## Section 11 – Fecal Coliform/E. coli Levels and Bacterial Source Tracking

*(Scope of Services 1.i)*

The fecal coliform and *E. coli* levels were assessed at ten (10) sampling sites during the 2005-2006 study period. These data were supplemented with data from 2002-2004 collected by Merrimack College. The fecal coliform results for this portion of the study are presented in Table 40. It should be noted that all fecal coliform and *E. coli* sampling occurred during non-storm events and at least 24 hours following any rainfall.

The fecal coliform standard for Class B waters in Massachusetts is as follows:

> *Fecal coliform shall not exceed a geometric mean of 200 organisms per 100 ml in any representative set of samples nor shall more than 10% of the samples exceed 400 organisms per 100 ml. This criterion may be applied on a seasonal basis at the discretion of the Department.*

There is one private wastewater treatment plant in the Martins Pond watershed located at the Colonial Drive Condominiums in Andover, MA (Permit 96-2). Based on operator reports obtained from the facility to the Andover Board of Health, the plant releases some 12 to 13,000 gallons of effluent per day. In addition, there are four monitoring wells on the property where water quality is monitored. Based on records reviewed from 2003 to mid-2005 prepared by Martinage Engineering Associates, Inc. (Reading, MA), this facility has not been a point source of fecal coliform release at any level of concern.

### Section 11.1 – Fecal Coliform and *E. coli* Results

Table 38 summarizes the fecal coliform data available during non-storm events in Martins Pond and its watershed from 2002 to 2006. While there was variability in fecal coliform at all sampling sites in Martins Pond and the Skug River, sites WW5 (subwatersheds E and I) and WW2 (subwatershed F) exhibited both the highest maximum values and the highest overall means for the 2005-06 study. Except for the headwater wetland site (WW-1), all sites exceeded the standard at least once.

**Table 38.** A comparison of fecal coliform levels during non-storm events in Martins Pond and its watershed. All samples were collected at least 24 hours after any rainfall event. The units of all results are colonies/100 ml. MP refers to Martins Pond. All values ≥ 200 colonies are highlighted in yellow.

| Date | Sampling Sites in Martins Pond and Along Skug River | | | | | |
|---|---|---|---|---|---|---|
| | **MP** | **WW6** | **WW5** | **WW3** | **WW2** | **WW1** |
| 4/17/02 | 13 | | | | | |
| 5/30/02 | 303 | | | | | |
| 6/3/02 | 40 | | | | | |
| 6/13/02 | 8 | | | | | |
| 6/27/02 | 8 | | | | | |
| 7/11/02 | 8 | | | | | |
| 7/23/02 | 10 | | | | | |
| 8/12/02 | 17 | | | | | |
| 9/13/02 | 28 | | | | | |
| 9/26/02 | 16 | | | | | |
| 10/17/02 | 68 | | | | | |
| 10/31/02 | 12 | | | | | |
| 11/14/02 | 10 | 20 | 240 | | | |
| | | | | | | |
| 2/20/03 | <10 | | | | | |
| 3/6/03 | 10 | 10 | 110 | <10 | 30 | <10 |
| 3/20/03 | 5 | 5 | 25 | 5 | 5 | <5 |
| 4/03/03 | 25 | 10 | 15 | 20 | 5 | <5 |
| 4/17/03 | 10 | 5 | 30 | 5 | <5 | <5 |
| 5/01/03 | 13 | 10 | 18 | 3 | 50 | <3 |
| 5/21/03 | 4 | 84 | 224 | 48 | 24 | 8 |
| 6/05/03 | 24 | 12 | 116 | 16 | 32 | <4 |
| 6/24/03 | 8 | 380 | 360 | <4 | 120 | 8 |
| 7/16/03 | 28 | 76 | 380 | 44 | 116 | 52 |
| 7/31/03 | 8 | 72 | 104 | 36 | 306 | 24 |
| 8/21//03 | 28 | 152 | 208 | 48 | 344 | <4 |
| 9/18/03 | 22 | 216 | 164 | 104 | 600 | 84 |
| 10/15/03 | 22 | 200 | 68 | 248 | 120 | <4 |
| 11/12/03 | 14 | 20 | 100 | 12 | 4 | <4 |
| 12/04/03 | 16 | 348 | 240 | 12 | - | <4 |
| | | | | | | |
| 3/7/05 | 40 | 20 | 40 | 20 | 10 | <5 |
| 4/14/05 | 200 | 20 | 120 | <10 | 10 | <10 |
| 5/10/05 | <5 | 200 | 50 | 10 | 5 | 10 |
| 6/2/05 | 10 | 20 | 20 | 20 | 60 | 60 |
| 6/24/05 | * | * | * | * | * | * |
| 7/13/05 | 5 | 66 | 125 | 60 | 45 | 20 |
| 7/26/05 | 5 | 20 | 100 | 25 | 200 | 45 |
| 8/9/2005 | 30 | 30 | 125 | 10 | 350 | 5 |
| 8/23/05 | 22 | 50 | 250 | 25 | 70 | 20 |
| 9/14/05 | 250 | 90 | 55 | 30 | 130 | 35 |
| 10/19/05 | 22 | 80 | 45 | 60 | 60 | 50 |
| 11/9/05 | 20 | 20 | 4 | 20 | * | 40 |
| 12/22/05 | 24 | 60 | 180 | 20 | * | 4 |
| 1/10/06 | 4 | 35 | 35 | 4 | * | 10 |
| 1/24/06 | 452 | 20 | 35 | 4 | * | 4 |
| 2/7/06 | 12 | 4 | 24 | 4 | * | 4 |
| 2/23/06 | 3 | 12 | 24 | 4 | * | 3 |
| 3/21/06 | 3 | 12 | 12 | 3 | * | 3 |
| 4/12/06 | 150 | 50 | 120 | 10 | 10 | 25 |
| 6/7/06 | 35 | 75 | 80 | 20 | 10 | 5 |
| 6/29/06 | 60 | 110 | 175 | 20 | 10 | 40 |
| **Means** | **44** | **74** | **108** | **29** | **105** | **17** |

