

**Mount Hope Bay  
Kickemuit River Wet Weather  
Bacteria Sampling 2006**

**Final Data Report**

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## **ABSTRACT**

This report describes the results of a water quality investigation that was undertaken by the Rhode Island Department of Environmental Management (DEM) to support a Total Maximum Daily Load (TMDL) evaluation of Mount Hope Bay and the Kickemuit River, located in the northeast portion of the Narragansett Bay estuary in Rhode Island. Two separate wet weather surveys were conducted during June and October of 2006. The Massachusetts Division of Marine Fisheries (MADMF) Shellfish Sanitation and Management staff concurrently collected samples for fecal coliform analysis from a majority of established stations within growing areas in Mount Hope Bay, Taunton River, Lee River, and Coles River during the June wet weather sampling event. In addition to estuarine fecal coliform sampling, RIDEM staff collected samples from prioritized outfalls and streams that were analyzed for fecal coliform bacteria and male-specific coliphage.

The main objectives of the study were to: (1) characterize bacteria conditions at existing shellfish sampling stations in Mt. Hope Bay and the Kickemuit River during periods of wet weather, (2) expand the geographical scope of the study area to include upper Mount Hope Bay, Taunton River, Lee River, and Cole River-all located within Massachusetts, (3) evaluate human and non-human bacterial contributions to the study area from prioritized sources in Rhode Island, and (4) assess the spatial and temporal extent of bacterial pollution during ‘typical’ wet weather events in the study area.

The technical approach to wet weather sampling study consisted of the following: determination of frequency and duration of bacterial sampling at current shellfish sampling stations; prioritization and selection of source sampling stations based on the results of prior sanitary surveys and follow up investigations; analysis of data and follow up on suspected sources of human-derived bacteria.

Results of the sampling indicate that the majority of Mount Hope Bay and the Kickemuit River exceeded the state’s water quality standards for fecal coliform bacteria in Class SA and SB waters during both wet weather events. The sanitary quality of the bay appears to be primarily dominated by sources within the Fall River area (combined sewer overflows and stormwater runoff), as well as upstream sources in the Taunton River. Smaller sources exist within Rhode Island and have a notable, although localized impact on water quality during wet weather events, particularly in the Kickemuit River.

Several significant sources of contamination were identified during the water quality studies. Sources of primary concern were the combined sewer overflow discharges from the City of Fall River, MA, stormwater outfalls located in the northern portion of the Kickemuit River within the Town of Warren and several outfalls located in Bristol, RI and the northern portion of Tiverton, RI which discharge directly to Mount Hope Bay. These are the sources of contamination to Mount Hope Bay and the Kickemuit River which merit the highest consideration for resources allocated to both illicit discharge detection investigations and pollution abatement measures.

## 1.0 INTRODUCTION

Mount Hope Bay and the Kickemuit River are on Rhode Island's 2008 303(d) list of impaired waterbodies due to violations of one or more water quality criteria. Portions of Mount Hope Bay are included on the 2008 303(d) list of impaired waters for low dissolved oxygen, nutrients, biodiversity impacts, thermal modifications, and pathogens. This report summarizes the recent assessment of the bacteriological condition of the estuarine waters during two wet weather events. The Kickemuit River is on the 2008 303(d) list of impaired waterbodies for fecal coliform only.

Section 303(d) of the Clean Water Act and United States Environmental Protection Agency's Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to develop Total Maximum Daily Load (TMDL) studies for waterbodies that are not meeting water quality standards. The objective of a TMDL is to establish water-quality-based limits for pollutant loads that allow the impaired waterbody to meet standards. This report presents sampling data in support of a TMDL under development to address pathogen impairments to Mount Hope Bay and the tidal portion of the Kickemuit River.

The field measurement portion of the TMDL study began in 2006 and included bacteria sampling during two wet-weather events. Sampling was conducted within Mount Hope Bay, the lower Kickemuit River, and also within major tributaries. Sampling of sources (outfalls and streams) was also conducted in 2005 and 2006.

RIDEM staff sampled 26 to 27 stations within the tidal portion of the Kickemuit River and the Rhode Island portion of Mount Hope Bay. During the first wet weather event, staff from the MA Division of Marine Fisheries sampled 30 stations located in Mount Hope Bay and also in three major tributaries to the bay, including the Taunton, Lee, and Cole Rivers. During the second wet weather event, RIDEM staff sampled 26 estuarine stations within the Rhode Island portion of Mount Hope Bay and the tidal Kickemuit River as well as three stations located in Massachusetts near the mouths of the Taunton, Lee, and Cole Rivers.

DEM staff expended significant time and effort conducting shoreline surveys and preliminary sampling to help target sources for wet weather sampling. Sources were prioritized for wet weather sampling based on outfall or stream size, catchment land use, preliminary sampling results, and estimated fecal coliform loadings. This preliminary sampling resulted in sampling at 9 to 14 outfalls and streams during the wet weather events.

This report describes the results of two wet weather water quality surveys that were undertaken to support a Total Maximum Daily Load (TMDL) evaluation of the Mount Hope Bay and the Kickemuit River, located in the northeastern portion of Narragansett Bay, Rhode Island. The main objectives of this water quality investigation were:

1. To investigate the existing sanitary condition of Mount Hope Bay and the Kickemuit River, including the Taunton River, upper Mount Hope Bay, Lee River, and Cole River during wet weather conditions.
2. To assess the spatial and temporal scale of bacterial contamination in the study area under a specified wet weather event.
3. To conduct targeted sampling of prioritized sources of pollution that include streams and outfalls.

## 1.1. STUDY AREA

Mount Hope Bay forms the northeast corner of the Narragansett Bay estuary and covers an area of about 36 km<sup>2</sup> (Figure 1.1). The Rhode Island-Massachusetts State boundary traverses the area in a southeasterly direction. Although over 70% of Mt. Hope Bay is located in Rhode Island, over 90% of its drainage basin is located in Massachusetts. The drainage area covers more than 1476 km<sup>2</sup>. Major rivers discharging into the bay include the Taunton, Cole, Lee, Kickemuit, and Quequechan. Each of these rivers originates and terminates in Massachusetts, with the exception of the Kickemuit, which terminates in Rhode Island waters. The Taunton River is by far the largest freshwater source with a mean daily flow rate of approximately 636 ft<sup>3</sup>/sec (18 m<sup>3</sup>/sec) at its mouth.

Mt. Hope Bay empties into the East Passage of Narragansett Bay and the Sakonnet River. Approximately 70% of the Bay has a mean low water depth of 5.5 meters or less. The mean tide range is approximately 1.4 meters. The average currents are approximately 0.4 and 0.5 knots on the flood and ebb tides, respectively (ASA 1990). Wind direction strongly influences the Bay water's mixing patterns, with the greatest mixing provided by southerly winds (ASA 1990).

The Kickemuit River forms the most northwestern embayment of the Mt. Hope Bay estuary, extending northwest from its mouth at Mt. Hope Bay into portions of the Towns of Swansea and Rehoboth, MA. The Kickemuit River originates in Rehoboth and flows into the Warren reservoir in northern Swansea. From here, the river flows south under interstate 195 and then Rt. 6 toward the MA – RI border where it empties into the Kickemuit Reservoir. The dam at the southern end of the Kickemuit Reservoir marks the boundary between the river's fresh and salt-water segments. Through the remainder of the town of Warren and the northeastern portion of Bristol, the river is tidal.

A description of the applicable waterbodies within the Rhode Island portion of the study area and those waterbodies for which the TMDL study will focus on is given in Table 1.1. Geographic detail of these areas is presented in Figure 1.2.

Designated shellfish waters within the Rhode Island portion of the study area are classified as "Permanently Closed", "Conditional", or "Seasonally Approved" (Appendix A). Regardless of classification, all areas are currently sampled 12 times per year consistent with a conditional approved status. Ten (10) stations are sampled in GA5 (Lower Kickemuit River) and 16 stations are sampled in GA17 (Mount Hope Bay).

Prior to 1996, all waters within GA17 were classified as "Prohibited". In 1995, waters within Mount Hope Bay and the Kickemuit River were re-evaluated by RIDEM. This reevaluation recommended that portions of the area be reclassified from 'restricted' to 'conditionally approved' for the harvesting of shellfish if certain conditions were met. In 2004, Mount Hope Bay was re-classified as "Prohibited" due to unpredictability of fecal coliform concentrations after large precipitation events. In 2008 it was re-classified as "Conditionally Approved" and is currently sampled twelve (12) times per year.

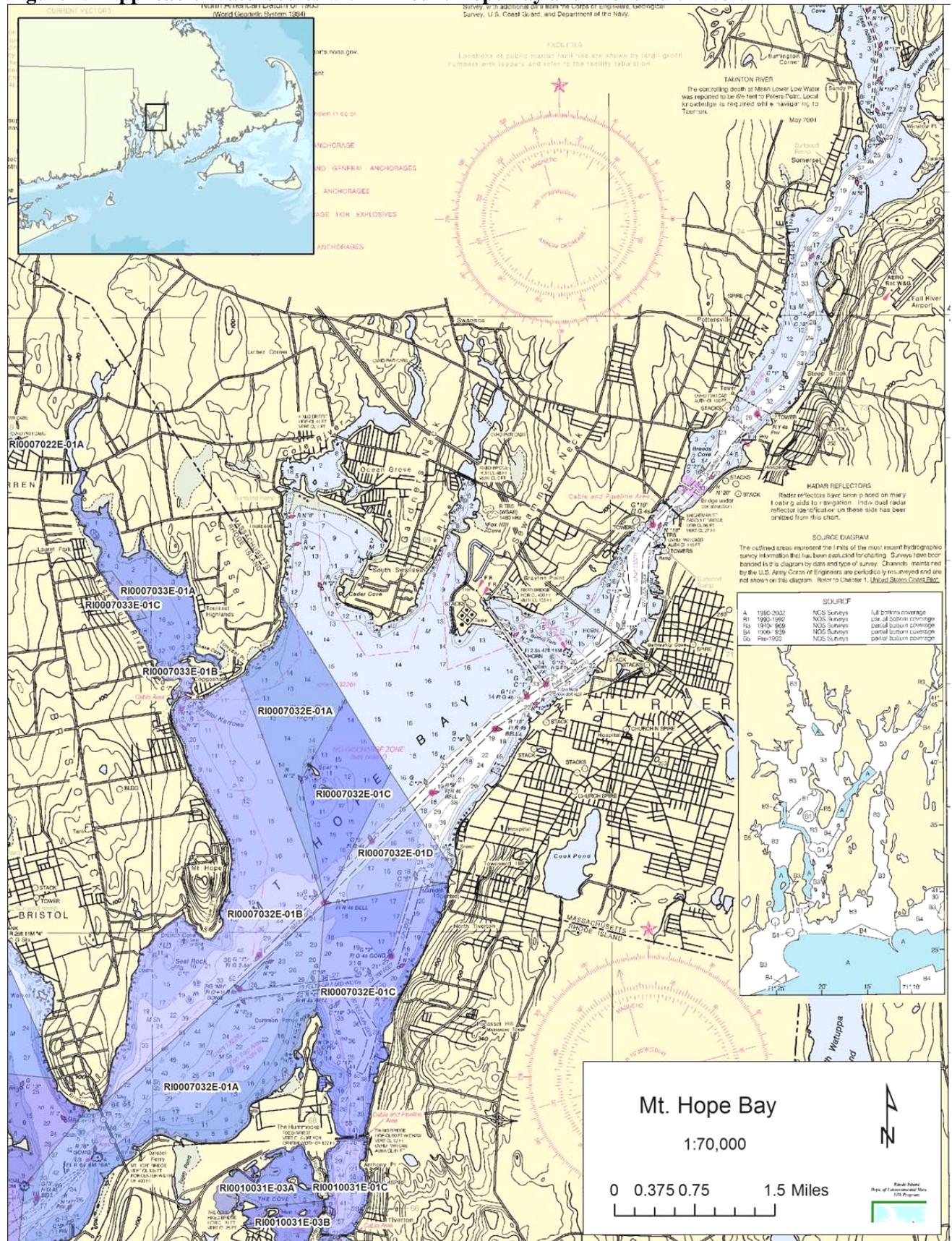
Figure 1.1 General Location of Study Area.



**Table 1.1 Applicable Waterbodies within the Rhode Island Portion of the Study Area.**

Waterbody ID Number	Waterbody Description	Classification
RI0007032E-01D	Mt. Hope Bay waters south and west of the MA-RI border and north of a line from Borden's Wharf, Tiverton to buoy R "4" and east of a line from buoy R "4" to Brayton Point in Somerset, MA. Bristol, Portsmouth, and Tiverton	SB1
RI0007032E-01C	Mt. Hope Bay waters south of a line from Borden's Wharf, Tiverton, to buoy R "4" and west of a line from buoy R "4" to Brayton Point, Somerset, MA, and east of a line from the end of Gardiner's Neck Road in Swansea to buoy N "2" through buoy C "3" to Common Fence Point, Portsmouth, and north of a line from Portsmouth to Tiverton at the railroad bridge at "The Hummocks" on the northeast point of Portsmouth.	SB
RI0007032E-01A	Mt. Hope Bay south and west of the MA/RI border, and east of a line from Touisset Point to the channel marker buoy R "4" and south and east of a line from buoy R "4" to the southernmost landward end of Bristol Point and south of a line from Bristol Point to the Hog Island shoal light to the southwestern extremity of Arnold Point in Portsmouth where a RIDEM range marker has been established; And west of a line from the end of Gardiner's Neck Road, Swansea to buoy N "2", through buoy C "3" to Common Fence Point, Portsmouth excluding the waters defined in RI0007032E-01E below. Warren, Portsmouth	SA
RI0007032E-01B	Mt. Hope Bay waters north and west of a line from the southernmost landward end of Bristol Point to buoy R "4" and west of a line from buoy R "4" to the DEM range marker on Touisset Point, and south of the Bristol Narrows. Bristol, Warren	SA
RI0007033E-01A	Kickemuit River from the Child Street bridge (Route 103) in Warren, south to the river mouth at "Bristol Narrows" excluding the waters described below. Bristol, Warren	SA
RI0007033E-01B	Kickemuit River south of a line from the eastern extension of Kickemuit Avenue in Bristol to the DEM range marker located on the western tip of Little Neck in Touisset, and north of a line from the DEM range markers located on the east shore and west shore at the entrance to the Kickemuit River including the "Bristol Narrows" in its entirety. Bristol, Warren	SAb
RI0007033E-01C	Kickemuit River west of a line from the DEM range marker located on the western tip of Little Neck in Touisset to the brick stack located at 426 Metacom Avenue in Warren (formally known as the Carol Cable Building), north of a line from the eastern extension of Sherman Avenue in Bristol to the western extension of Chase Avenue Touisset, and south of a line from the eastern extension of Harris Avenue in Warren to the "5MPH No Wake" buoy. Bristol, Warren.	SAb

**Figure 1.2 Applicable Waterbodies within Mount Hope Bay and Kickemuit River.**



## **1.2.APPLICABLE WATER QUALITY STANDARDS**

SA, SB, and partial use waters exist within the study area. Designated uses for these waters are described in Rhode Island's Water Quality Regulations, as follows:

**Class SA waters** are designated for shellfish harvesting for direct human consumption, primary and secondary contact recreational activities, and fish and wildlife habitat.

**Class SAb waters** are in the vicinity of marinas and/or mooring fields and therefore seasonal shellfishing closures will likely be required, however all Class SA criteria must be attained.

**Class SB waters** are designated for primary and secondary contact recreational activities; shellfish harvesting for controlled relay and depuration, and fish and wildlife habitat.

**Class SB1 waters** are designated for primary and secondary contact recreational activities and fish and wildlife habitat. Primary contact recreational activities may be impacted due to pathogens from approved wastewater discharges. However all Class SB criteria must be met.

The fecal coliform standards for Class SA, SB, partial use waters are established in Rule 8.D. of DEM's Water Quality Regulations (RIDEM, 2006a). Applicable water quality standards in the study area are designed to protect designated uses of shellfishing and/or primary contact recreation/swimming. Water Quality Regulations require all SA and SA partial use waters to meet shellfishing criteria. All SB and SB partial use waters must meet primary contact recreational/swimming criteria. The shellfishing standard specifies that the maximum allowable level of fecal coliform bacteria (Most Probable Number (MPN) per 100 milliliter) may not exceed a geometric mean MPN value of 14 and not more than 10% of the samples shall exceed an MPN value of 49.

The primary contact recreational/swimming criteria, which applies to all Class SA and SB waters, specifies that the maximum allowable level of fecal coliform bacteria may not exceed a geometric mean value of 50 MPN/100ml and not more than 10% of the total samples taken shall exceed 400

## 2.0 METHODS

### 2.1. STUDY DESIGN

The study design is described in detail in the Quality Assurance (QA) Project Plan for the Mount Hope Bay and Kickemuit River TMDL study (RIDEM 2006b) <http://www.dem.ri.gov/pubs/qapp/mthope.pdf> and one addendum to the QA Plan (RIDEM 2006c). A detailed description of survey methods and analytical or instrument methods for the field and laboratory parameters are also provided in the QAPP. Much of the sampling program design was based on existing information collected primarily by the Office of Water Resources Shellfish Monitoring Group. This information included long-term fecal coliform datasets at established shellfish sampling stations and a sanitary survey conducted in 2002 along the entire shoreline of the RI-portion of the study area. The sanitary survey identified outfalls and streams discharging to the lower Kickemuit and the Rhode Island portion of Mount Hope Bay and included fecal sampling of flowing sources. Additional information was gleaned from historic wet weather and dye-release studies conducted by the U.S. Department of Health and Human Services Food and Drug Administration (1989) and Applied Science Associates (ASA 1990).

Two wet weather sampling surveys were conducted in summer and fall of 2006, to support TMDL development. Both estuarine stations and sources (outfalls and streams) were sampled during the wet weather events. Establishing rainfall criteria was critical to the success of the wet weather monitoring program and interpretation of the data. The criterion for storm-event surveys was 1.5 inches of rainfall in a 24-hour period. Best professional judgment was used to make a decision whether or not to sample a given precipitation event. All estuarine samples were analyzed for fecal coliform bacteria. Estuarine sampling was conducted once prior to the storm event and then approximately every 24 hours for a period of 4-6 days after cessation of precipitation. All stormwater outfalls and stream samples were analyzed for both fecal coliform bacteria and male-specific coliphage. Estimates of streamflow and stormwater flow from point sources were made in the field at the time of sample collection. Samples were collected from sources approximately every two hours during the wet weather event, as long as an acceptable level of flow was observed.

