a μ g/L	Temp – 0.1 °C; pH – +/- 0.02 units; DO – 0.5 mg/L.; Chloro-a 3 μ g/L Conductivity 10 μ S
Chlorophyll-a	Method 10200	Standard Methods ²	μ g/L	n/a
Turbidity	Method 180.1.	EPA	NTU	0.02 NTU
Total Suspended Solids	Method 2540 D Method 2540 E	Standard Methods	mg/L	0.0001 g
Apparent Color	Method 2120B	DWM	PCU	15 PCU
Ortho Phosphorus	Method 4500-PE	Standard Methods	μ g/L	15 μ g/L
Total Phosphorus ³	Method 4500-PB.5 Method 4500-PE	Standard Methods	μ g/L	7 μ g/L
Nitrate	Method 300.0	EPA	mg/L	0.030 mg/L
Nitrite	Method 300.0	EPA	μ g/L	0.015 mg/L
Total N	Method 4500-N C.	Standard Methods	mg/L	n/a
Chloride	Method 300.0	EPA	mg/L	0.060 mg/L
Fecal Coliform Bacteria ⁴	9222(D) for Membrane Filter Technique	Standard Methods	Number of colonies per 100ml	n/a
<i>E. coli</i> ⁴	9222(D) for Membrane Filter Technique	Standard Methods	Number of colonies per 100ml	Determined by DEP certified laboratory
Secchi Depth	SOP Lakes-3	MassWWP	m	n/a
Light Attenuation	Vertical PAR measurements	LI-COR 250	μ mol/cm	8 μ mol/cm
Flow Rate		Flo-Mate 2000	cfs (ft ³ /sec)	0.02 ft ³ /sec

¹ MDL = Minimum Detection Limit

² APHA (1998)

³ Split samples (18% of total samples) sent to UMass Environmental Analysis Laboratory for QC

⁴ All bacteria samples (fecal coliform colonies and *E. coli*) were analyzed at The Andover Water Treatment Plant Laboratory, 397 Lowell Street, Andover, MA 01810 (Mass Lab ID MA005).

4.2 – Overview of Water Quality Assessment Objectives

In the approved Scope of Services for the project, it is noted that water quality assessment should focus on resolving why the tributaries and Martins Pond vary from year to year in total phosphorus and other parameters and if the high levels are due to a natural source such as wetlands or due to anthropogenic pollution.

Given this charge, water quality monitoring and assessments were both focused at and conducted at the subwatershed level. A total of 10 major subwatersheds were delineated (labeled A through J) for water quality monitoring purposes. These 10 subwatersheds were further delineated into 29 individual catchments for SWMM hydrological and hydraulic modeling purposes.

To assist with the interpretation of the surface water quality results and to correlate the results with land use patterns, we determined the percent coverage for a range of land use categories in each subwatershed. The results of that analysis are presented in Table 17. Land use layers from MassGIS were corrected using recent DEP wetland layers as well as detailed, smaller-scale surface water layers. Thus, the final land use polygons (and their corresponding areas found in the attribute tables) used to determine the land use area coverages shown in Table 17 reflect modified MassGIS land use data. The correction of MassGIS data was necessary given the relatively small-scale of the subwatersheds and the need for accurate and non-overlapping land coverage shapefiles.

Table 17. A comparison of relative percent land use cover on the ten study subwatersheds. Subwatershed J has been used as a reference watershed because of its low residential land use cover, high forest cover and its relatively low disturbance levels in the past 50 years. Subwatershed J is mostly within the Harold Parker State Forest. The total area of each subwatershed (acres) is also provided.

Percent Land Use in Each Major Subwatershed										
Land Use	A	B	C	D	E	F	G	H	I	J
Cropland	0.6				0.6	2.0	0.9			
Pasture			0.2			3.1	3.1			2.2
Forest	30.7	32.6	67.0	27.4	36.8	34.1	55	44.2	32.5	59.5
Wetland	16.0	23.0	15.8	7.4	16.1	8.0	21.9	17.3	21.5	7.3
Mining						0.3				
Open Land	0.4			0.3	8.1	1.1	0.5		0.8	
Participation Recreation		4.0		1.5	4.6					
RO Residential		5.9								
R1 Residential	7.0	4.9	1.4	8.5	3.6	31.3		9.6	3.0	4.2
R3 Residential	17.7	4.6	11.7	54.0	24.4	19.6	17.7	28.6	41.8	5.9
Commercial	0.7	4.2	0.2	0.4	0.1			0.3		
Industrial	2.8		0.7							
Urban Open		1.3	0.2	0.5	4.1	0.1	0.6		0.3	
Transportation		13.1			0.6					
Waste Disposal			0.5							
Water	23.5	2.5	2.3		1.0	0.4		0.1		20.9
Woody Perennial	0.6	3.9					0.3		0.1	
Total Cover	100	100	100	100	100	100	100	100	100	100
Total Area - acres	394.2	308.0	749.7	467.2	593.9	478.7	472.2	754.9	242.0	466.1
Surface Water Sampling Point Code	MP-3	WW-6	WW-NC	WW-NE	WW-5	WW-NA	WW-1	WW-3	WW-5	WW-4

Section 5 – Surface Water Chemistry in Subwatersheds (*Scope of Services 1.c*)

During the 2005-06 study period, all surface water quality samples were analyzed for numerous parameters as outlined in Table 16. Parameters analyzed included temperature (°C), pH, conductivity (µs/cm), dissolved oxygen (mg/L), turbidity (NTU), color (PCU), total suspended solids (mg/L), chlorophyll-a (µg/L), total P (µg/L), total N (mg/L), nitrate (mg/L), chloride (mg/L) and sulfate (mg/L). Appendix C contains a summary of the water quality analysis results during the study period. Flow measurements were also collected at each site when possible and those results are presented later in this report in Section 9. Fecal coliform bacteria and *E. coli* were also analyzed at 10 sites for each sampling period.

It should be noted that due to the low summer rainfall conditions, the Skug River and its tributaries in the upper reaches of the watershed exhibited very low or no flow conditions during some sample periods in later summer and early fall 2005, so neither complete surface water nor flow samples could be taken on some sample dates.