Table 39 summarizes the 2005-06 *E. coli* results for all ten sample sites monitored in this study. Based on these results, *E. coli* appears to be the main constituent of the fecal coliform levels noted in Table 38. Subwatershed D showed the highest mean E. coli levels and also exceeded the standard the most times (19% of total samples).

**Table 39.** *E coli* results for the 2005-06 sample season. All numbers represent colonies /100 ml. MP refers to mean values for Martins Pond. All values > 200 colonies are highlighted in yellow.

| Sampling Sites and Corresponding Subwatershed | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **MP** | **WW6** | **WW5** | **WW3** | **WW2** | **WW1** | **WW4** | **WW-NE** | **WW-NA** | **WW-NC** |
| Date | *A* | *B* | *E, I* | *H* | *H* | *G* | *J* | *D* | *F* | *C* |
| 3/7/2005 | <10 | 15 | 45 | <10 | 10 | <5 | <10 | 20 | <10 | <10 |
| 4/14/2005 | <5 | 20 | 60 | <10 | 10 | <10 | <10 | 20 | 10 | <10 |
| 5/10/2005 | <5 | 190 | 45 | 5 | 5 | 10 | <5 | 20 | 10 | <5 |
| 6/2/2005 | 10 | 20 | 20 | 20 | 60 | 60 | <5 | 40 | 50 | 15 |
| 6/24/2005 | * | * | * | * | * | * | * | * | * | * |
| 7/13/2005 | <5 | 30 | 30 | 45 | 35 | 15 | <5 | 75 | 30 | 10 |
| 7/26/2005 | <5 | 20 | 90 | 25 | 200 | 45 | <5 | 150 | 55 | 15 |
| 8/9/2005 | 15 | 25 | 100 | 5 | 300 | <5 | <5 | 250 | 45 | 45 |
| 8/23/2005 | 20 | 40 | 200 | <5 | 20 | 60 | 20 | 225 | 20 | 10 |
| 9/14/2005 | 250 | 85 | 50 | 10 | 120 | 30 | <5 | 180 | 20 | 5 |
| 10/19/2005 | 20 | 80 | 40 | 50 | 30 | 50 | 15 | 140 | <5 | 50 |
| 11/9/2005 | 40 | 19 | <5 | 20 | 35 | 20 | <5 | <5 | <5 | 10 |
| 12/22/2005 | <5 | 30 | 19 | <5 | * | <5 | 19 | 1000 | 20 | * |
| 1/10/2006 | <5 | 35 | 35 | <5 | * | <5 | <5 | 55 | 10 | 10 |
| 2/7/2006 | 900 | <5 | 24 | <5 | 25 | <5 | <5 | 1000 | * | <5 |
| 2/23/2006 | <5 | 8 | 24 | <5 | 10 | <5 | <5 | 72 | 24 | <5 |
| 3/21/2006 | <5 | 12 | 12 | <5 | 20 | <5 | <5 | 3 | 12 | 20 |
| 4/20/2006 | 10 | 20 | 12 | 5 | 20 | 10 | 10 | 30 | 40 | 15 |
| 5/25/2006 | 20 | 120 | 45 | 10 | 25 | <5 | 10 | 40 | 65 | 10 |
| 6/7/2006 | 30 | 75 | 50 | 20 | - | <5 | <5 | 75 | 200 | 10 |
| 6/29/2006 | 45 | 110 | 175 | 20 | - | 35 | <5 | 100 | 150 | 20 |
| 7/8/2006 | 20 | 80 | 90 | 10 | 20 | 15 | <5 | 185 | 120 | 20 |
| **Means** | **68** | **49** | **56** | **14** | **56** | **19** | **7** | **184** | **45** | **15** |