### 2.2. ESTUARINE AND SOURCE SAMPLING STATIONS

The main goal of the study was to assess the sanitary quality of established shellfish growing areas in Mount Hope Bay, Kickemuit River, Taunton River, Lee River, and the Cole River under wet weather conditions. Therefore all sampling was conducted at existing FDA-approved shellfish stations in both RI and MA waters. One additional supplemental station, located in the southwestern portion of Mount Hope Bay off Mount Hope, RI, was sampled by DEM to better characterize water quality conditions in this area. This station was discontinued following the first wet weather event.

During the first wet weather event, 27 stations were sampled in RI waters and 30 stations were sampled in MA waters. Table 2.1 and Figures 2.1 and 2.2 present an overview regarding sampling stations. More detail is provided in following sections, which describe individual sampling events. Appendix A shows detailed station locations in all sampled growing areas in Mount Hope Bay, Kickemuit River, Taunton River, Lee River, and Cole River. Figure 2.3 shows source sampling locations for various periods during the study. During the first and second wet weather events, sources were sampled prior to the storm event and approximately every two hours during the event. Sources were also sampled in months prior and subsequent to the first wet weather event. All source sampling results, including both fecal coliform and male-specific bacteriophage concentrations and loadings, are presented in Appendix B. Appendix B also differentiates storm-influenced values from dry-weather values. On days where rain is indicated, samples taken prior to the start of the rain are recorded as dry-weather values. Storm influenced samples were taken either during a rain event or subsequent to a rain event, during periods of increased residual flow. Streams associated with large catchments or wetlands may remain storm-influenced longer after the cessation of rainfall, than those streams associated with small catchments or steep slopes. Likewise,

samples taken from large diameter pipes associated with larger catchments may remain storm-influenced longer than samples taken from smaller outfalls where flow may cease or return to pre-storm levels almost immediately after the rain event.

**Table 2.1 Waterbody and Sampling Location Overview.**

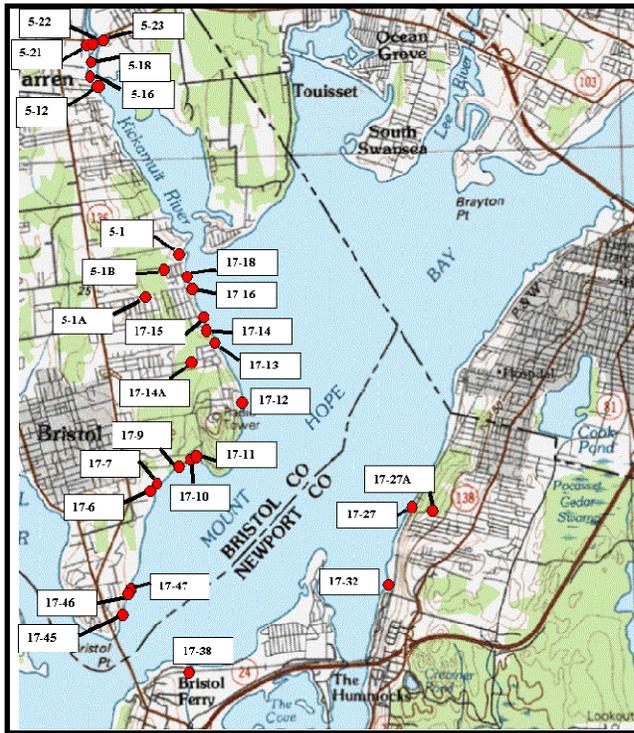
State	Growing Area	Description/Waterbody	Size in acres	Number of Sampling Stations
RI	GA17	Mount Hope Bay	6285	17
	GA5	Kickemuit River	551	10
	MHB1	Mount Hope Bay	1659	9
MA	MHB2	Taunton River	3615	10
	MHB3	Lee River	347	5
	MHB4	Cole River	690	6

**Figure 2.1 General Schematic of Estuarine Sampling Locations.**

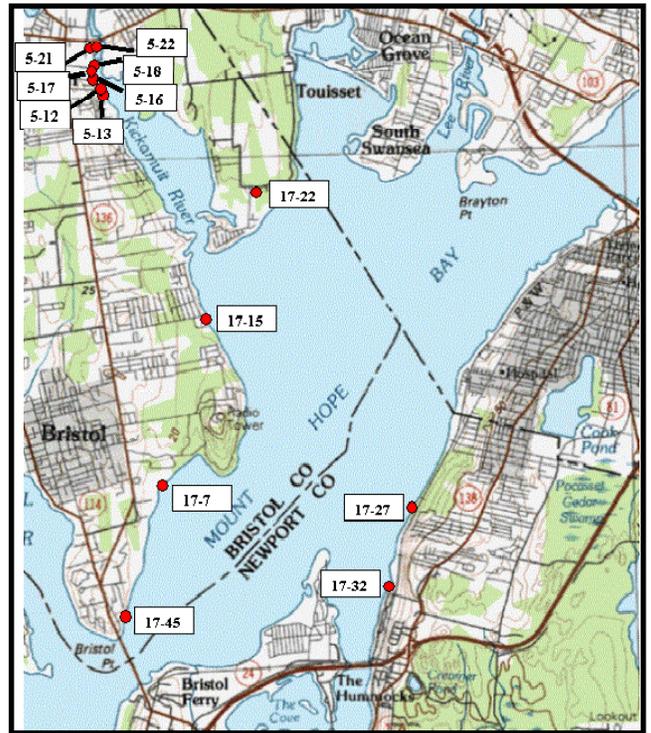




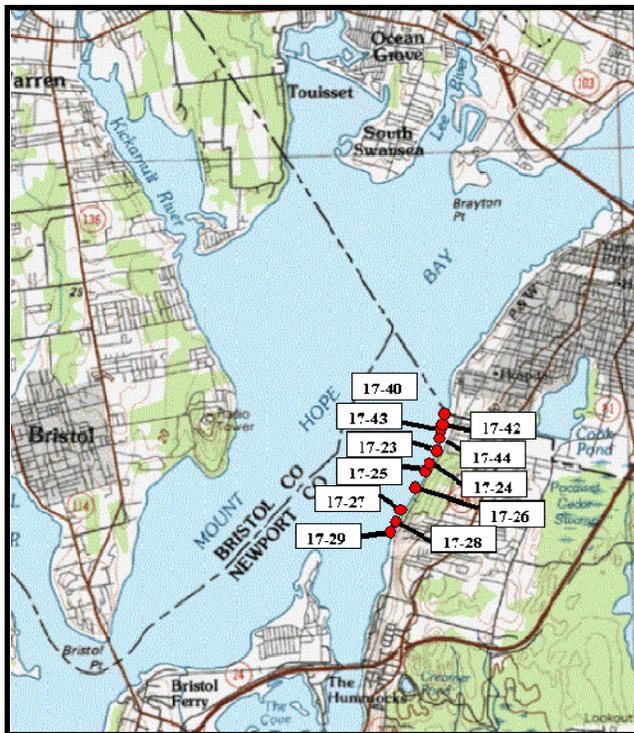
Figure 2.3 Source Sampling Locations.



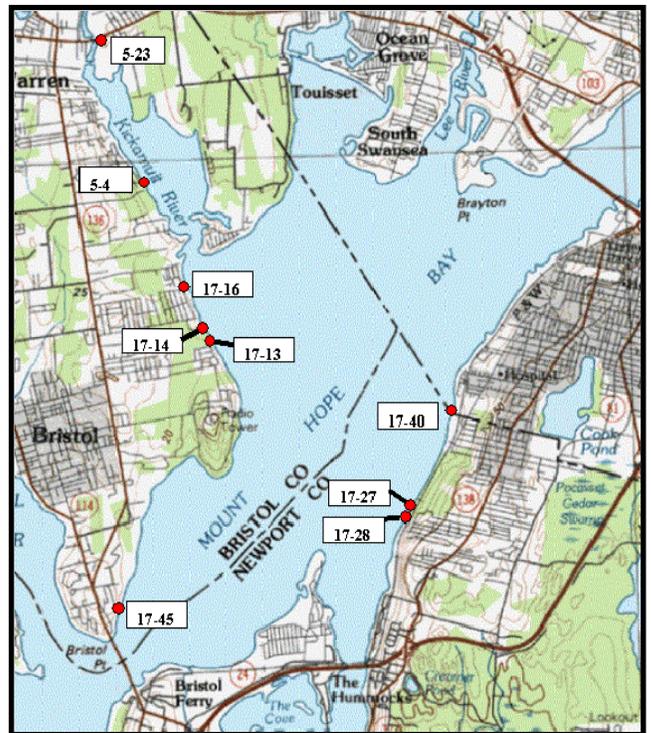
Pre-Wet Weather Event 1



Wet Weather Event I



Pre-Wet Weather Event II



Wet Weather Event II

### 3.0 SAMPLING RESULTS

#### 3.1. PRELIMINARY SOURCE SAMPLING (SEPTEMBER, 2005 AND MAY, 2006)

Prior to the first wet weather event, RIDEM staff sampled 7 sources in the lower Kickemuit River and 21 sources to Mount Hope Bay. Sampling was conducted for three days during September 2005, and two days during May 2006. The September samples were analyzed for fecal coliform bacteria. The May samples were analyzed for both fecal coliform and male-specific coliphage.

The results of the five days of preliminary sampling are shown in Figures 3.1 and 3.2 and Tables 3.1 and 3.2 below. The highest fecal coliform concentrations ( $\geq 24,000$  MPN/100 ml), recorded during September 2005, occurred in the upper portion of the tidal Kickemuit River at Barker Ave. (5-18) and Child St. (5-21). The September, 2005 sampling was conducted during dry weather.

Source sampling was conducted on May 16, 2006 during a 0.62-in precipitation event, focusing mainly on the Bristol coastline of Mount Hope Bay. The highest fecal concentrations (15,000-75,000 MPN/100 ml) were recorded, at King Phillip Av. (17-18), Annawamscutt Dr. (17-15) and Viking Dr. (17-13). Coliphage sampling on the same date revealed high coliphage concentrations (89 to  $\geq 800$  pfu/100 ml) at Viking Dr. (17-13), and in streams at the state boat launch near Annawamscutt Dr. (17-14), near Bristol Landing condominiums (17-7) and at Mount Hope Farm (17-9). High coliphage concentrations (107-232 pfu/100ml) were also recorded in a stream at the Narrows at the mouth of the Kickemuit River (5-1) and also upstream near the western terminus of Sowams Dr. (5-1A)

Additional sampling was conducted during dry weather on May 25, 2006. Fecal concentrations during this period were consistently low (all less than 220 MPN/100 ml). Only one high coliphage concentration was recorded at this time at a stream near Sowams Dr. (5-1A).

**Figure 3.1 Source Fecal Results (MPN/100 ml)- September, 2005**

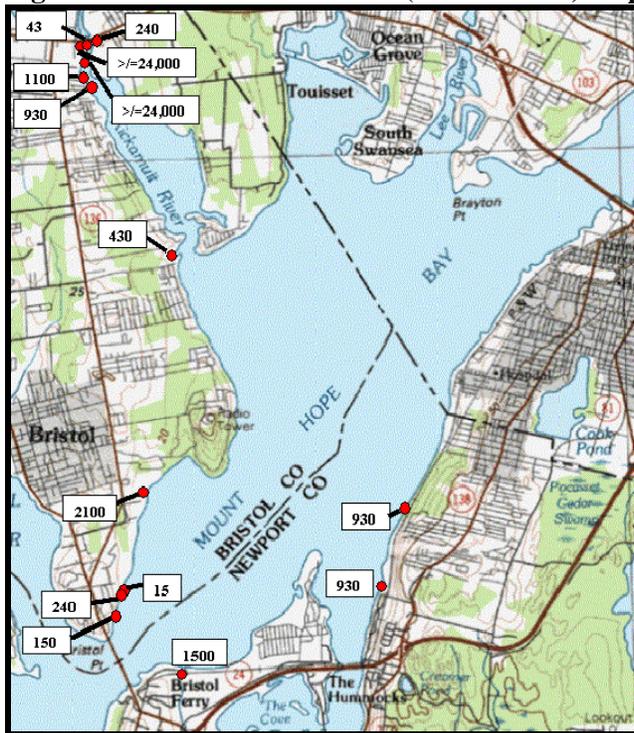


Figure 3.2 Source Results May 16, 2006  
Fecal Results (MPN/100 ml)



Coliphage Results (pfu/100ml)

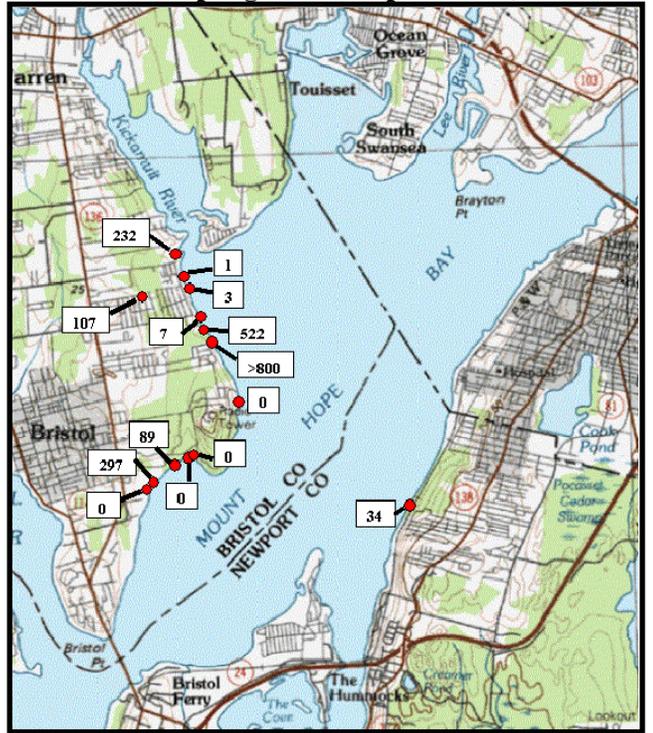
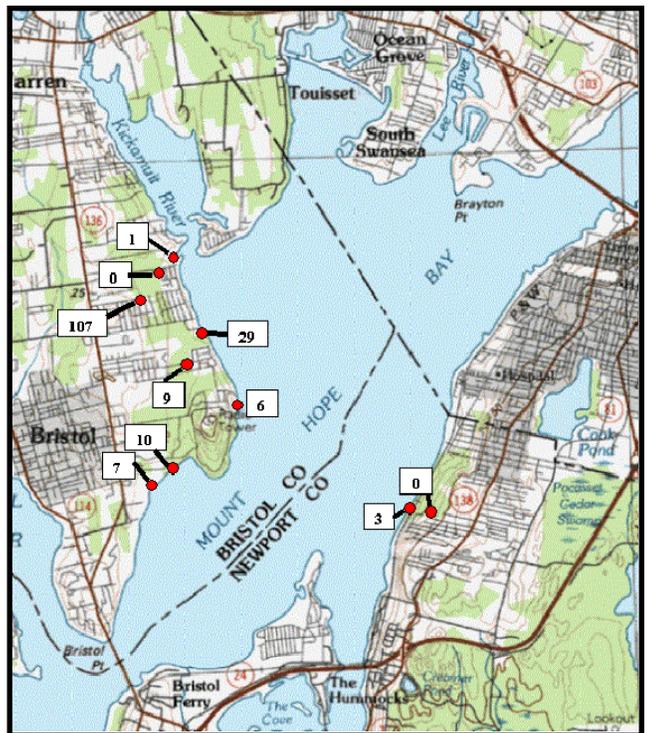


Figure 3.3 Source Results-May 25,2006  
Fecal Results (MPN/100 ml)



Coliphage Results (pfu/100ml)



**Table 3.1 Fecal Coliform Concentrations (MPN/100 ml)-Preliminary Sampling.**

				09/01/05	09/02/05	09/21/05	05/16/06	5/25/06
Precipitation Day of Sampling (in.)				None	None	None	0.62	None
Station	Description	Town	Location					
5-1	Stream	Bristol	Kickemuit mouth north of Narrows Rd.		430		2,300	46
5-1A	Stream 100' down-gradient of 2 pipes	Bristol	Sowams Dr. upstream from 5-1				9,300	33
5-1B	Stream	Bristol	Narrows Rd. between 5-1 & 5-1A					49
5-12	42 x 20" box culvert	Warren	Parker Av.		930			
5-16	Stream	Warren	Cove north of Adams La.	1,100				
5-18	Stream from culvert	Warren	Broken R.R. bridge at Barker Av.		≥24,000			
5-21	18" pipe	Warren	Child St. west of bridge	≥24,000				
5-22	Culverted outflow of Kickemuit Reservoir	Warren	Child St. west of bridge	43				
5-23	36" pipe	Warren	Child St. east of bridge	240				
17-45	Stream from detention pond	Bristol	Roger Williams Campus			150		
17-46	Stream	Bristol	Roger Williams Campus			240		
17-47	8" pipe	Bristol	Roger Williams Campus underneath university dock			15		
17-6	Stream	Bristol	Bristol Landing Condos	2,100			430	
17-7	Stream	Bristol	Bristol Landing Condos				9,300	11
17-9	Stream from coastal pond	Bristol	Near Mt. Hope Farm				1,100	140
17-10	Stream	Bristol	Near Mt. Hope Farm				930	
17-11	Stream	Bristol	Near Mt. Hope Farm				150	
17-12	24" pipe	Bristol	Mt. Hope Farm				≥2,400	110
17-13	12" pipe	Bristol	Viking Dr.				15,000	
17-14	Stream	Bristol	State boat ramp south of Annawamscutt Dr.				2,300	49
17-14A	Stream	Bristol	Hopeworth Av. upstream of 17-14					220
17-15	36" pipe	Bristol	Annawamscutt Dr.				15,000	
17-16	36" pipe	Bristol	Sunrise Dr.				930	
17-18	10" pipe	Bristol	King Phillip Av.				75,000	
17-27	Stream	Tiverton	Summerfield La.		930		4,300	79
17-27A	Stream	Tiverton	Craig Av. upstream of 17-27					130
17-32	10' x 4' concrete structure	Tiverton	Villages @ Mt. Hope Bay			930		
17-38	Stream from wetland	Portsmouth	Outlet of Town Pond		1,500			