The results in Table 39 indicate that subwatersheds D (WW-NE), H (WW2) and E & I (WW5) are the most consistently problematic for *E. coli*. These same watersheds also showed relatively high levels of fecal coliform. Taken as a whole, only some of the sample dates and sites had levels above the Class B standard (200 colonies / 100 ml). Even given the high number and density of septic systems (see Section 11.2) throughout most of the subwatersheds, overall there was no positive correlation between residential land cover and *E. coli* or fecal coliform levels. Thus, certain subwatersheds seem more prone to higher fecal coliform and *E. coli* levels. The IEP (1977) study also noted that subwatershed D (WW-NE) was problematic in terms of fecal

coliform levels. Any efforts to potentially address the issue of high fecal coliform and/or *E. coli* levels will need to start in those subwatersheds with the highest observed bacterial levels. Remember also that all the results in Tables 38 and 39 represent samples during non-storm events. It is very likely that during storm events the bacterial levels would be much higher.

The use of subwatershed J as a reference watershed in this study again seems warranted by these data. This subwatershed showed consistent and low levels of *E. coli* and fecal coliform throughout 2005-06. Not surprisingly, it also has the lowest residential density of any subwatershed and the highest percentage of forest cover. This result provides supporting evidence that fecal coliform sources in the Martins Pond watershed are at least in part, human sources.

## 11.2 - Septic Systems

An investigation into the age of septic systems within the Martins Pond watershed was also conducted to determine any patterns across the watershed and within any of the subwatersheds. The septic system mapping results are presented in Figures 39A and 39B. The age of individual property septic system was gleaned from records in Town Offices in both North Reading and Andover as well as from GIS data. While it was not possible to piece together a complete picture that included all property parcels, some 87% of the properties in the watershed had their septic systems aged. The results presented show both the distribution of homes in the watershed and a general sense of the variation in age of septic systems by subwatershed.