**Table 3.2. Male-Specific Coliphage Concentrations (pfu/100ml)-Preliminary Sampling.**

				5/16/2006	5/25/2005
Precipitation Day of Sampling (in.)				0.62	None
Station	Description	Town	Location		
5-1	Stream	Bristol	Kickemuit mouth north of Narrows Rd.	232	1
5-1A	Stream 100' down-gradient of 2 pipes	Bristol	Sowams Dr. upstream from 5-1	107	107
5-1B	Stream	Bristol	Narrows Rd. between 5-1 & 5-1A		<1
17-6	Stream	Bristol	Bristol Landing Condos	<1	
17-7	Stream	Bristol	Bristol Landing Condos	297	7
17-9	Stream from coastal pond	Bristol	Near Mt. Hope Farm	89	10
17-10	Stream	Bristol	Near Mt. Hope Farm	<1	
17-11	Stream	Bristol	Near Mt. Hope Farm	<1	
17-12	24" pipe	Bristol	Mt. Hope Farm	<1	6
17-13	12" pipe	Bristol	Viking Dr.	>800	
17-14	Stream	Bristol	State boat ramp south of Annawamscutt Dr.	522	29
17-14A	Stream	Bristol	Hopeworth Av. upstream of 17-14		9
17-15	36" pipe	Bristol	Annawamscutt Dr.	7	
17-16	36" pipe	Bristol	Sunrise Dr.	3	
17-18	10" pipe	Bristol	King Phillip Av.	1	
17-27	Stream	Tiverton	Summerfield La.	34	3
17-27A	Stream	Tiverton	Craig Av. upstream of 17-27		<1

**3.2. FIRST WET WEATHER EVENT (JUNE 2 AND 3, 2006)****3.2.1. Characterization of Storm Event**

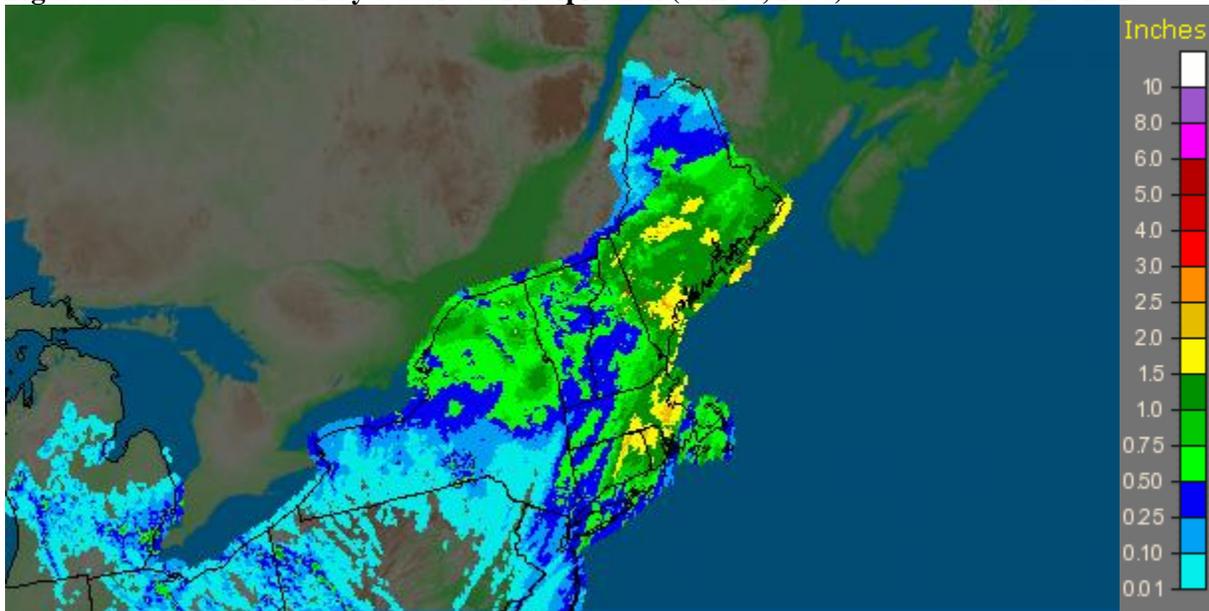
Fifteen minute and hourly rainfall data were obtained for stations located in Fall River, MA, Providence, RI, and Taunton, MA. Cumulative rainfall totals for the first wet weather event from several other National Weather Service (NWS) stations within or near the watershed are presented in Table 3.3 and Figure 3.4. Rainfall was fairly widespread during the event, but rainfall totals within the watershed varied more than was ideal. Cumulative precipitation averaged approximately 1.9 inches in 26 hours. The event was less than ideal in terms of discreteness and uniformity of coverage within the watershed, however nearly all outfalls exhibited significant discharge, and periods of continuous to moderate runoff occurred throughout the sampling period. The event also resulted in several combined sewer overflows in the Fall River area, however data, such as total volume, was not recorded and cannot be obtained.

Figure 3.5 shows the stream discharge as recorded at the Taunton River in Bridgewater, MA during the first wet weather event. Flow prior to the event was approximately 350 cfs and rose to approximately 1200 cfs by June 4, 2006.

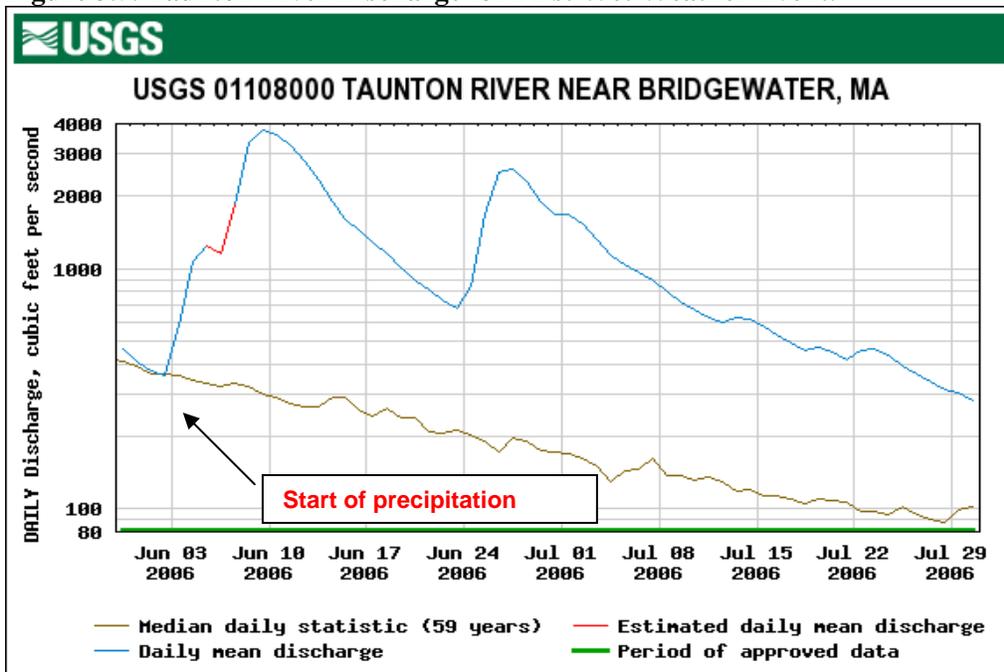
**Table 3.3 Total Rainfall for first Wet Weather Event (June 2-4, 2006).**

Location	Storm Total Rainfall (inches)
Providence, RI	1.71
Warwick, RI	1.68
Woonsocket, RI	2.20
Taunton, MA	2.29
Mansfield, MA	2.00
New Bedford, MA	1.52

**Figure 3.4 Cumulative 1-Day Observed Precipitation (June 4, 2006)- Wet Weather Event 1.**



**Figure 3.5. Taunton River Discharge for First Wet Weather Event.**

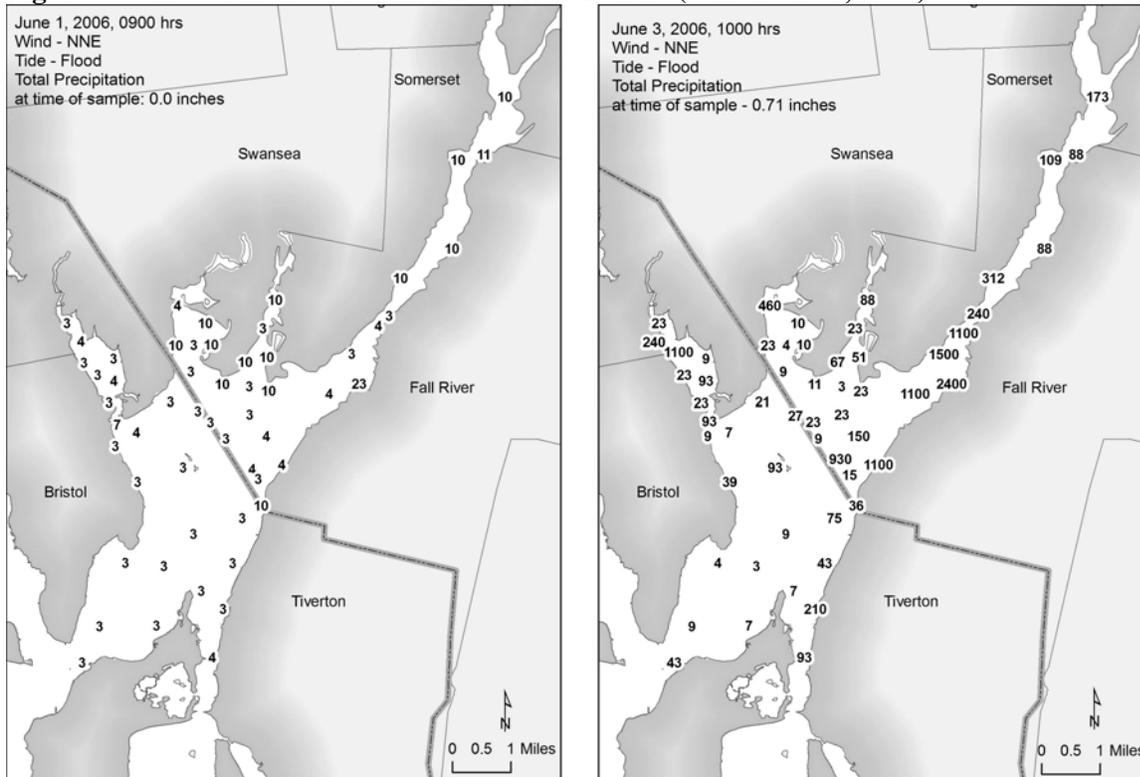


### 3.2.2. Estuarine Sampling Results (June 1-6, 2006)

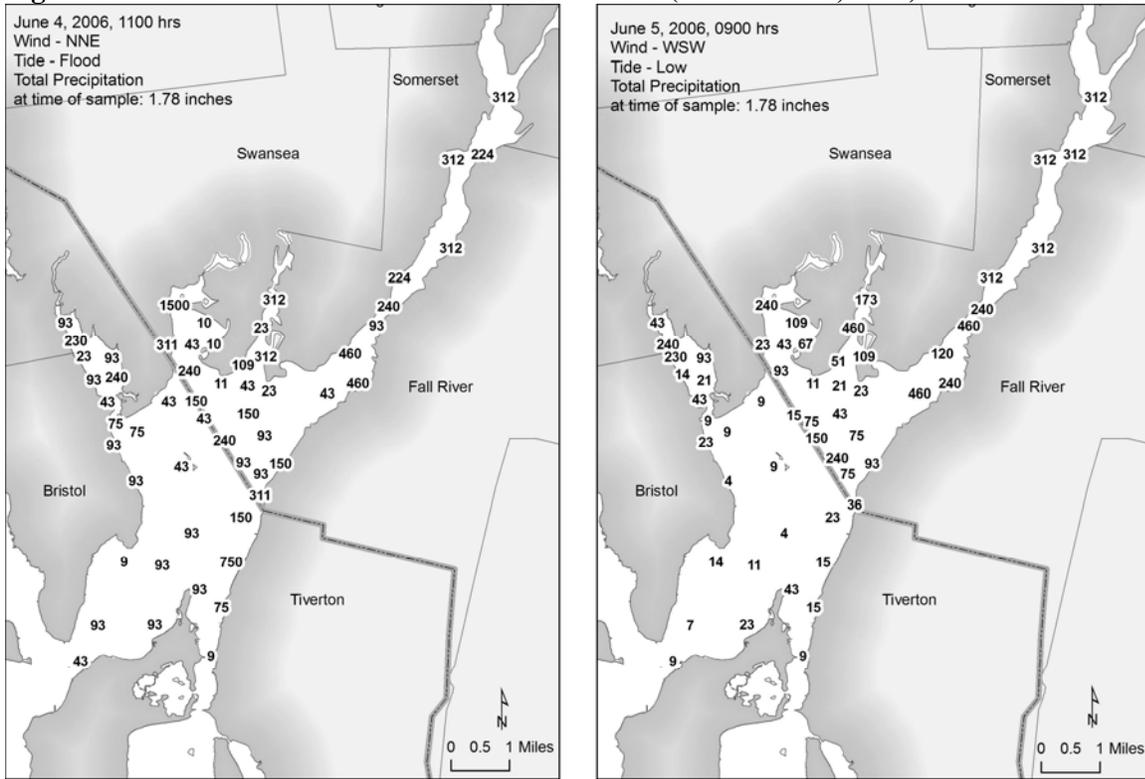
For the first wet weather event, RIDEM staff sampled 27 stations in the lower Kickemuit and the RI portion of Mount Hope Bay, and MA Division of Marine Fisheries (MADMF) staff sampled 30 stations in MA waters, including the upper (northeastern) portion Mount Hope Bay, as well as the three main tributaries to the bay (the Taunton, Lee and Cole Rivers). Pre-storm samples were collected at estuarine stations on June 1, 2006 in anticipation of a potential sampling event. Sampling commenced at established estuarine stations at approximately 1100 hrs from June 3 through June 6.

The results of the 5-day sampling event associated with the first wet weather event are shown in Figures 3.6 through 3.8 and Tables 3.4 and 3.5 below. On June 1, prior to the rain event, the highest fecal coliform concentration in the entire study area was 23 MPN/100 ml. Fecal concentrations tended to be slightly higher in the Massachusetts portion of the study area (upper Mount hope Bay and the Taunton, Lee and Cole Rivers) than in the Rhode Island portion (the RI potion of Mount Hope Bay and the Kickemuit River). By June 3, bacteria concentrations had increased significantly in the tidal Kickemuit River (maximum concentration of 240 MPN/100 ml), and within the Rhode Island waters of Mount Hope Bay, especially within that portion of the bay adjacent to the Town of Tiverton (maximum concentration of 210 MPN/100 ml). Concentrations within the Massachusetts portion of the study area were even higher, especially in the Taunton River near Fall River (maximum concentration of 2400 MPN/100 ml), and in the upper portion of the Cole River (maximum concentration of 460 MPN/100 ml). On June 4, the bacteria concentrations continued to increase throughout most of the study area, except in the vicinity of Fall River, where bacteria levels actually fell from the previous day. By June 5, fecal coliform concentrations decrease throughout most of the study area, except for the upper Taunton River.

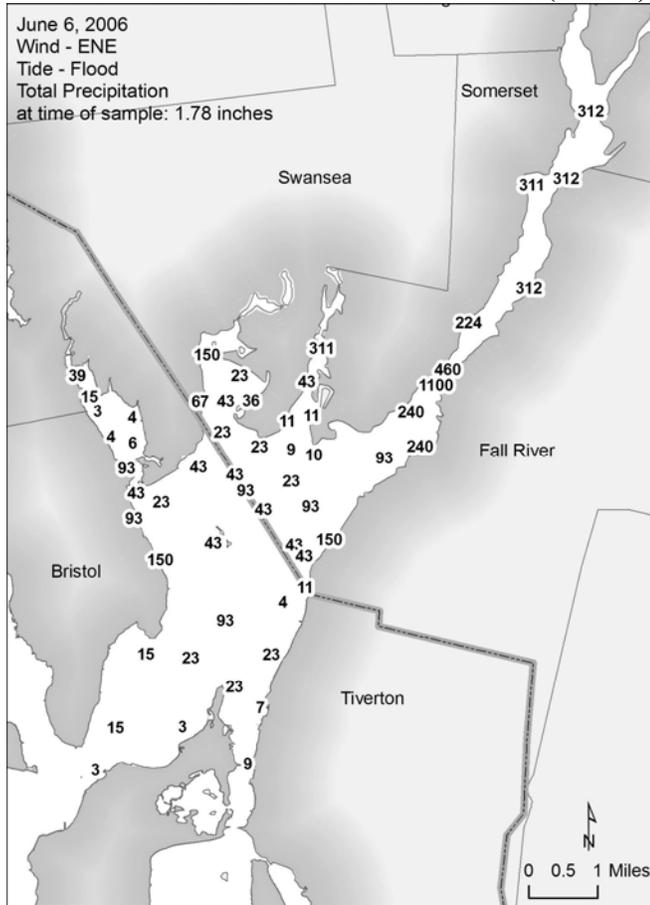
**Figure 3.6. Estuarine Fecal Coliform Concentrations (June 1 and 2, 2006)**



**Figure 3.7. Estuarine Fecal Coliform Concentrations (June 4 and 5, 2006)**



**Figure 3.8. Estuarine Fecal Coliform Concentrations (June 6, 2006)**



**Table 3.4. Fecal Coliform Concentrations (MPN/100 ml)-Mount Hope Bay.**

Other Info	1-Jun-06	3-Jun-06	4-Jun-06	5-Jun-06	6-Jun-06			
Avg Wind Dir.	NNE	NNE	NNE	WSW	ENE			
Cumulative precip (in) <sup>1</sup>	0	0.71	1.71	1.71	1.71			
Tide at time of sample	Flood	Flood	Flood	low	low			
Station						Event mean <sup>2</sup>	Max	
GA17-1	3	21	43	9	43	29	43	Rhode Island Waters
GA17-2	3	27	150	15	43	59	150	
GA17-3	3	93	43	9	43	47	93	
GA17-4	4	930	93	240	43	327	930	
GA17-5	3	9	93	4	93	50	93	
GA17-6	3	75	150	23	4	63	150	
GA17-7	3	43	750	15	23	208	750	
GA17-8	3	210	75	15	7	77	210	
GA17-9	4	93	9	9	9	30	93	
GA17-10	3	7	93	43	23	42	93	
GA17-11	3	7	93	23	3	32	93	
GA17-12	3	43	43	9	3	25	43	
GA17-13	3	9	93	7	15	31	93	
GA17-13A	ns	ns	23	9	9	14	23	
GA17-14	3	4	9	14	15	11	15	
GA17-15	3	3	93	11	23	33	93	
GA17-16	3	39	93	4	150	72	150	
MHB1-2	10	11	11	11	23	14	23	Massachusetts Waters- Sampled by MADM Staff
MHB1-3	10	23	23	23	10	20	23	
MHB1-5	4	1100	150	93	150	373	1100	
MHB1-6	10	36	311	36	11	99	311	
MHB1-7	3	15	93	75	43	57	93	
MHB1-9	3	23	43	75	93	59	93	
MHB1-10	3	23	150	43	23	60	150	
MHB1-11	4	150	93	75	93	103	150	
MHB1-8	3	9	240	150	43	111	240	
MHB3-2A	3	3	43	21	9	19	43	
MHB3-4	10	88	312	173	311	221	312	
MHB3-6	3	23	23	460	43	137	460	
MHB3-9	10	67	109	51	11	60	109	
MHB3-11	10	51	312	109	11	121	312	
MHB4-1	4	460	1500	240	150	588	1500	
MHB4-3	10	23	311	23	67	106	311	
MHB4-5	10	10	10	109	23	38	109	
MHB4-7	10	10	10	67	36	31	67	
MHB4-9	3	3.6	43	43	43	33	43	
MHB4-1A	3	9	240	93	23	91	240	
MHB2-3	4	1100	43	460	93	424	1100	
MHB2-4	23	2400	460	240	240	835	2400	
MHB2-4A	3	1500	460	120	240	580	1500	
MHB2-6	3	240	240	240	460	295	460	
MHB2-7	10	312	224	312	224	268	312	
MHB2-9	10	88	312	312	312	256	312	
MHB2-10	10	109	312	312	311	261	312	
MHB2-11	11	88	224	312	312	234	312	
MHB2-13	10	173	312	312	312	277	312	
MHB2-5	4	1100	93	460	1100	688	1100	