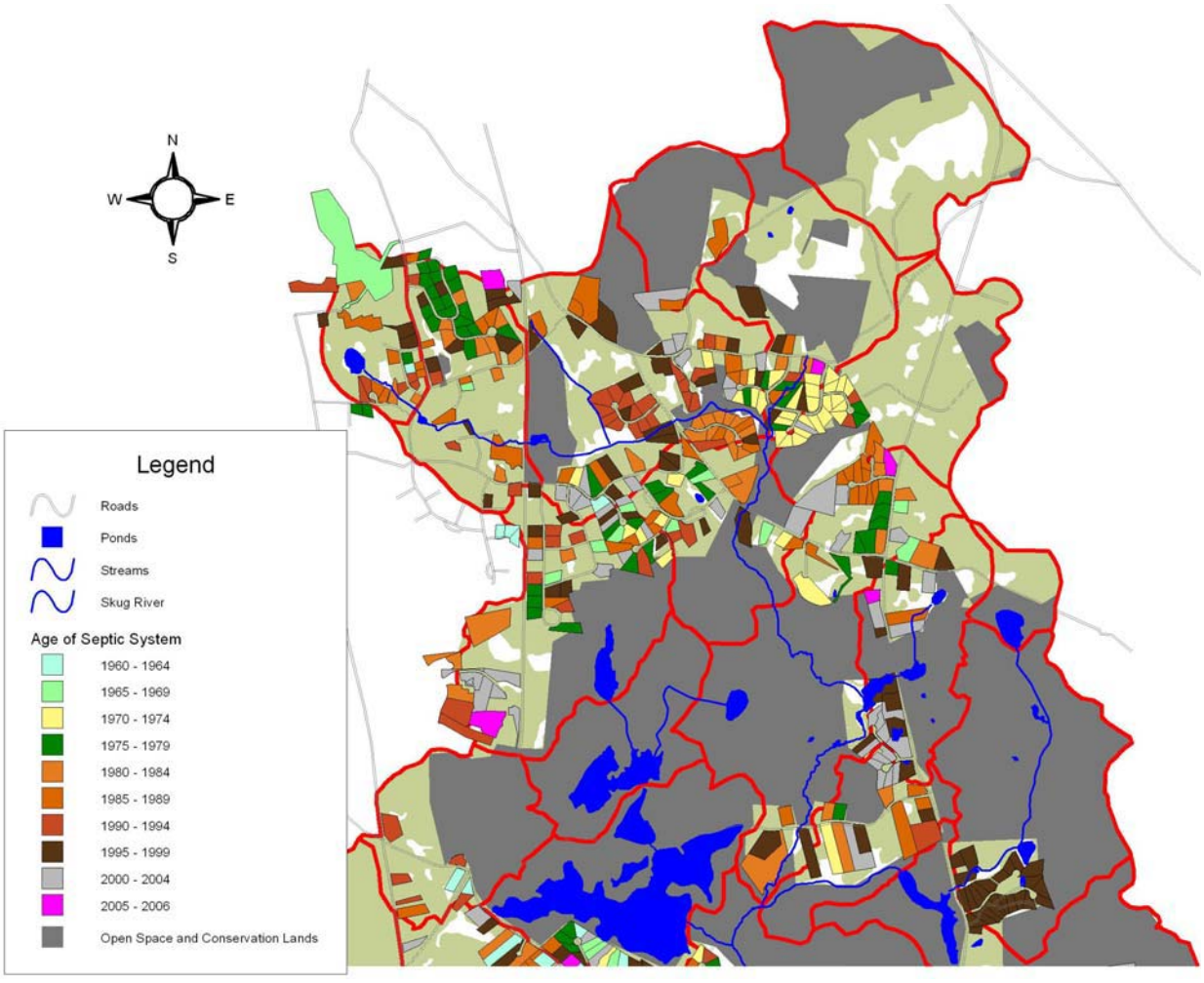



**Figure 39A**. A summary of septic system ages in the northern portion of the Martins Pond watershed. Septic age is color coded in five-year categories. Land ownership parcels are shown as are the conservation and open lands (gray) in the watershed. During the 2005-06 study, all the homes and building in the watershed had septic systems. The lone exception is the Colonial Arms Apartments which has its own on-site waste treatment facility.