1. Precipitation Recorded at RIDEM Offices in Providence, RI.

2. Event Mean does not Include Dry Weather Data.

ns=not sampled

**Table 3.5. Fecal Coliform Concentrations (MPN/100 ml)-Kickemuit River.**

Other Info	1-Jun-06	3-Jun-06	4-Jun-06	5-Jun-06	6-Jun-06		
Avg Wind Dir.	NNE	NNE	NNE	WSW	ENE		
Cumulative precip (in) <sup>1</sup>	0	0.71	1.71	1.71	1.71		
Tide at time of sample	Flood	Flood	Flood	low	low		
Station						Event mean <sup>2</sup>	Max
GA5-1	3	9	93	23	93	55	93
GA5-2	4	7	75	9	23	29	75
GA5-3	7	93	75	9	43	55	93
GA5-4	3	23	43	43	93	51	93
GA5-5	3	23	93	14	4	34	93
GA5-6	3	1100	23	230	3	339	1100
GA5-7	4	240	230	240	15	181	240
GA5-8	3	23	93	43	39	50	93
GA5-9	3	9	93	93	4	50	93
GA5-10	4	93	240	21	6	90	240

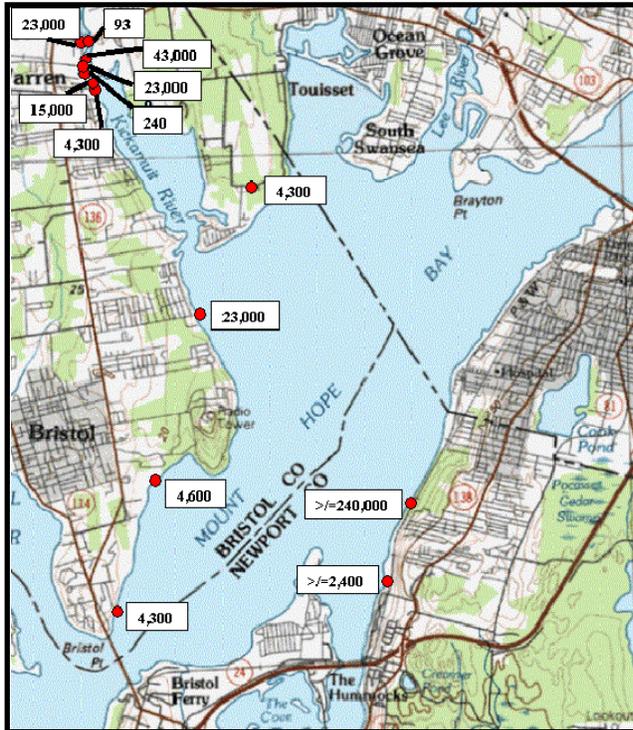
1. Precipitation Recorded at RIDEM Offices in Providence, RI.
2. Event Mean does not Include Dry Weather Data.

### 3.2.3. Source Sampling Results (June 2 and 3, 2006)

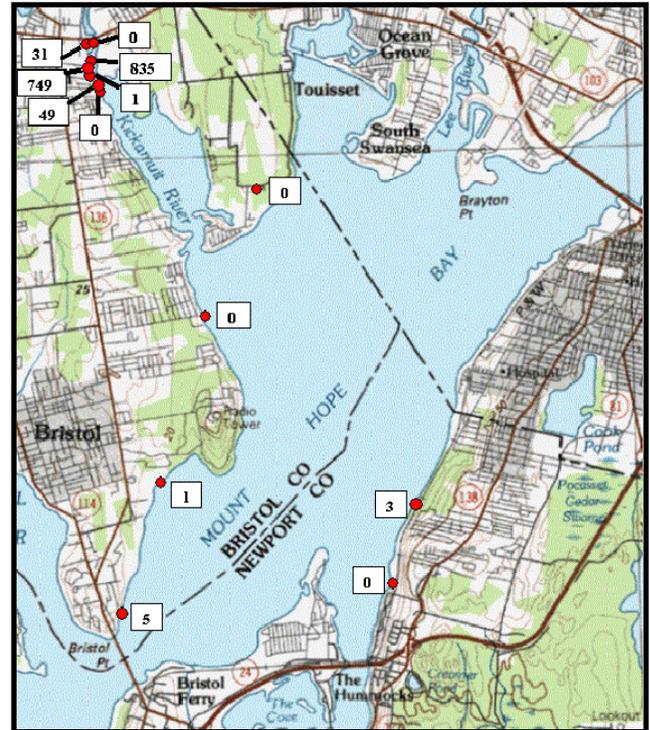
Wet weather source sampling was conducted on June 2<sup>nd</sup> and 3<sup>rd</sup>, 2006 at the upper end of the tidal estuary of the Kickemuit River and scattered along the Mount Hope Bay shoreline. The highest fecal concentration ( $\geq 240,000$  MPN/100 ml) during the June 2<sup>nd</sup> sampling event was recorded at Summerfield La. (17-27) in Tiverton (Figure 3.9 and Table 3.6). The fecal concentration at Annawamscutt Dr. (17-15), located in Bristol on Mount Hope Bay, was 23,000 MPN/100 ml. Higher concentrations (15,000-43,000 MPN/100 ml) were also recorded in the upper portion of the tidal Kickemuit River at Barker Av. (5-18), Child St. (5-21), Libby La. (5-17), and Parker Av. (5-12). The coliphage concentrations of all the Mount Hope Bay sources were low (Figure 3.9 and Table 3.7). Coliphage concentrations at Libby La. (5-17), and Barker Av. (5-18), located in the in the upper portion of the tidal Kickemuit River, were both high (749 and 835 pfu/100 ml, respectively).

The highest fecal concentrations recorded during the June 3<sup>rd</sup> sampling event (24,000-93,000 MPN/100 ml) occurred at sources on the Bristol side of Mount Hope Bay (Figure 3.10 and Table 3.6). The fecal concentrations at Annawamscutt Dr. (17-15) and Bristol Landing condominiums (17-7) were 93,000 and 24,000 MPN/100 ml, respectively. High concentrations (15,000-23,000) were also recorded in the upper portion of the tidal Kickemuit River at both outfalls at Parker Av. (5-12 and 5-13) and also at Barker Av. (5-18). Coliphage concentrations were generally low at the sampled sources located throughout Mount Hope Bay and the upper portion of the tidal Kickemuit River. The highest coliphage concentration (2,054 pfu/100 ml) was recorded at a source located on the Roger Williams University campus (17-45) (Figure 3.10 and Table 3.7). The coliphage concentrations at Child St. (5-21), and Parker Av. (5-13), located in the upper portion of the tidal Kickemuit River, were also high (1,725 and 130 pfu/100 ml, respectively).

**Figure 3.9. Source Results-6/2/06**  
**Fecal Results (MPN/100 ml)**



**Coliphage Results (pfu/100ml)**



**Figure 3.10. Source Results-6/3/06**  
**Fecal Results (MPN/100 ml)**



**Coliphage Results (pfu/100ml)**



**Table 3.6. Fecal Coliform Concentrations (MPN/100 ml)-Wet Weather Event 1.**

				6/02/06	6/03/06
Precipitation Day of Sampling (in.)				0.16	1.32
Station	Description	Town	Location		
5-12	42 x 20" box culvert	Warren	Parker Av.	15,000	23,000
5-13	30" culvert	Warren	Parker Av.	4,300	23,000
5-16	Stream	Warren	Cove north of Adams La.	240	11,000
5-17	18" pipe	Warren	Libby La.	23,000	2,100
5-18	Stream fom culvert	Warren	Broken R.R. bridge at Barker Av.	43,000	15,000
5-21	18" pipe	Warren	Child St. west of bridge	23,000	9,300
5-22	Culverted outflow of Kickemuit Reservoir	Warren	Child St. west of bridge	93	75
17-45	Stream from detention pond	Bristol	Roger Williams Campus	4,300	6,400
17-7	Stream	Bristol	Bristol Landing Condos	4,600	24,000
17-15	36" pipe	Bristol	Annawamscutt Dr.	23,000	93,000
17-22	Stream	Warren	Maple Rd.	4,300	12,000
17-22D <sup>1</sup>	Stream	Warren	Maple Rd.	930	4,300
17-27	Stream	Tiverton	Summerfield La.	≥240,000	9,300
17-32	10' x 4' concrete structure	Tiverton	Villages @ Mt. Hope Bay	≥2,400	230

1. D=Duplicate.

**Table 3.7. Male-Specific Coliphage Concentrations (pfu/100ml)- Wet Weather Event 1.**

				6/02/06	6/03/06
Precipitation Day of Sampling (in.)				0.16	1.32
Station	Description	Town	Location		
5-12	42 x 20" box culvert	Warren	Parker Av.	49	<1
5-13	30" culvert	Warren	Parker Av.	<1	130
5-16	Stream	Warren	Cove north of Adams La.	1	2
5-17	18" pipe	Warren	Libby La.	749	<1
5-18	Stream from culvert	Warren	Broken R.R. bridge at Barker Av.	835	<1
5-21	18" pipe	Warren	Child St. west of bridge	31	1,725
5-22	Culverted outflow of Kickemuit Reservoir	Warren	Child St. west of bridge	<1	<1
17-45	Stream from detention pond	Bristol	Roger Williams Campus	5	2,054
17-7	Stream	Bristol	Bristol Landing Condos	1	<1
17-15	36" pipe	Bristol	Annawamscutt Dr.	<1	<1
17-22	Stream	Warren	Maple Rd.	<1	<1
17-22D <sup>1</sup>	Stream	Warren	Maple Rd.	<1	3
17-27	Stream	Tiverton	Summerfield La.	3	<1
17-32	10' x 4' concrete structure	Tiverton	Villages @ Mt. Hope Bay	<1	<1

1. D=Duplicate.

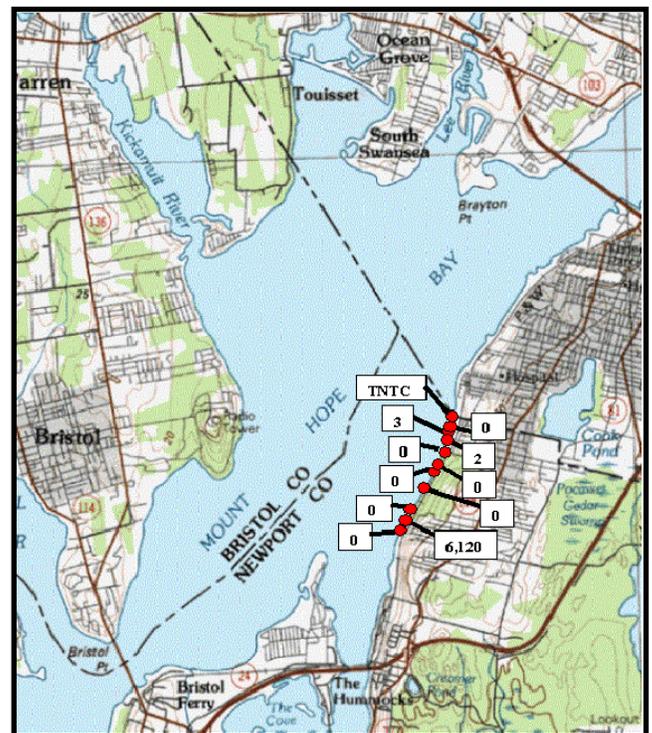
### 3.3. SUPPLEMENTAL (PRE-WET WEATHER EVENT II) SOURCE SAMPLING (AUGUST AND SEPTEMBER, 2006)

Subsequent to the first, and prior to the second wet weather event, RIDEM staff sampled eleven sources, all located in northern Tiverton on the Mount Hope Bay. Sampling was conducted on August 29<sup>th</sup> during a 0.12 rain event, and on September 8<sup>th</sup>, during dry weather. The highest fecal concentrations during this sampling period were recorded at Robert Gray and State Avenues (Figure 3.11 and Table 3.8). Fecal concentrations at Robert Gray Av. (17-28) and State Av. (17-40) were  $\geq 24,000$  and 21,000 pfu/100 ml, respectively. Coliphage results are presented in Figure 3.11 and Table 3.9. The coliphage concentrations at Robert Gray Av. were extremely high (6,120 pfu/100 ml). The coliphage concentration at State Avenue could not be quantified, due to extremely high levels. The remaining sources had very low coliphage concentrations.

**Figure 3.11. Source Results-8/29/06 and 9/8/06**  
**Fecal Results (MPN/100 ml)**



**Coliphage Results (pfu/100ml)**



**Table 3.8. Fecal Coliform Concentrations (MPN/100 ml)-Supplemental Sampling**

				8/29/06	9/08/06
Precipitation Day of Sampling (in.)				0.12	None
Station	Description	Town	Location		
17-40	24" pipe	Tiverton	State Av.		21,000
17-42	8" pipe	Tiverton	Chase Av.		23
17-43	30" pipe	Tiverton	Chase Av.		4
17-44	36" pipe	Tiverton	Canonicus St.		930
17-23	30" pipe	Tiverton	Judson St.	150	
17-23D <sup>1</sup>	30" pipe	Tiverton	Judson St.	93	
17-24	Stream	Tiverton	Lepes Rd.	93	
17-25	Stream	Tiverton	Horizon Dr.	93	
17-26	Stream	Tiverton	North of Summerfield La.	930	
17-27	Stream	Tiverton	Summerfield La.	4,600	
17-28	Stream	Tiverton	Robert Gray Av.	≥24,000	
17-29	Stream	Tiverton	Brackett Av.	2,400	

1. D=Duplicate.

**Table 3.9. Male-Specific Coliphage Concentrations (pfu/100ml)- Supplemental Sampling**

				8/29/2006	9/08/06
Precipitation Day of Sampling (in.)				0.12	None
Station	Description	Town	Location		
17-40	24" pipe	Tiverton	State Av.		TNTC <sup>2</sup>
17-42	8" pipe	Tiverton	Chase Av.		<1
17-43	30" pipe	Tiverton	Chase Av.		3
17-44	36" pipe	Tiverton	Canonicus St.		2
17-23	30" pipe	Tiverton	Judson St.	<1	
17-23D <sup>1</sup>	30" pipe	Tiverton	Judson St.	<1	
17-24	Stream	Tiverton	Lepes Rd.	<1	
17-25	Stream	Tiverton	Horizon Dr.	<1	
17-26	Stream	Tiverton	North of Summerfield La.	<1	
17-27	Stream	Tiverton	Summerfield La.	<1	
17-28	Stream	Tiverton	Robert Gray Av.	6,120	
17-29	Stream	Tiverton	Brackett Av.	<1	

1. D=Duplicate.

2. TNTC=Too Numerous To Count

### 3.4. SECOND WET WEATHER EVENT (OCTOBER 11-12, 2006)

#### 3.4.1. Characterization of Storm Event

Wet weather event 2 cumulative rainfall totals for stations located in Fall River, MA, Providence, RI, and Taunton, MA are presented in Table 3.10 and Figure 3.12. Rainfall was fairly widespread during the event, but rainfall totals within the watershed varied more than was ideal. Cumulative precipitation for the storm averaged approximately 1.0 in., significantly less than the 1.9 in. mean of wet weather event 1. The event was less than ideal in terms of discreteness and uniformity of coverage within the watershed, however nearly all outfalls exhibited significant stormwater discharges with periods of continuous and moderate runoff occurring throughout most of the sampling period. The event also resulted in several combined sewer overflows in the Fall River area, however data such as total volume was not recorded, and cannot be obtained.

**Table 3.10. Total Rainfall for Second Wet Weather Event (October 11-12, 2006)**

Location	Storm Total Rainfall (inches)
Providence, RI	0.87
Warwick, RI	1.22
Woonsocket, RI	2.01
Taunton, MA	0.82
New Bedford, MA	0.74
Fall River, MA	0.63

**Figure 3.12. Cumulative 1-Day Observed Precipitation (October 12, 2006)- Wet Weather Event 2.**

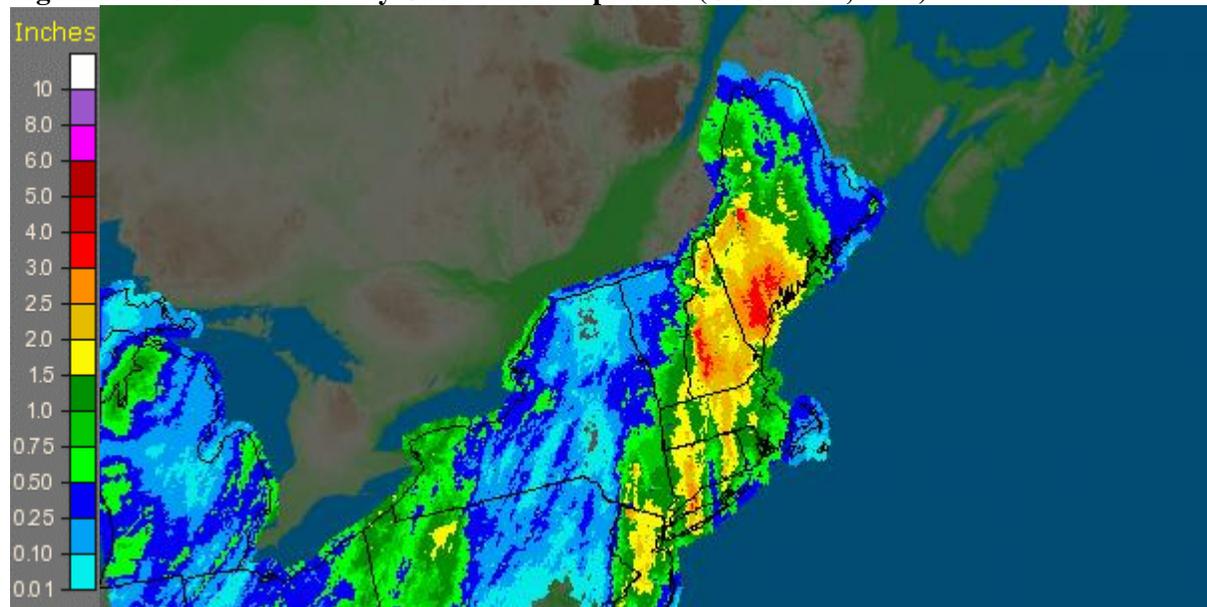
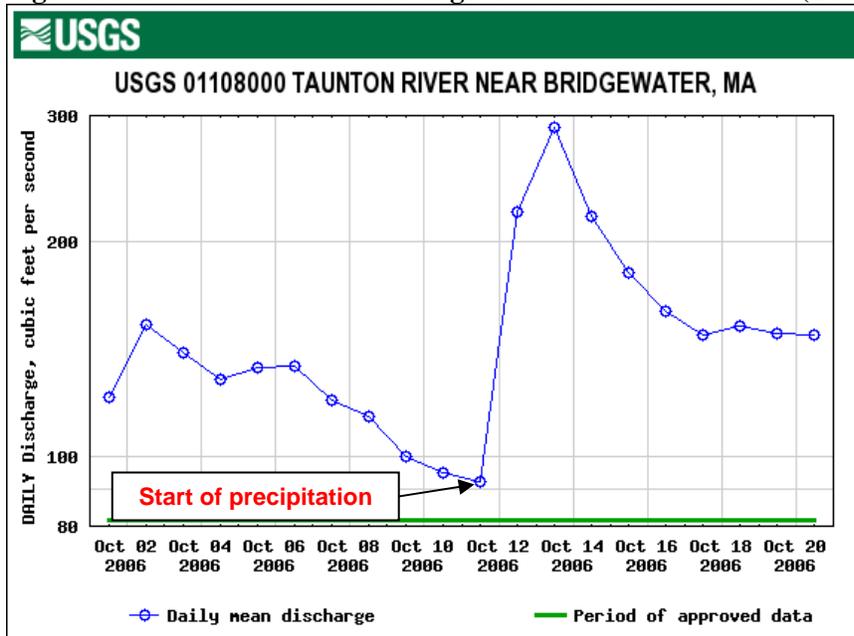


Figure 3.13 below shows stream discharge as recorded at the Taunton River in Bridgewater, MA during the second wet weather event. Flow prior to the event was approximately 90 cfs and rose to approximately 300 cfs by October 13, 2006. This 300 cfs peak flow is less than the flow that was recorded immediately prior to wet weather event 1.

**Figure 3.13. Taunton River Discharge for Wet Weather Event 2(October 11 and 12, 2006)**

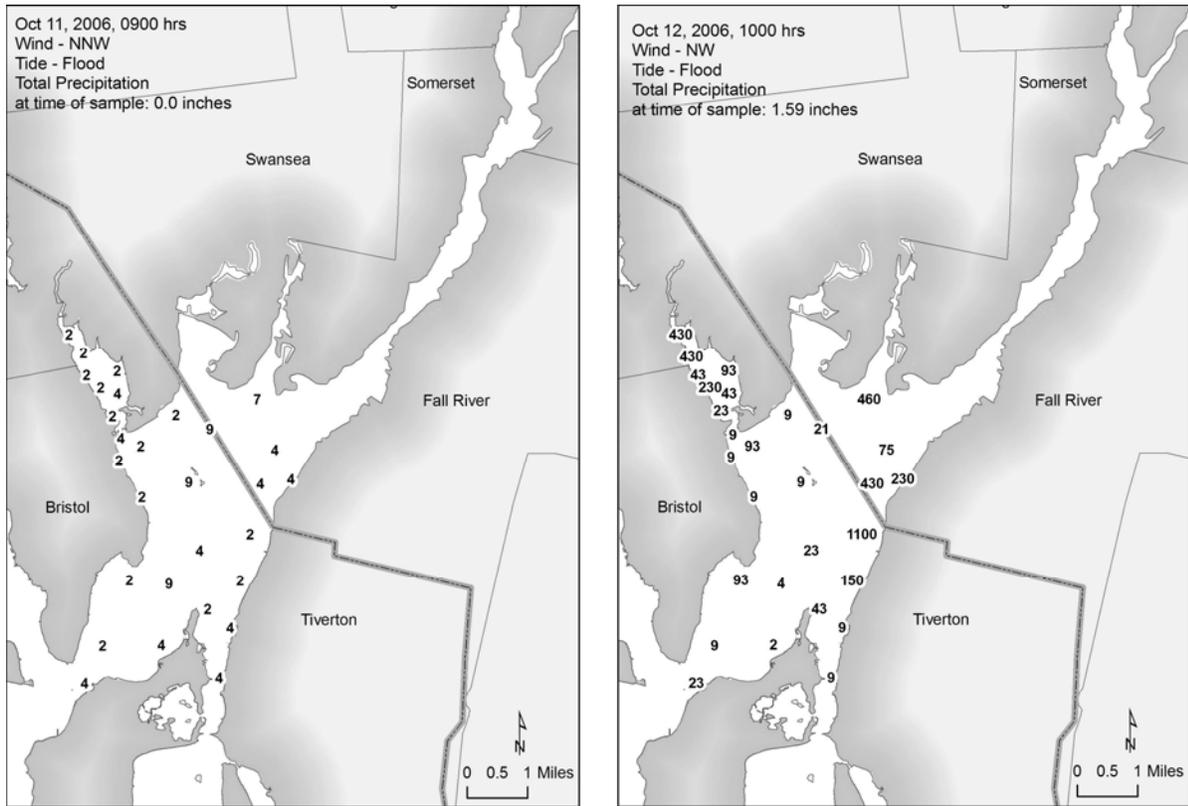


### 3.4.2. Estuarine Sampling Results (October 11-17)

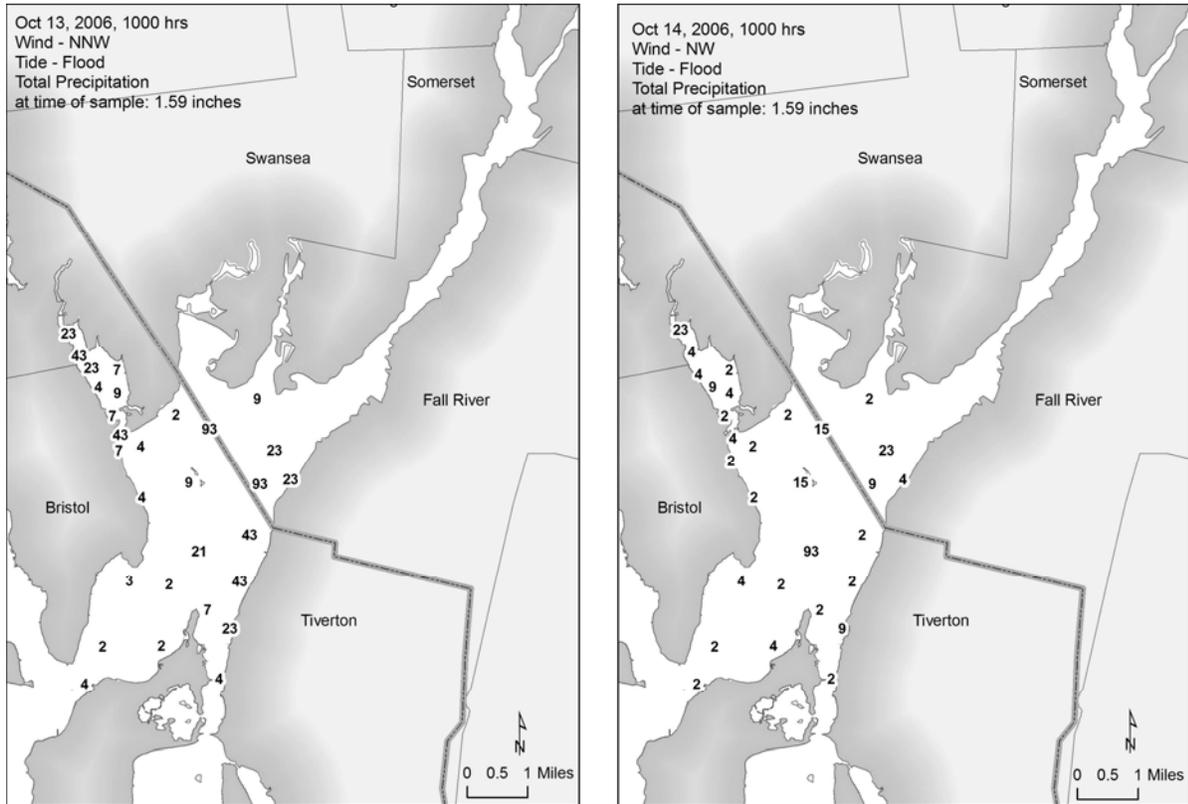
During wet weather event 2, RIDEM staff sampled 26 stations in the lower Kickemuit and the RI portion of Mount Hope Bay. The MA Division of Marine Fisheries (MADMF) did not participate in sampling during this event, however RIDEM staff sampled 3 stations in Massachusetts waters to characterize the water quality of the Taunton and Lee Rivers. Pre-storm samples were collected at estuarine stations on October 11, 2006 in anticipation of a potential sampling event. Sampling commenced at established estuarine stations at approximately the same time (~1000 hrs) from October 12 through October 17.

The results of the 5-day sampling event associated with weather event 2 are shown in Figures 3.14 through 3.17 and Table 3.11 below. On October 11, prior to the rain event, the highest fecal coliform concentration in the entire study area was 9 MPN/100 ml. By October 12, bacteria concentrations had increased significantly in the tidal Kickemuit River, especially in the upper portion of the tidal Kickemuit River north of the Bristol Town line (maximum concentration of 430 MPN/100 ml). Bacteria concentrations also increased significantly within the Rhode Island waters of Mount Hope Bay, especially that portion of the bay adjacent to the northern shore of the Town of Tiverton (maximum concentration of 1100 MPN/100 ml). Concentrations within the Massachusetts portion of the study area were also elevated, especially at the mouth of the Taunton River near Fall River (maximum concentration of 430 MPN/100 ml), and at the mouth of the Lees River (maximum concentration of 460 MPN/100 ml). By October 13, bacteria concentrations decreased at the vast majority of sampling stations throughout the study area. Maximum fecal concentrations (93 MPN/100 ml) occur in Mount Hope Bay at the state boundary. Higher concentrations (43 MPN/100 ml) were also recorded at the upper end of the tidal Kickemuit River and also at its mouth, in addition to the northern Tiverton shore of Mount Hope Bay. On October 14, the highest fecal concentration (93 MPN/100 ml) was recorded in the central part of the Rhode Island portion of Mount Hope Bay. With the exception of station GA17-3 near Spar Island, located in the northern portion of Mount Hope Bay, fecal concentrations were below 23 for the remainder of the sampling period (October 15 through October 17). The fecal concentration at Spar Island was 240 and 43 MPN/100 ml on October 16 and 17, respectively.

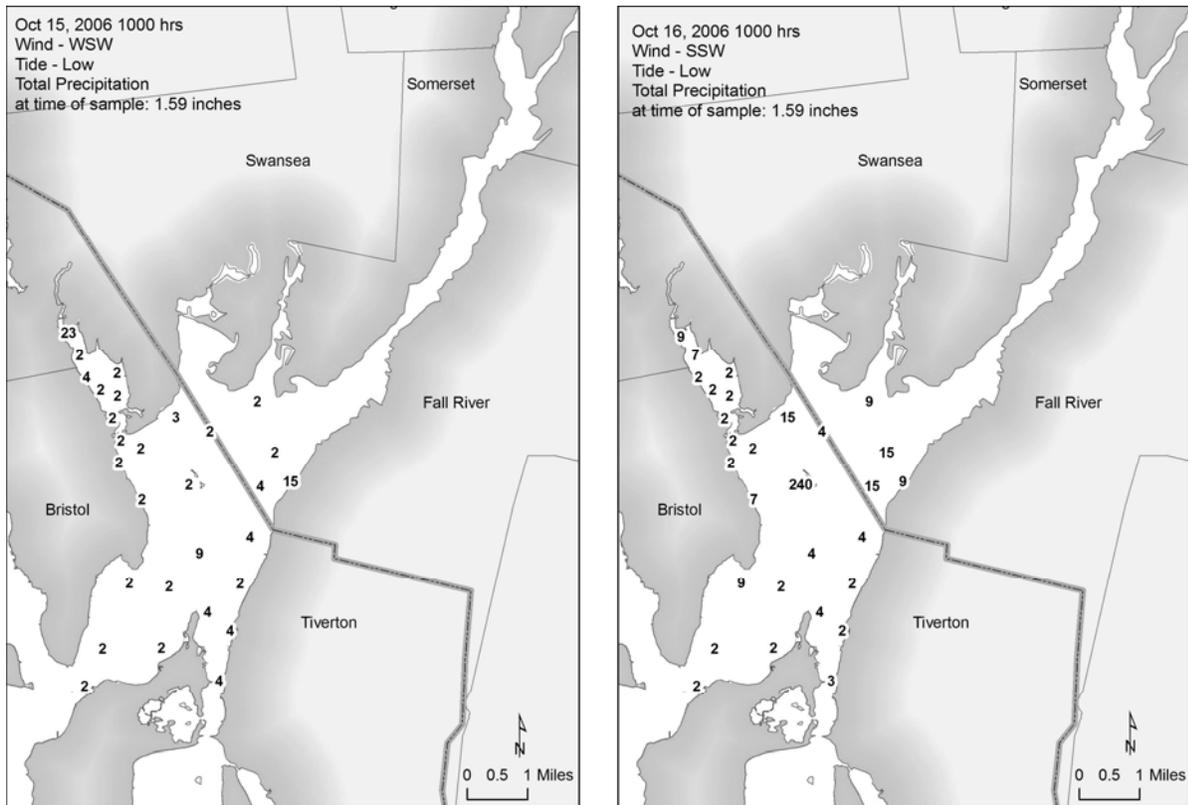
**Figure 3.14. Estuarine Fecal Coliform Concentrations (October 11 and 12, 2006).**



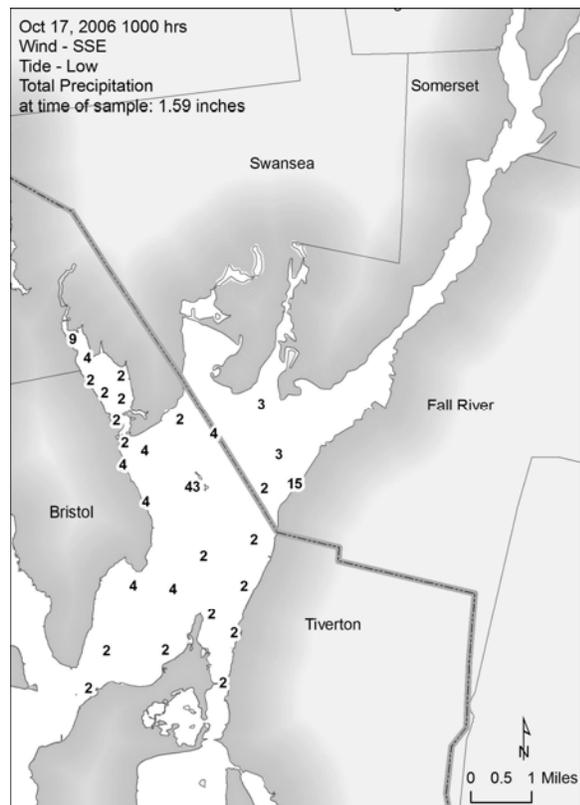
**Figure 3.15. Estuarine Fecal Coliform Concentrations (October 13 and 14, 2006).**



**Figure 3.16. Estuarine Fecal Coliform Concentrations (October 15 and 16, 2006).**



**Figure 3.17. Estuarine Fecal Coliform Concentrations (October 17, 2006).**



**Table 3.11. Fecal Coliform Concentrations (MPN/100 ml)-Mount Hope Bay and the Kickemuit River.**

Other Info.	11-Oct-06	12-Oct-06	13-Oct-06	14-Oct-06	15-Oct-06	16-Oct-06	17-Oct-06		
Wind dir	NE	SSE	NNW	NW	WSW	SSW	SSE		
Cum precip (in) <sup>1</sup>	0	0.87	0.87	0.87	0.87	0.87	0.87		
Tide	Flood	Flood	Flood	Flood	Low	Low	Low		
Station	11-Oct-06	12-Oct-06	13-Oct-06	14-Oct-06	15-Oct-06	16-Oct-06	17-Oct-06	Event mean <sup>2</sup>	Max
GA5-1	2	9	7	2	2	2	4	4.3	9
GA5-2	2	93	4	2	2	2	4	17.8	93
GA5-3	4	9	43	4	2	2	2	10.3	43
GA5-4	2	23	7	2	2	2	2	6.3	23
GA5-5	2	9	4	9	2	2	2	4.7	9
GA5-6	2	230	23	4	4	2	2	44.2	230
GA5-7	2	430	43	4	2	7	4	81.7	430
GA5-8	2	430	23	23	23	9	9	86.2	430
GA5-9	2	93	7	2	2	2	2	18.0	93
GA5-10	4	43	9	4	2	2	2	10.3	43
GA17-1	2	9	2	2	3	15	2	5.5	15
GA17-2	9	21	93	15	2	4	4	23.2	93
GA17-3	9	9	9	15	2	240	43	53.0	240
GA17-4	4	430	93	9	4	15	2	92.2	430
GA17-5	4	23	21	93	9	4	2	25.3	93
GA17-6	2	1100	43	2	4	4	2	192.5	1100
GA17-7	2	150	43	2	2	2	2	33.5	150
GA17-8	4	9	23	9	4	2	2	8.2	23
GA17-9	4	9	4	2	4	3	2	4.0	9
GA17-10	2	43	7	2	4	4	2	10.3	43
GA17-11	4	2	2	4	2	2	2	2.3	4
GA17-12	4	23	4	2	2	2	2	5.8	23
GA17-13	2	9	2	2	2	2	2	3.2	9
GA17-14	2	93	3	4	2	9	4	19.2	93
GA17-15	9	4	2	2	2	2	4	2.7	4
GA17-16	2	9	4	2	2	7	4	4.7	9
MHBA	4	230	23	4	15	9	15	49.3	230
MHBH	4	75	23	23	2	15	3	23.5	75
MHBI	7	460	9	2	2	9	3	80.8	460

1. Precipitation Recorded at RIDEM Offices in Providence, RI.
2. Event Mean does not Include Dry Weather Data.

### 3.4.3. Source Sampling Results (October 11 and 12, 2006)

Nine sources were sampled during wet weather sampling event 2. Sources were sampled on three separate occasions starting on October 11<sup>th</sup> at 10 P.M., and October 12<sup>th</sup> at 12 A.M. and 9 A.M. Fecal concentrations recorded during the October 11<sup>th</sup> sampling event were relatively low, with the highest concentration (9,300 MPN/100 ml) recorded at Robert Gray Av. (17-28). High coliphage concentrations were recorded at two sources in northern Tiverton on the Mount Hope Bay. The coliphage concentrations at State Av. (17-40) and Robert Gray Av. (17-28) were 7,060 and 138 pfu/100 ml, respectively. A high coliphage concentration (2,270 pfu/100 ml) was also recorded on the campus of Roger Williams University (17-45) in Bristol.