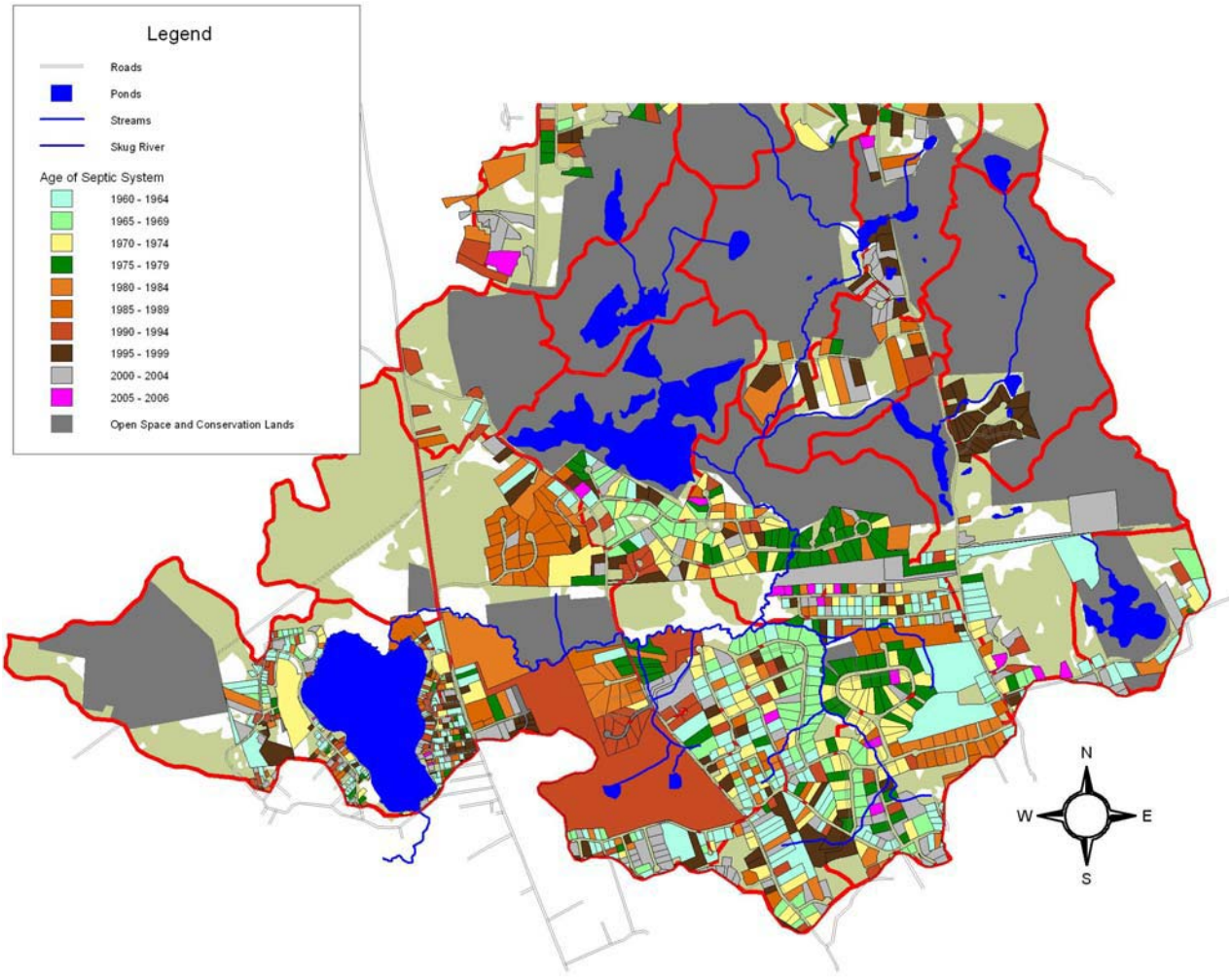



**Figure 39B**. A summary of septic system ages in the southern portion of the Martins Pond watershed. Septic age is color coded in five-year categories. Land ownership parcels are shown as are the conservation and open lands (gray) in the watershed. During the 2005-06 study, all the homes and building in the watershed had septic systems. The lone exception is the Colonial Arms Apartments which has its own on-site waste treatment facility.

Based in part, on the results presented in Figures 39A and 39B, the mean and median age of septic system for each of the 10 main subwatersheds in this study was calculated. Those results are presented in Table 40.

**Table 40.** Results of septic system age study conducted by subwatershed.

| Subwatershed | Area (acres) | Mean Age | Median Age | Std Dev | Number of Septics | Septic Density* |
|---|---|---|---|---|---|---|
| **A** | 392 | 1980.1 | 1982 | 16.1 | 250 | 0.64 |
| **B** | 305 | 1984.5 | 1987 | 14.9 | 72 | 0.24 |
| **C** | 746 | 1984.5 | 1991 | 16.5 | 99 | 0.13 |
| **D** | 464 | 1976.8 | 1974 | 14.3 | 417 | 0.90 |
| **E** | 590 | 1983.6 | 1986 | 14.2 | 213 | 0.36 |
| **F** | 474 | 1988.2 | 1988 | 9.4 | 165 | 0.35 |
| **G** | 470 | 1985.8 | 1984 | 12.7 | 36 | 0.08 |
| **H** | 752 | 1986.4 | 1986 | 11.4 | 137 | 0.18 |
| **I** | 241 | 1979.8 | 1976 | 11.8 | 134 | 0.56 |
| **J** | 466 | 1985.3 | 1987 | 13.8 | 87 | 0.19 |

* estimated number of septic systems per acre based on parcel and septic system mapping

The results in Table 40 indicate that subwatershed D has the oldest mean and median age septic systems of any in the Martins Pond watershed. This subwatershed also exhibited some of the highest fecal coliform and *E. coli* levels as shown in Table 39. Subwatershed D also exhibits the highest density of septic systems of any subwatershed. Thus, there is clearly a positive correlation between the age and density of septic systems with the observed higher levels of both fecal coliform and *E. coli* in surface waters. Subwatershed A includes the properties adjacent to Martins Pond. It had the second highest septic density in the Martins Pond watershed and the third oldest mean and median septic age.

### Adjacent Properties to Martins Pond

There is a relatively high density of homes surrounding Martins Pond. The homes within the 100 m buffer zone surrounding the pond are shown in Figure 40. As noted previously the Martins Pond subwatershed (A) has the second highest septic density and second oldest mean and median septic age in the entire watershed. Septics systems in this zone are the likely contributors to any human sources of fecal coliform and *E. coli* into Martins Pond.

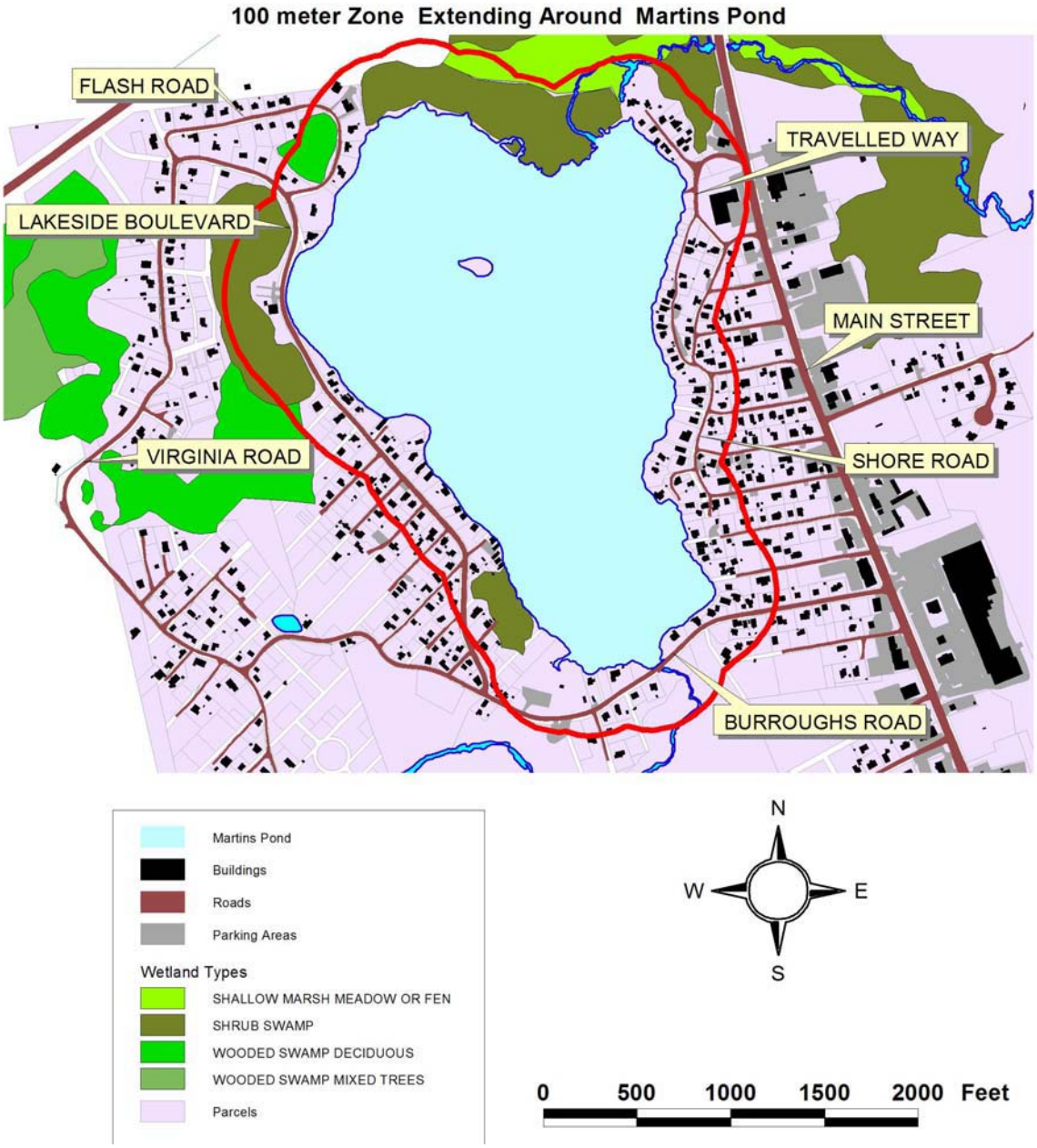
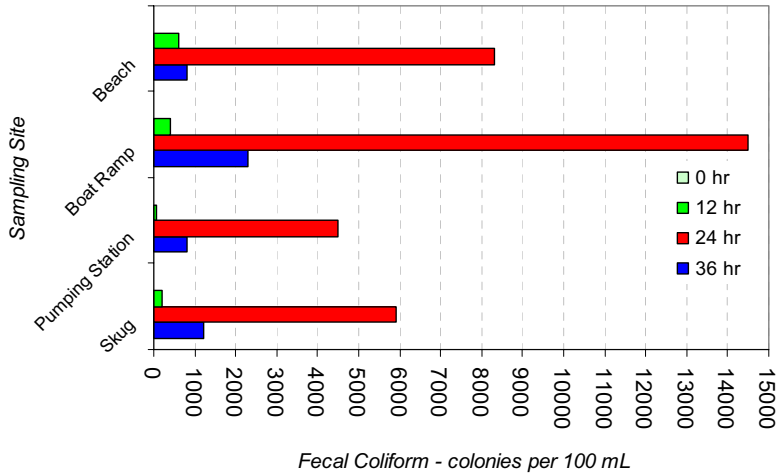