Fecal concentrations recorded during the 12 A.M. October 12<sup>th</sup> sampling event were higher than the October 11<sup>th</sup> results at most of the sources. The highest fecal concentration (93,000 MPN/100 ml) occurred again at Robert Gray Av. in Tiverton (17-28). High fecal concentrations (23,000-43,000 MPN/100 ml) were also recorded at some Bristol sources to Mount Hope Bay, located at Sunrise Dr. (17-16), Viking Dr. (17-13), the state boat ramp near Annawamscutt Dr. (17-14), and the Roger Williams University campus (17-45). High coliphage concentrations were recorded in northern Tiverton. The coliphage concentration at Summerfield La. (17-27) was 4,150 pfu/100 ml. The coliphage concentration at Robert Gray Av. (17-28) could not be quantified, due to extremely high levels. A coliphage concentration of 146 pfu/100 ml was recorded at State Av. (17-45). High coliphage concentrations also

occurred at the Bristol sources to Mount Hope Bay. The coliphage concentrations at Viking Dr. (17-13) and on the Roger Williams University campus (17-45) were 150 and 119 pfu/ 100 ml, respectively.

Fecal concentrations recorded during the 9 A.M. October 12<sup>th</sup> sampling event tended to decrease from the levels observed earlier that morning. Like the results from the two previous source sampling events, the highest fecal concentration (39,000 MPN/100 ml) occurred at Robert Gray Av. in Tiverton (17-28). The fecal concentrations at the Roger Williams University campus and the state boat ramp near Annawamscutt Dr. were 23,000 and 15,000 MPN/100 ml, respectively. Coliphage concentrations were elevated at the Tiverton sources to Mount Hope Bay. The coliphage concentrations at Summerfield La. (17-27) and State Av. (17-45) were 1,280 and 1,250 pfu/100 ml, respectively. The coliphage level at Robert Gray Av. (17-28) could not be quantified, due to extremely high levels. High coliphage concentrations also occurred at the Bristol sources to Mount Hope Bay. The coliphage concentrations at the state boat ramp near Annawamscutt Dr. (17-14) and on the Roger Williams University campus (17-45) were 4,530 and 92 pfu/ 100 ml, respectively.

**Figure 3.18. Source Results-10/11/06**  
**Fecal Results (MPN/100 ml)**



**Coliphage Results (pfu/100ml)**

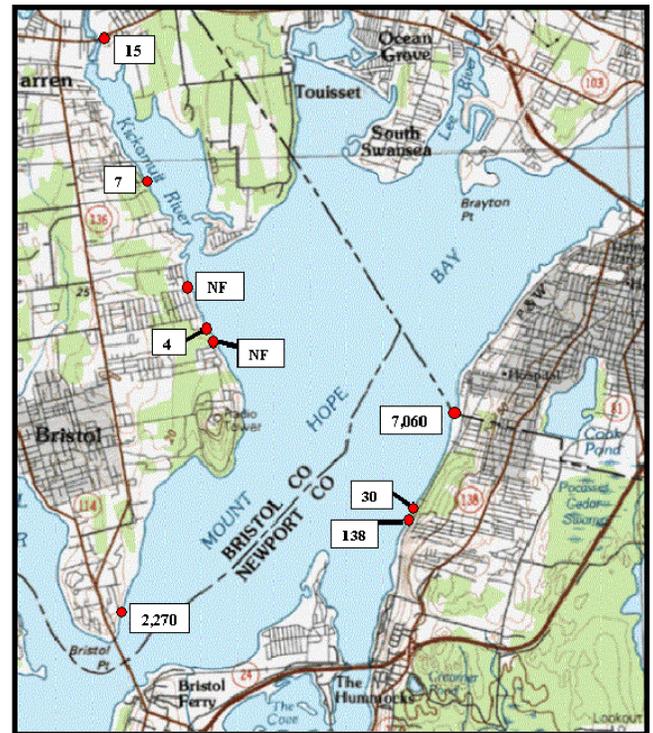


Figure 3.19. Source Results-10/12/06 (12 A.M.)  
Fecal Results (MPN/100 ml)



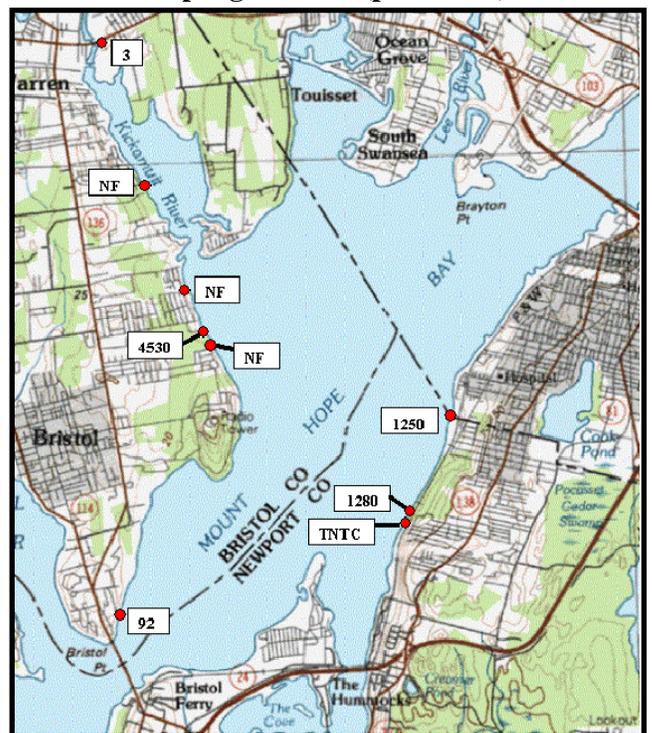
Coliphage Results (pfu/100ml)



Figure 3.20. Source Results-10/12/06 (9 A.M.)  
Fecal Results (MPN/100 ml)



Coliphage Results (pfu/100ml)



**Table 3.12. Fecal Coliform Concentrations (MPN/100 ml)-Mount Hope Bay-Wet Weather Event 2 (October 11 and 12, 2006).**

				10/11/06 (10 P.M.)	10/12/06 (12 A.M.)	10/12/06 (9 A.M.)
Precipitation Day of Sampling (in.)				0.48	0.34	0.34
Station	Description	Town	Location			
5-4	18" pipe	Bristol	Sherman Av	3,900	2,300	NS <sup>2</sup>
5-23	36" pipe	Warren	Child St. east of bridge	230	150	4
17-45	Stream from detention pond	Bristol	Roger Williams Campus	2,300	23,000	23,000
17-13	12" pipe	Bristol	Viking Dr.	NS <sup>2</sup>	≥24,000	NS <sup>2</sup>
17-14	Stream	Bristol	State boat ramp south of Annawamscutt Dr.	2,400	23,000	15,000
17-16	36" pipe	Bristol	Sunrise Dr.	NS <sup>2</sup>	43,000	NS <sup>2</sup>
17-40	24" pipe	Tiverton	State Av.	4,300	9,300	39,000
17-27	Stream	Tiverton	Summerfield La.	210	9,300	4,300
17-27D <sup>1</sup>	Stream	Tiverton	Summerfield La.	NS <sup>2</sup>	NS <sup>2</sup>	2,300
17-28	Stream	Tiverton	Robert Gray Av.	9,300	93,000	4,300

1. D=Duplicate.  
2. NS=No Sample

**Table 3.13. Male-Specific Coliphage Concentrations (pfu/100ml)- Wet Weather Event 2 (October 11 and 12, 2006).**

				10/11/06 (10 P.M.)	10/12/06 (12 A.M.)	10/12/06 (9 A.M.)
Precipitation Day of Sampling (in.)				0.48	0.34	0.34
Station	Description	Town	Location			
5-4	18" pipe	Bristol	Sherman Av	7	2	NS <sup>2</sup>
5-23	36" pipe	Warren	Child St. east of bridge	15	8	3
17-45	Stream from detention pond	Bristol	Roger Williams Campus	2270	119	92
17-13	12" pipe	Bristol	Viking Dr.	NS <sup>2</sup>	150	NS <sup>2</sup>
17-14	Stream	Bristol	State boat ramp south of Annawamscutt Dr.	4	<1	4530
17-16	36" pipe	Bristol	Sunrise Dr.	NS <sup>2</sup>	6	NS <sup>2</sup>
17-40	24" pipe	Tiverton	State Av.	7060	146	1250
17-27	Stream	Tiverton	Summerfield La.	30	4150	1280
17-27D <sup>1</sup>	Stream	Tiverton	Summerfield La.			108
17-28	Stream	Tiverton	Robert Gray Av.	138	TNTC <sup>3</sup>	TNTC <sup>3</sup>

- D=Duplicate.  
NS=No Sample  
3. TNTC=Too Numerous To Count

#### 4.0 EVALUATION OF DATA QUALITY

Field replicates were taken during each wet weather sampling event at both estuarine sampling stations and at sources. The Rhode Island Department of Health laboratories analyzed fecal samples using the multiple tube fermentation or MPN technique. The precision of the MPN technique for fecal coliform is  $\pm 20\%$  at the 95% confidence interval (Kerry Patterson, RI Dept. of Health, personal communication). Field replicates were compared to the confidence interval criteria mentioned above and the mean of the original and replicate values to assess data reliability. The results are presented in Table 4.1 for the estuarine results and Table 4.2 for the source results and Table 3.7 for the laboratory duplicates. Although most of the replicates fell outside the 95% confidence interval, the estuarine replicates either fell inside or just outside of the confidence interval. Source replicates missed the 95% confidence interval by a much greater margin. Source fecal concentrations are generally an order of magnitude higher than the estuarine values and are intrinsically much more variable. All source replicates fall well within an order of magnitude of the original samples, which may be a more appropriate measure of source data quality, given the high variability of the source data.

**Table 4.1. Confidence Intervals for the Estuarine Field Replicate Samples.**

Sample ID	Sample Date	Original Sample (MPN/100ml)	Field Replicate (MPN/100ml)	Mean (MPN/100ml)	Confidence Interval		Are the Data within the Confidence Interval?
					Lower 95% (MPN/100 ml)	Upper 95% (MPN/100 ml)	
GA17STA14	10/15/06	1.5	1.5	1.5	1.2	1.8	Yes
GA5STA10	10/15/06	1.5	3	2.3	1.8	2.7	No
GA17STA14	10/17/06	4	9	6.5	5.2	7.8	No

**Table 4.2. Confidence Intervals for the Source Field Replicate Samples.**

Sample ID	Sample Date	Original Sample (MPN/100ml)	Field Replicate (MPN/100ml)	Mean (MPN/100ml)	Confidence Interval		Are the Data within the Confidence Interval?
					Lower 95% (MPN/100 ml)	Upper 95% (MPN/100 ml)	
17-22	6/2/06	4300	930	2615	2092	3138	No
17-22	6/3/06	12000	4300	8150	6520	9780	No
17-23	8/29/06	150	93	122	97	146	No
17-27	10/12/06	4300	2300	3300	2640	3960	No

## 5.0 DISCUSSION OF RHODE ISLAND SOURCE SAMPLING

### 5.1. SOURCE PRIORITIZATION

Sources were prioritized based on observed dry and wet weather fecal and bacteriophage concentrations, culvert diameter, culvert and stream discharge, and proximity to localized elevated fecal concentrations observed in the estuary during the two wet-weather events.

Dry weather fecal levels exceeding 2,300 MPN/100 ml were generally flagged as priority sources for immediate follow-up. The Office of Compliance and Inspection uses this fecal level as a general guideline because at this level there is a reasonable possibility that any human source of fecal pollution can be identified. Standard Operating Procedure for DEM's Shellfish program specifies a similar threshold concentration (2,400 MPN/100 ml), which triggers follow-up sampling and referral to the Office of Compliance and Inspection. Also, sources exceeding this dry-weather fecal guideline generally also had high levels of bacteriophage. Many of the sources of fecal contamination to stormwater drains, such as pets and most wildlife, may be discounted during dry weather. It is therefore more likely that high fecal concentrations measured during dry weather are derived from human sources, such as failing septic systems, illicit connections, leaky sewers, or cross connections.

Fecal coliform are ubiquitous in the environment and are produced from a variety of watershed sources including sewer lines, septic systems, livestock, wildlife, waterfowl, pets, soils, plants, and even within the stormwater system itself. Moderate or even high concentrations of fecal coliform, observed during wet weather may not necessarily be associated with a human source. Pitt (1998) reported a mean fecal concentration in stormwater runoff of about 20,000 MPN/100 ml and suggests that human sources of sewage should be suspected when fecal coliform concentrations are consistently higher than  $10^5$  MPN/100 ml. This threshold for fecal coliform was exceeded in only one instance for the duration of the study (a stream at Summerfield La. in Tiverton).

High bacteriophage concentrations are reportedly a more reliable indicator of human sources of fecal pollution than high fecal concentrations alone (Calci, et al., 1998; Long et al., 2005). Calci (1998) reports that the mean bacteriophage concentration in wastewater from single-family dwellings is  $1.0 \times 10^5$  pfu/100ml. This is supported by Long et al. (2005) who reports that the mean bacteriophage concentration in septic system liquid is  $7.2 \times 10^5$  pfu/100ml. In addition, Calci et al. (1998) report that the mean bacteriophage concentration for in-line sewage and sewage plant influent is  $2.3 \times 10^5$  and  $5.2 \times 10^5$  pfu/100 ml, respectively. Again this is corroborated by Long et al. who report a mean bacteriophage concentration in wastewater influent of  $1.1 \times 10^5$  pfu/100 ml. Although feces from other animals, including seagulls, chickens, hogs horses, may have relatively high bacteriophage concentrations, it would take thousands of birds and over a million dogs to equal the bacteriophage load of a single failing septic system or illicit connection (Calci et al., 1998). Since the reported bacteriophage levels derived from both septic systems and sewage pipes are on the order of  $10^5$  pfu/100 ml, and a dilution of 1:100 or even 1:1000 can occur once the effluent discharges to a storm drain, a bacteriophage concentration of 50 pfu/100 ml was selected as a general guideline to flag priority outfalls for further investigation or pollution abatement.

Outfalls were also prioritized, at least partially, by pipe diameter, deducing that the culverts were sized according to their drainage areas and the potential for fecal contamination increases with the size of the catchment. Measured loadings were also used to a limited extent to determine the relative impacts of streams and pipes. Prioritizing sources by loading rates was difficult, since flow measurements were not taken over a discrete time period. Lastly, sources were also prioritized according to proximity to localized elevated fecal concentrations observed in the estuary during the two wet-weather events. These areas are discussed in greater detail in Section 5.1.3.

### 5.1.1. Priority Sources in the Town of Warren

The priority sources in Warren generally had high dry weather values for both fecal coliform and coliphage (Table 5.1). The relatively high dry weather values may be an indication of illegal tie-ins and cross connections. The wet weather coliphage concentrations were generally below the detection limit, while the fecal concentrations recorded during wet weather were generally typical of stormwater.

#### 5-18

This 24 in. culvert conducts stormwater from Metacom Avenue and discharges at the southern edge of the broken railroad bridge near Barker Avenue. This culvert had the highest observed dry weather fecal concentration and coliphage loading rate of any of the priority outfalls located in the Town of Warren.

#### 5-12

Based on its relatively high observed flow rate it appears that the box culvert at Parker Avenue drains Metacom Avenue in addition to Parker Avenue itself. The Parker Avenue box culvert had the highest observed fecal load of any of the Warren outfalls.

#### 5-21

This 18-in. culvert drains Child Street and perpendicular roads to the north. This outfall had the highest dry weather coliphage concentration of any of the Warren outfalls.

#### 5-13

The 30-inch Parker Avenue outfall drains Patterson Street to the south. Both fecal coliform and coliphage concentrations were higher during wet weather, possibly indicating that the source is from a failing septic system rather than an illegal tie-in or cross-connection..

#### 5-17

The Libby Lane outfall had high dry weather fecal coliform and coliphage concentrations. The Libby Lane outfall appears to drain the lower half of Libby Lane only.

**Table 5.1 Priority Sources in the Town of Warren.**

Source ID	Receiving Water	Location	Description	Max. Concentration During Dry Weather		Max. Concentration During Wet Weather	
				Fecal (MPN/100 ml)	Phage (pfu/100 ml)	Fecal (MPN/100 ml)	Phage (pfu/100 ml)
5-18	KR	Broken R.R. bridge at Barker Av.	24" culvert	43,000	835	15,000	<1
5-12	KR	Parker Av.	42 x 20" box culvert	15,000	49	23,000	<1
5-21	KR	Child St. west of bridge	18" culvert	≥24,000	1725	NS	NS
5-13	KR	Parker Av.	30" culvert	4,300	<1	23,000	130
5-17	KR	Libby La.	18" culvert	23,000	749	21,000	<1

KR=Kickemuit River

NS=No Sample

### **5.1.2. Priority Sources in the Town of Bristol**

Five priority outfalls were identified in the Town of Bristol (Table 5.2). These outfalls include: three streams and a culvert that discharge to Mount Hope Bay and one stream that discharges at the mouth of the Kickemuit River. Almost all of the area adjacent to the streams and pipe are sewered. The only unsewered area is a small area of large single-family lots along Metacom Avenue between Tower Street and Weetamoe Farm Drive. All of the priority outfalls were characterized by high coliphage concentrations during wet weather, possibly indicating the presence of leaking sewer systems, cross-connections, or perhaps failing septic systems.