**Figure 40**. Map showing the 100 m buffer zone around Martins Pond. Within this zone are septic systems that are most likely to impact water quality in the Pond. The 100 m zone has been utilized in developing nutrient export models for surface waters.

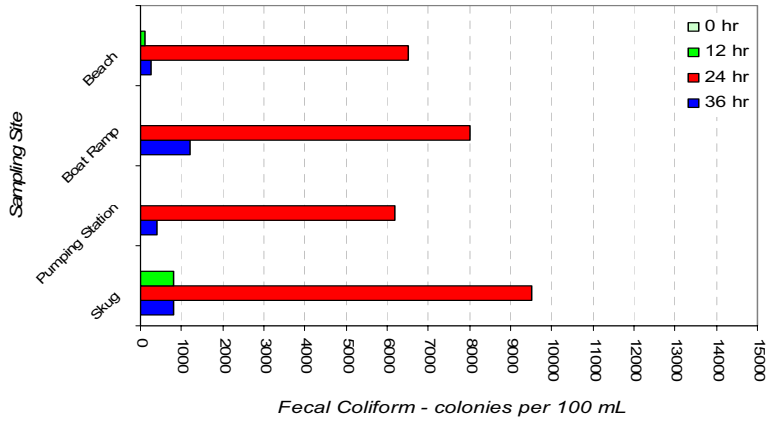
### 11.3 - Storm Event Bacterial Levels in Martins Pond

Since 2002, Merrimack College has been monitoring fecal coliform bacteria in and around Martins Pond. Part of this monitoring effort has focused on bacterial levels during moderate storm events. Figure 41 shows the results of three storm event samples taken at different locations around Martins Pond on 15-17 October 2002, 16-18 June 2004 and 20-21 April 2005. Samples were collected every 12 hours starting immediately before rainfall and concluding after rainfall had ended. Sample collection and analysis followed the project QAPP.