In addition to stormwater outfalls to Mount Hope Bay and the Kickemuit River, sewer overflows have also occurred at the Mount Hope and Kickemuit pumping stations located at intersection of King Phillip Avenue and Annawamscutt Drive and the intersection of Kickemuit Avenue and Harrison Street, respectively. A few sewer manhole overflows have also been documented in the Mount Hope Bay watershed at 15 Jennifer Drive, 104 King Phillip Avenue, and 3 Polk Court (BETA Group Inc., 2007). These sewer system overflows occur during extreme rainfall events when seasonal groundwater levels are highest. The Town of Bristol is working with USEPA, RIDEM and BETA Group, Inc. to eliminate the problems with sewer system overflows.

#### ***17-14***

This unnamed stream discharges into Mount Hope Bay immediately south of the RIDEM boat launch at Annawamscutt Road. Inspection of aerial photographs reveals that the stream originates in a large swamp located between Hopeworth Avenue and Tower Road, east of the Minturn Farm Landfill. High-density residential development flanks the swamp in the vicinity of Hopeworth Avenue. Coliphage concentrations were particularly high (4530 pfu/100 ml) during wet weather.

#### ***17-45***

This stream or manmade swale originates at a detention basin located at the FCAS South Lecture Hall on the campus of Roger Williams University. Several pipes conduct stormwater to the basin. Coliphage concentrations were high during both dry and wet weather (2270 and 2054 pfu/100 ml, respectively).

#### ***17-7***

This unnamed stream discharges into Mount Hope Bay east of Bristol Landing. The stream appears to originate in a wetland just north of Tower Road. The only residential development in the immediate vicinity of the stream is along Russell Avenue, and several large unsewered properties east of Metacom Avenue, between Tower Street and Weetamoe Farm Drive. The stream flows through two old farm ponds. The stream may be accessed from a grassed cart path at Bristol Landing condominiums, which extends to the shoreline from the intersection of Weetamoe Farm and Sequoia Drive. There are two streams that are culverted underneath the cart path. The subject stream is the easternmost one. High coliphage concentrations (297 pfu/100 ml) were recorded at this location during wet weather.

#### ***5-1***

This unnamed stream discharges into the Kickemuit River at a small cove, just north of Narrows Road. This stream originates in a swamp that straddles Narrows Road. The swamp is flanked by high-density residential development to the south of Narrows Road. A sewer line crosses the swamp from Sowams to Sunrise Drive. High coliphage concentrations were recorded during wet weather (232 pfu/100 m).

#### ***17-13***

This 18-inch culvert is located east of Viking Drive, approximately 150 feet north of its intersection with Glen View Drive. The drain appears to service an isolated neighborhood straddling the terminus of Hopeworth Avenue. High coliphage concentrations were recorded during wet weather (>800 pfu/ml).

**Table 5.2. Priority Sources in the Town of Bristol.**

Source ID	Receiving Water	Location	Description	Max. Concentration During Dry Weather		Max. Concentration During Wet Weather	
				Fecal (MPN/100 ml)	Phage (pfu/100 ml)	Fecal (MPN/100 ml)	Phage (pfu/100 ml)
17-14	MHB	State boat ramp south of Annawamscutt Dr.	Stream	2,400	29	23,000	4530
17-45	MHB	Roger Williams University	Stream from detention pond	4,300	2270	23,000	2054
17-7	MHB	Bristol Landing Condominiums	Stream	4,600	7	24,000	297
5-1	KR	Kickemuit mouth north of Narrows Rd.	Stream	430	1	2,300	232
17-13	MHB	Viking Dr.	18" culvert	NS	NS	≥24,000	>800

MHB=Mount Hope Bay  
 KR=Kickemuit River  
 NS=No Sample

**5.1.3 Priority Sources in the Town of Tiverton**

Two priority sources (a 24-in. outfall and a stream) were identified in the Town of Tiverton, both located in close proximity to each other between Robert Gray Avenue and Summerfield Lane. This area is serviced by older, individual septic systems, including cesspools. The area is characterized by a high water table, high ledge, extreme slopes, and high-density residential development, which increase the likelihood of septic system failure. Note that high dry weather fecal coliform (21,000 MPN/100 ml) and coliphage concentrations (Too Numerous To Count) were recorded at a 24-in. outfall at State Avenue (17-40), which is located along the Rhode Island-Massachusetts border. Since it appears that most, if not all of the drainage associated with this outfall is from Massachusetts, this outfall was not identified as a priority outfall.

**17-28**

This 24-in. culvert discharges into Mount Hope Bay just north of the intersection of Robert Gray Av. and Colony Terrace. The pipe drains a portion of Main Road (Route 138), Pleasant Avenue, most of Robert Gray Avenue, Kearns Avenue west of Terry Lane, and Brackett Avenue east of Terry Lane. This drain has a history of surcharging, and there appears to be an overflow pipe, located at the intersection of Kearns Avenue and Terry Lane, that shunts stormwater to a stream to the north (17-27). Results from the outflow show high fecal coliform and coliphage concentrations during both dry and wet weather (Table 5.3). The results appear to indicate the presence of illicit tie-ins as well as failing septic systems.

**17-27**

This stream discharges into Mount Hope Bay west-southwest of the cul-de-sac of Summerfield Lane. Inspection of aerial photographs reveals that the stream originates north of Kearns Avenue down-gradient of Rose Road. Another stream, originating north of Randolph Avenue and down-gradient of the western terminus of Cleg Avenue, and culverted under Last Street, discharges into the stream at a 36-in. outfall to the south-southeast of the cul-de-sac of Summerfield Lane. This same 36 in. culvert conducts stormwater from Randolph Avenue and probably Main Road. A 12-in. outfall drains stormwater from Summerfield

Lane and discharges into the stream south-southwest of its cul-de-sac. A 24-in. stormwater overflow pipe from Kearns Avenue storm drain system discharges to the subject stream near the intersection of Kearns Avenue and Terry Lane. High concentrations of fecal and coliphage were recorded at the stream terminus. Coliphage concentrations were generally high only during rain events, with several very low coliphage results recorded during dry weather. However, the highest fecal coliform concentration was recorded during dry weather. This would appear to indicate the presence of failing septic systems.

**Table 5.3. Priority Sources in the Town of Tiverton.**

Source ID	Receiving Water	Location	Description	Max. Concentration During Dry Weather		Max. Concentration During Wet Weather	
				Fecal (MPN/100 ml)	Phage (pfu/100 ml)	Fecal (MPN/100 ml)	Phage (pfu/100 ml)
17-28	MHB	Robert Gray Av.	24" culvert	≥24,000	6120	93,000	TNTC
17-27	MHB	Summerfield La.	Stream	≥240,000	30	9,300	4150

MHB=Mount Hope Bay

TNTC=Too Numerous to Count

## 5.2. STREAMS AND WETLANDS CHARACTERIZED BY HIGH FECAL COLIFORM LEVELS

Numerous tributaries to Mount Hope Bay and the Kickemuit River were found to have high levels of fecal coliform bacteria. These tributaries were not identified as priority sources for immediate follow-up, however fecal coliform concentrations were found to exceed R.I. Water Quality Criteria, warranting longer-term attention for these impacted waterbodies. Although there is not enough data to classify these water bodies as impaired, they are identified in Tables 5.4 through 5.6 below.

**Table 5.4. Warren Streams with Fecal Concentrations Exceeding Water Quality Criteria.**

Source ID	Receiving Water	Location	Description	Max. Concentration During Dry Weather		Max. Concentration During Wet Weather	
				Fecal (MPN/100 ml)	Phage (pfu/100 ml)	Fecal (MPN/100 ml)	Phage (pfu/100 ml)
5-16	KR	Farm south of Libby La.	Stream	1,100	1	11,000	2
17-22	MHB	Maple Av.	Stream	4,300	<1	12,000	<1

KR=Kickemuit River

MHB=Mount Hope Bay

**Table 5.5. Tiverton Streams with Fecal Concentrations Exceeding Water Quality Criteria.**

Source ID	Receiving Water	Location	Description	Max. Concentration During Dry Weather		Max. Concentration During Wet Weather	
				Fecal (MPN/100 ml)	Phage (pfu/100 ml)	Fecal (MPN/100 ml)	Phage (pfu/100 ml)
17-26	MHB	North of Summerfield La.	Stream	930	<1	NS	NS

NS=Not Sampled

**Table 5.6. Bristol Streams and Wetlands with Fecal Concentrations Exceeding Water Quality Criteria.**

Source ID	Receiving Water	Location	Description	Max. Concentration During Dry Weather		Max. Concentration During Wet Weather	
				Fecal (MPN/100 ml)	Phage (pfu/100 ml)	Fecal (MPN/100 ml)	Phage (pfu/100 ml)
17-6	MHB	Bristol Landing Condominiums	Stream	NS	NS	2,100	<1
17-10	MHB	Near Mt. Hope Farm	Stream	NS	NS	930	<1
17-9	MHB	Near Mt. Hope Farm	Outlet from coastal wetland	140	10	1,100	89
17-10	MHB	Near Mt. Hope Farm	Stream	NS	NS	930	<1

NS=Not Sampled

### 5.3. LOCALIZED ESTUARINE AREAS CHARACTERIZED BY HIGH FECAL COLIFORM LEVELS

#### 5.3.1. Mount Hope Bay

There is a localized area of elevated fecal coliform levels at estuarine sampling stations GA17-6 and GA17-7 in the northern Tiverton area of Mount Hope Bay. Elevated fecal concentrations at these stations were recorded within one or two days after significant rain events. The elevated levels are probably due mainly to the proximity of these stations to numerous Fall River CSO's and to the Fall River wastewater treatment facility. However, the priority outfalls discussed previously in section 5.1.3 are located within very close proximity to estuarine station GA17-7, and may also have a significant impact on the local water quality. It should be noted that since the completion of the wet weather sampling of Mount Hope Bay, the City of Fall River has undergone a CSO abatement program. It is anticipated that the water quality in this area of northern Tiverton should improve as a result.

#### 5.3.2. Kickemuit River

The upper portion of the tidal Kickemuit River in the Town of Warren is characterized by high fecal coliform concentrations. Elevated fecal levels were recorded at stations GA5-6 through GA5-8, from one to three days following the rain event. This portion of the Kickemuit River is narrow and constricted relative to the lower portion, perhaps contributing to diminished tidal flushing. Five of the six priority outfalls, discharging to the Kickemuit River discharge to this upper portion of the river. The combined effect of these priority outfalls probably has a significant impact on the water quality of the area. Discharge from the freshwater portion of the Kickemuit River also has a negative impact on this localized area. High fecal levels (75 and 93 MPN/100 ml) were also recorded during wet weather at the outflow of the freshwater portion of the Kickemuit River at the Child Street bridge. A mean wet-weather fecal concentration of 212 MPN/100 ml has also been previously reported at the terminus of the freshwater portion of the Kickemuit River (RIDEM, 2006).

## **6.0 DISCUSSION OF MASSACHUSETTS SOURCES**

### **6.1. MOUNT HOPE BAY**

In 2005, MADEP along with USEPA and ENSR International completed a draft TMDL for the Taunton River watershed. Known and suspected bacteria sources were identified including failing septic systems, leaking sewer pipes, illicit connections of septic systems to storm drains, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, illicit boat discharges, wildlife including birds, domestic pets and animals, and direct overland runoff. MADEP developed a concentration-based TMDL, designed to meet the state's water quality standards. It was estimated that greater than 90% reductions in fecal coliform loading was necessary, especially in urban areas. The goal for illicit sources is complete elimination.

The Massachusetts Division of Marine Fisheries conducted a shellfish survey of the Massachusetts portion of the study area in the winter of 1996-97. Potential sources of bacterial contamination to Mount Hope Bay were identified and include the Lees and Coles Rivers, which have poor water quality after rain events, and the Taunton River, which has poor water quality most of the time. The Fall River WWTP was also identified as a source. The MADEP shellfish survey also sampled storm drains for fecal coliform, identifying numerous sources of fecal pollution. The study also identified numerous potential illicit septic system discharges, located along Atlantic Boulevard, which may discharge directly into the bay.

There have been several initiatives in Massachusetts in recent years to improve water quality in the Taunton River watershed. The City of Taunton upgraded their wastewater treatment plant (WWTP) in 2001 and 2002 and, as a result, the number of CSO events dropped from 24 events in 2000, to only one event in 2004 (MADEP, USEPA, ENSR; 2005). The City of Fall River has been addressing its CSO problems since 1984, including upgrades to its WWTP, a CSO tunnel to enlarge its storage capacity, and partial separation of sanitary and stormwater sewers. The WWTP and tunnel project have been completed. In 2004, the City of Brockton began a facility-wide upgrade to its WWTF. The Town of Dighton has also received funds to identify areas where onsite sewage disposal systems are inadequate, and to develop wastewater management recommendations.

### **6.2. KICKEMUIT RIVER**

Both Rhode Island and Massachusetts criteria for fecal coliform are exceeded, during both dry and wet weather, from the tidal boundary at Child Street to the upper reach of the Kickemuit River at Grand Army Highway (Route 6) in Swansea, Massachusetts (RIDEM, 2006). Stormwater, agricultural runoff, failing septic systems, pet waste and wildlife have been identified as sources of fecal pollution to the freshwater portion of the Kickemuit River. EPA staff has previously identified 41 outfalls and other direct conveyances in the watershed of the freshwater Kickemuit River. Large housing developments bordering the river were identified as the probable dominant source of fecal pollution impacting the lower Massachusetts reach of the Kickemuit River. Specifically, failing septic systems in the Smoke Rise and Mount Claire Circle housing developments were named as a significant source. Livestock, dairy, and poultry operations along Heath Brook and an unnamed western tributary were also identified as significant bacterial sources. Agricultural land uses along the Warren Reservoir (aka Lower Kickemuit Reservoir) were also identified as a source of fecal pollution.

## 7.0 REFERENCES

Applied Science Associates, Inc., 1990. *Draft Report, City of Fall River, Combined Sewer Overflow Facilities Plan: Receiving Water Impacts Field Measurement Program* (Unpublished).

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RIDEM, 2006a. *State of Rhode Island and Providence Plantations, Department of Environmental Management, Water Resources, Water Quality Regulations* (Unpublished).

RIDEM, 2006b. *Quality Assurance Project Plan, Wet Weather Sampling of Mt Hope Bay and Kickemuit River Rhode Island Department of Environmental Management, Office of Water Resources, Water Quality Regulations* Unpublished report submitted to USEPA Region 1, Boston, and RIDEM, Providence, RI.

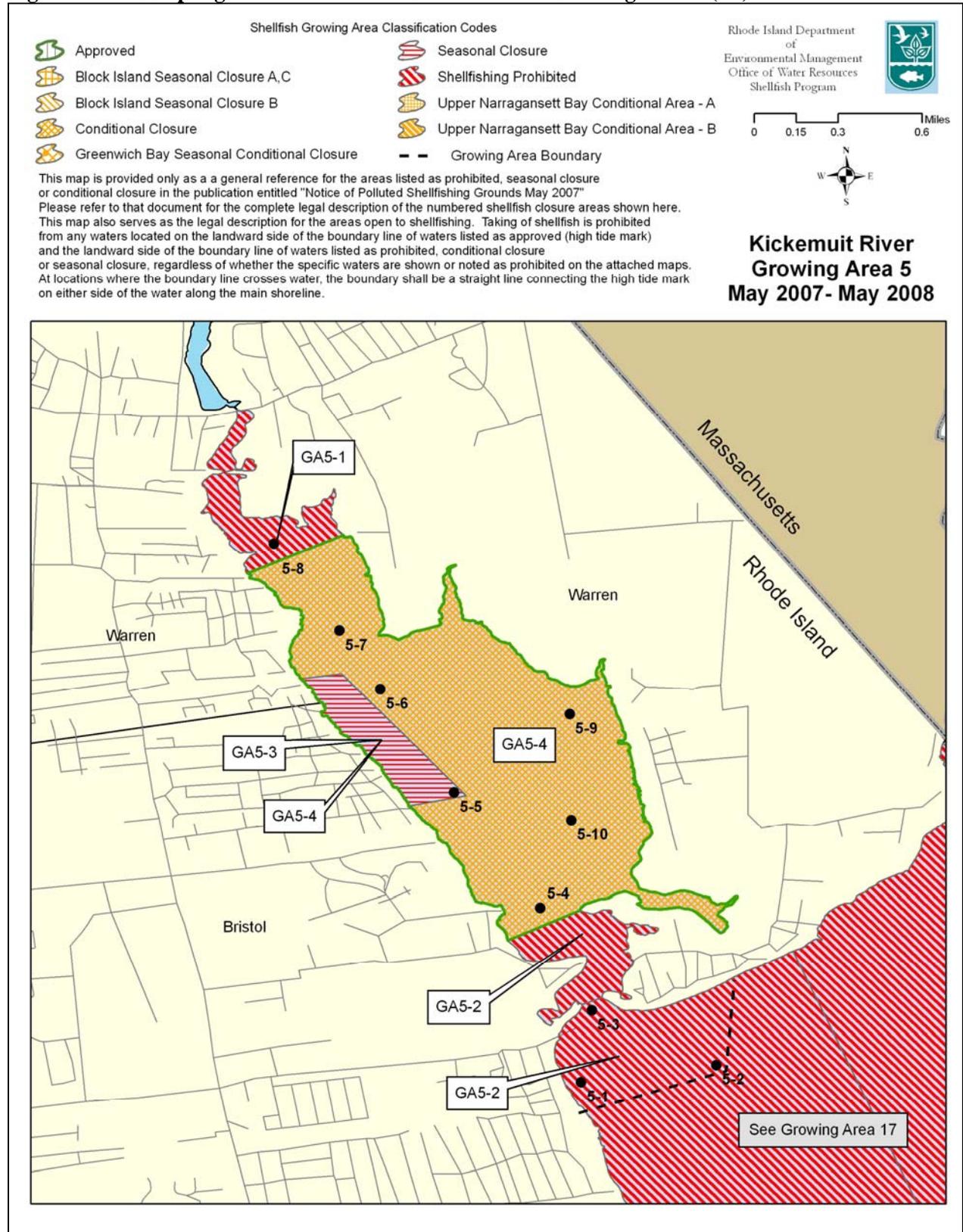
RIDEM 2006c. *Mount Hope and Kickemuit River QAPP Modification*, Unpublished report submitted to USEPA Region 1, Boston.

RIDEM, 2006d. *Fecal Coliform and Total Phosphorus TMDLs, Kickemuit Reservoir, Rhode Island (RI0007034L-01), Upper Kickemuit River (RI0007034R-01), Kickemuit River (MA61-08\_2004)*, Report submitted to USEPA Region 1, Boston, and RIDEM, Providence, RI.