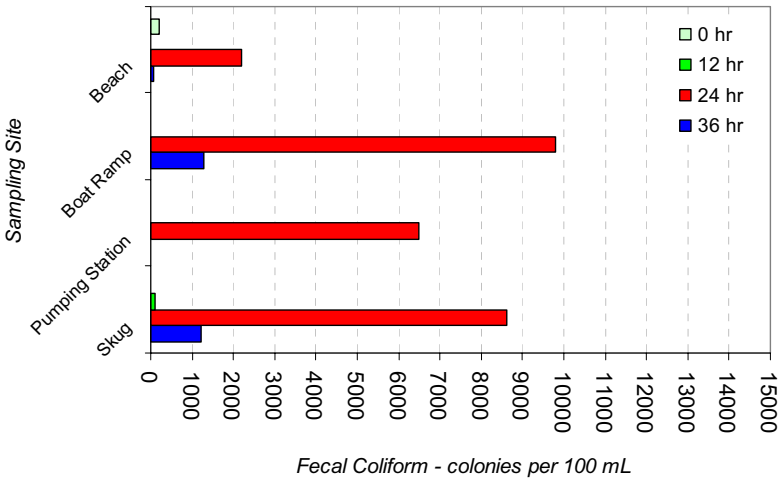
Figure 41 shows that fecal coliform levels exceeded the standard for a Class B water in Martins Pond during each storm event. The likely sources of these high bacterial levels during storm events increases include effluent from septic systems around the pond, animal and pet wastes and wildlife feces. Bacterial levels exceeded 4,000 colonies at each site and each date with levels as high as 14,500 colonies per 100 mL observed at the boat ramp on 16 October 2002. Regardless of the source, swimming and contact recreation in Martins Pond is not advised during or immediately after rainfall events. Fecal coliform levels spike during rain events and residents around Martins Pond and other users should be fully aware of the potential health risks of swimming under these impaired water conditions.




15-17 October 2002




16-18 June 2004




20-21 April 2005

**Figure 41**. A comparison of fecal coliform levels at three different sampling periods (in 2002, 2004, 2005) at four specific locations around Martins Pond: the Town Beach of Burroughs Road, the Public Boat Ramp off of Travelled Way, opposite the Pumping Station off Lakeside Boulevard and at the Route 28-Skug River crossing (WW-6).

## 11.4 – Bacterial Source Tracking

Given the results in Tables 26 and 27, human source tracking of bacteria in the surface waters of the Martins Pond watershed should be pursued. There is ongoing work between Merrimack College and the Senator William X. Wall Experiment Station (WES) in Lawrence, MA. The Station is part of the Division of Environmental Analysis in the DEP. There is still an opportunity in 2007, using specific protocols and techniques developed at the Wall Experiment Station (Tang et al. 2005) to assess whether or not the fecal pollution in Martins Pond and its watershed is of human origin.

An overview of a potential sampling design is as follows:

- Subwatershed A: location (Martins Pond) - five samples (5) taken from household septic systems and three (3) from ambient surface water sampling points (MP1, MP2, MP3).

- Subwatershed D: location (Anthony Road Area) - five (5) samples taken from a household septic system and one (1) from an ambient surface water sampling point (site WW-NE).

- Subwatershed J: location (Fields Pond)- zero (0)samples taken from a household septic system and one sample taken from an ambient surface water sampling point (WW-4).

The following assays could be performed by Wall Experiment Station (WES):

- MFC-MF-SM 9222D
- *E.Coli*-MF-EPA 1603
- *Enterococcus*-MF-EPA 1600
- *Bacteroides* Human Marker-PCR
- *Enterococcus* Human Marker-PCR
- FWA (Fluorescent Whitening Agent)- This assay will be performed on
- ambient waters only.
- Caffeine-GC/MS-Assay not available for first round testing

A QAPP (Quality Assurance Project Plan) will need to be created to pursue this line of investigation.

**Section 12 – Stormwater Conveyance**

It was not in the Scope of Services of this project to directly analyze stormwater impacts on water quality or analyze existing stormwater conveyance systems. Nonetheless, during the study, certain conveyance features within the watershed were mapped, including all catch basins, many stormwater conveyance drainage systems and all outfalls. All outfalls within 100 ft of surface waters, tributaries or the main stem of the Skug River were mapped and are shown in Figure 42 (in red) along with all other stormwater outfalls within the Martins Pond watershed. Outfalls around Martins Pond are not shown in detail in this figure.

The highest density of outfalls that occur within the 100 ft zone are in the southern portion of the watershed in subwatersheds D and E. Not surprisingly this high density of outfalls in subwatershed E is in a relatively dense residential district. Details on the 43 outfalls located within the 100 ft buffer zone (see Figure 39) are provided in Table 41. These 43 outfalls would be the logical starting point for implementing stormwater BMPs.