U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration 1989, *Shellfish Sanitation Program Technical Report, Hydrostatic Study of Mt. Hope Bay, Rhode Island*

**APPENDIX A. ESTUARINE SAMPLING LOCATIONS**

**Figure A.1. Sampling Locations in the Kickemuit River-Growing Area 5 (RI).**



**Figure A.2. Sampling Locations in Mount Hope Bay-Growing Area 17 (RI).**

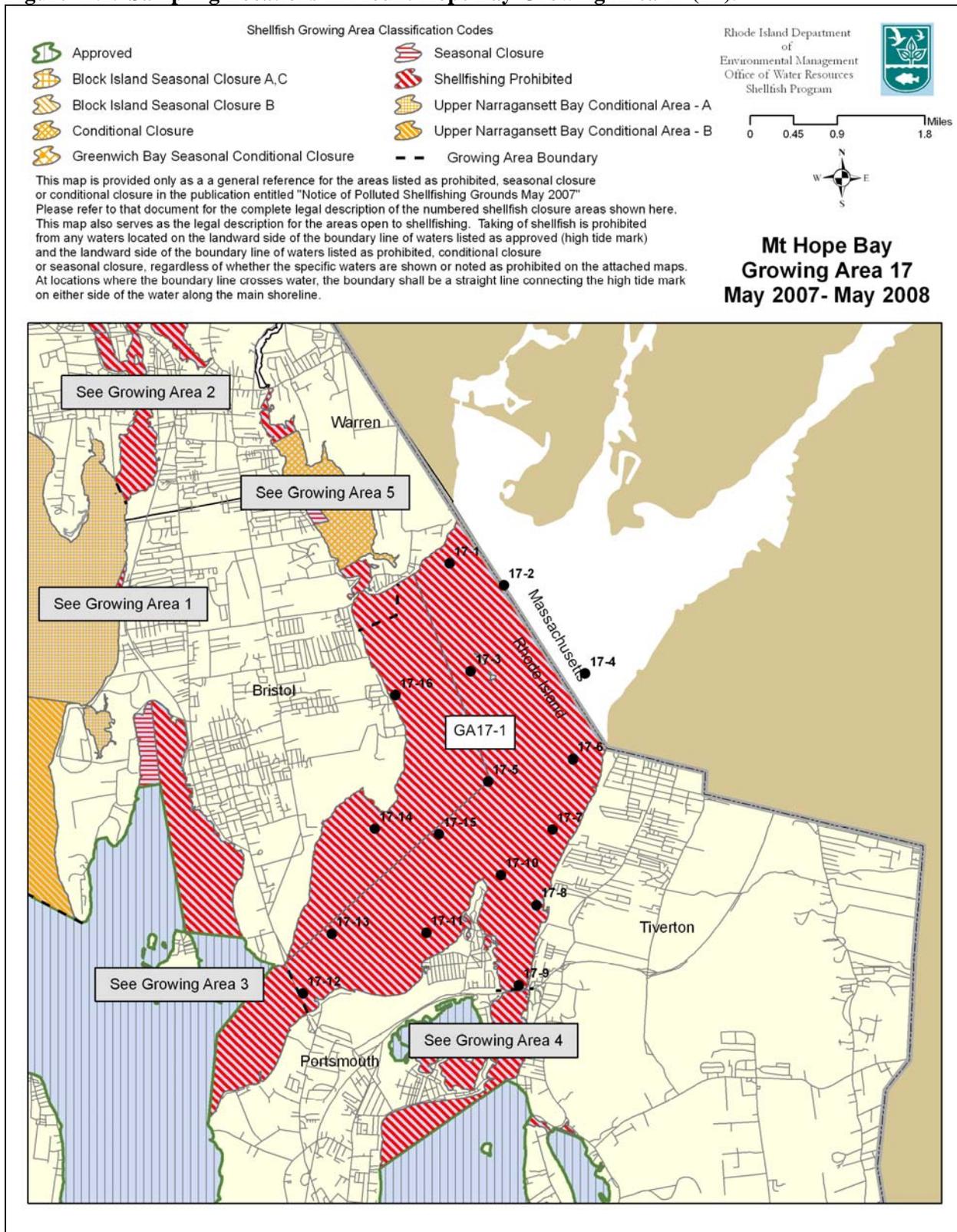


Figure A.3. Sampling Locations in Mount Hope Bay-Growing Area MHB1 (MA).

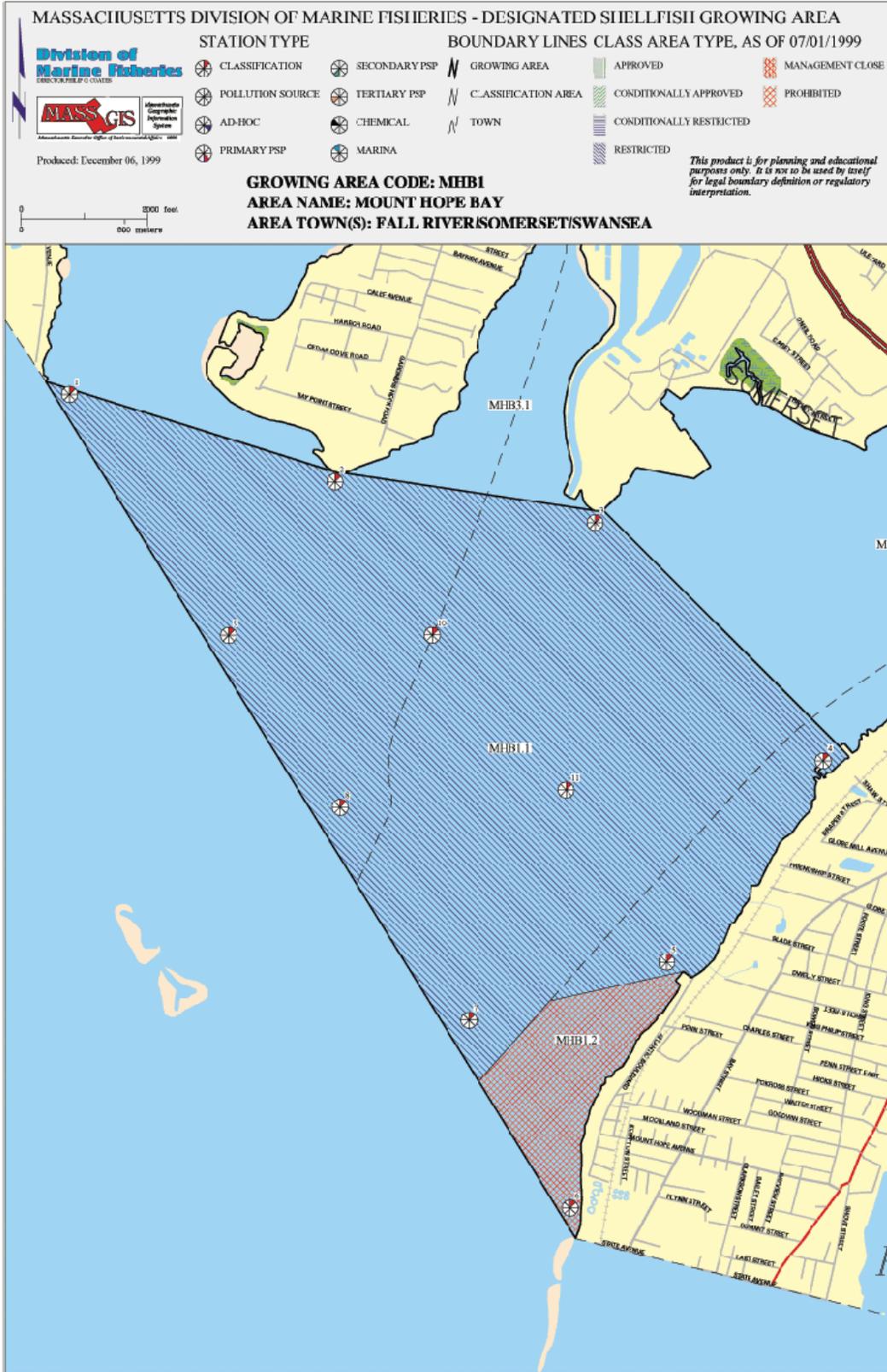


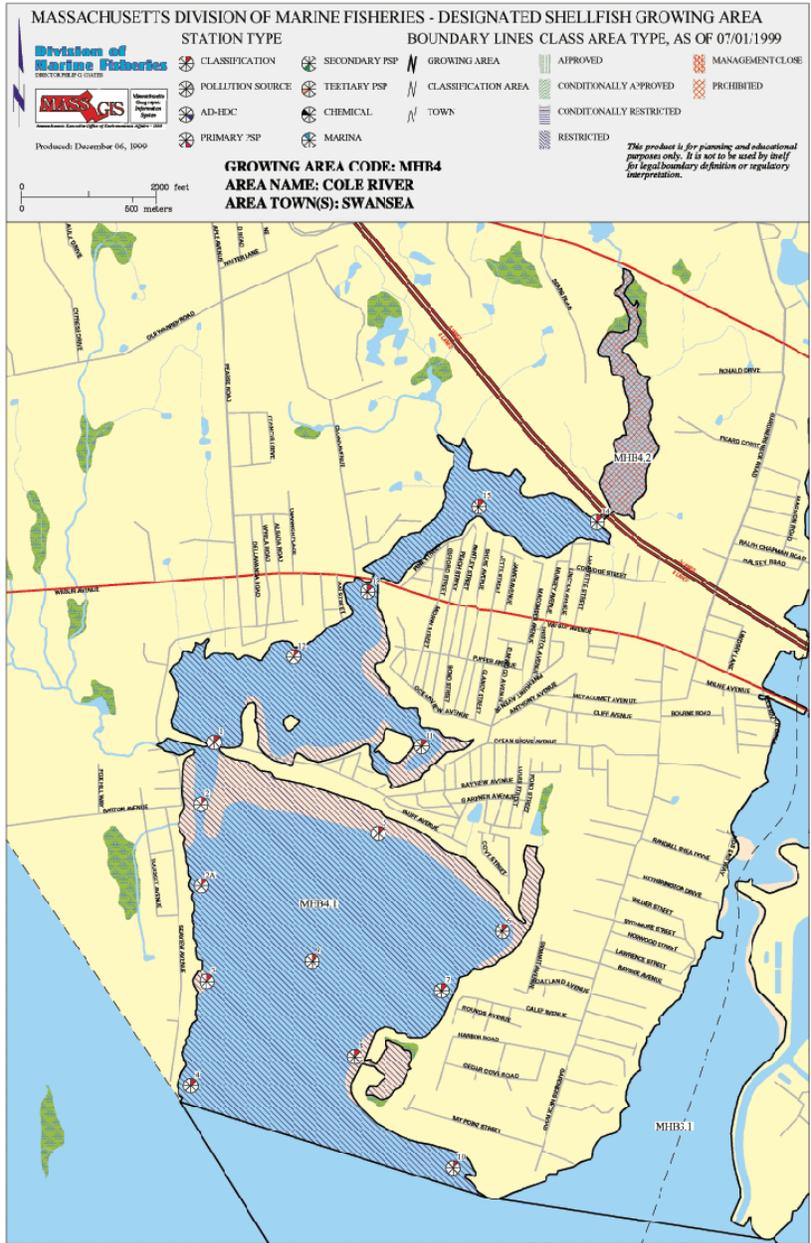
Figure A.4. Sampling Locations in Mount Hope Bay-Growing Area MHB2 (MA)



Figure A.5. Sampling Locations in Mount Hope Bay-Growing Area MHB3 (MA).



Figure A.6. Sampling Locations in Mount Hope Bay-Growing Area MHB4 (MA).



APPENDIX B. SOURCE RESULTS.

Shellfish Station	Description	Location	Warren Fecal Coliform Concentration (MPN/100 ml)									Min.	Max.	Mean	n	Rank	Mean Dry Weather (MPN/100 ml)	Mean Wet Weather (MPN/100 ml)
			2005			2006												
			9/1	9/2	6/2	6/3	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)									
5-21	18" pipe	Child St. west of bridge		>=24000	23000	9300				9300	>=24000	18767	3	1	18767	***		
5-12	42 x 20" box culvert	Parker Av.	930		15000	23000				930	23000	12977	3	2	7965	23000		
5-13	30" culvert	Parker Av.			4300	23000				4300	23000	13650	2	3	4300	23000		
5-17	18" pipe	Libby Ln.			23000	21000				21000	23000	22000	2	4	23000	21000		
5-18	24" pipe	Barker Av. (broken RR bridge)	>=24000		43000	15000				>=24000	15000	72334	3	5	33500	15000		
17-22	stream	Maple Av.			4300	12000				4300	12000	8150	2	6	4300	12000		
17-22D	stream	Maple Av.			930	4300												
5-16	stream	farm south of Libby La.		1100	240	11000				240	11000	4113	3	7	670	11000		
5-23	36" pipe	Child St. east of bridge		240			230	150	4	4	240	156	4	8	156	***		
5-22	outflow of Upper Kicki	Child St.		43	93	75				43	93	70	3	9	68	75		
													<b>Total Mean</b>	<b>10303</b>	<b>15011</b>			

Red Font = Wet Weather/Stormwater Influenced  
 D= Duplicate  
 9/1/2005 2 days after a 2.54" rain event  
 9/2/2005 3 days after a 2.54" rain event  
 6/2/2006 during a 0.16" and 1 day after a 0.48" rain event  
 6/3/2006 during a 1.32" rain event  
 10/11/2006 during a 0.48" rain event  
 10/12/2006 during a 0.34" rain event and one day after a 0.48" rain event

Shellfish Station	Description	Location	Warren Fecal Coliform Load (fc/day)										Mean Dry Weather (fc/day)	Mean Wet Weather (fc/day)
			2006											
			6/2	6/3	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)	Min.	Max.	Mean	n	Rank		
5-12	42 x 20" box culvert	Parker Av.	1.07E+11	1.31E+12				1.07E+11	1.31E+12	7.09E+11	2	1	1.07E+11	1.31E+12
5-18	24" culvert	Barker Av. (broken RR bridge)	7.89E+11	8.26E+11				7.89E+11	8.26E+11	8.08E+11	2	2	7.89E+11	8.26E+11
17-22	stream	Maple Av.	1.75E+10	4.28E+11				1.75E+10	4.28E+11	2.23E+11	2	3	1.75E+10	4.28E+11
17-22D	stream	Maple Av.	3.79E+09	1.53E+11										
5-16	stream	farm south of Libby La.	3.26E+09	1.35E+11				3.26E+09	1.35E+11	6.91E+10	2	4	3.26E+09	1.35E+11
5-13	30" culvert	Parker Av.	2.79E+08	1.13E+11				2.79E+08	1.13E+11	5.66E+10	2	5	2.79E+08	1.13E+11
5-21	18" pipe	Child St. west of bridge	8.43E+10	1.55E+10				1.55E+10	8.43E+10	4.99E+10	2	6	4.99E+10	***
5-17	18" pipe	Libby Ln.	9.03E+07	3.21E+10				9.03E+07	3.21E+10	1.61E+10	2	7	9.03E+07	3.21E+10
5-22	outflow of Upper Kicki	Child St.	1.52E+10	6.12E+09				6.12E+09	1.52E+10	1.07E+10	2	8	***	1.07E+10
5-23	36" pipe	Child St. east of bridge			1.69E+09	3.67E+09	4.24E+04	4.24E+04	3.67E+09	1.79E+09	3	9	4.24E+04	2.68E+09
												<b>Total Mean</b>	<b>1.21E+11</b>	<b>3.57E+11</b>

**Red Font** = Wet Weather/Stormwater Influenced  
 D= Duplicate  
  
 6/2/2006 during a 0.16" and 1 day after a 0.48" rain event  
 6/3/2006 during a 1.32" rain event  
 10/11/2006 during a 0.48" rain event  
 10/12/2006 during a 0.34" rain event and one day after a 0.48" rain event

Shellfish Station	Description	Location	Warren M.S. Bacteriophage Concentration (pfu/100 ml)										Mean Dry Weather (pfu/100ml)	Mean Wet Weather (pfu/100ml)
			2006					Min.	Max.	Mean	n	Rank		
			6/2	6/3	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)							
5-21	18" pipe	Child St. west of bridge	31	1725				31	1725	878	2	1	878	***
5-18	24" culvert	Barker Av. (broken RR bridge)	835	0				0	835	418	2	2	835	0
5-17	18" pipe	Libby Ln.	749	0				0	749	375	2	3	749	0
5-13	30" culvert	Parker Av.	0	130				0	130	65	2	4	0	130
5-12	42 x 20" box culvert	Parker Av.	49	0				0	49	25	2	5	49	0
5-23	36" pipe	Child St. east of bridge			15	8	3	3	15	9	3	6	3	12
17-22	stream	Maple Av.	0	0				0	0	0	2	7	2	0
17-22D	stream	Maple Av.	0	3										
5-16	stream	farm south of Libby La.	1	2				1	2	2	2	8	1	2
5-22	outflow of Upper Kicki	Child St.	0	0				0	0	0	2	9	***	0
											<b>Total Mean</b>	<b>315</b>	<b>18</b>	

Red Font = Wet Weather/Stormwater Influenced  
D= Duplicate

6/2/2006 during a 0.16" and 1 day after a 0.48" rain event  
6/3/2006 during a 1.32" rain event  
10/11/2006 during a 0.48" rain event  
10/12/2006 during a 0.34" rain event and one day after a 0.48" rain event

Shellfish Station	Description	Location	Warren M.S. Bacteriophage Loading (pfu/day)										Mean Dry Weather (pfu/day)	Mean Wet Weather (pfu/day)
			2006					Min.	Max.	Mean	n	Ranking		
			6/2	6/3	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)							
5-18	24" culvert	Barker Av. (broken RR bridge)	1.53E+10	0				0.00E+00	1.53E+10	7.65E+09	2	1	1.53E+10	0
5-21	18" pipe	Child St. west of bridge	1.14E+08	2.87E+09				1.14E+08	2.87E+09	1.49E+09	2	2	1.49E+09	***
5-13	30" culvert	Parker Av.	0	6.38E+08				0.00E+00	6.38E+08	3.19E+08	2	3	0	6.38E+08
5-12	42 x 20" box culvert	Parker Av.	3.50E+08	0				0.00E+00	3.50E+08	1.75E+08	2	4	3.50E+08	0
5-23	36" pipe	Child St. east of bridge			1.10E+08	1.96E+08	3.18E+04	3.18E+04	1.96E+08	1.02E+08	3	5	3.18E+04	1.53E+08
17-22	stream	Maple Av.	0	0				0.00E+00	0.00E+00	0.00E+00	2	6	0.00E+00	0.00E+00
17-22D	stream	Maple Av.	0	1.07E+08										
5-16	stream	farm south of Libby La.	1.36E+07	2.45E+07				1.36E+07	2.45E+07	1.91E+07	2	7	1.36E+07	2.45E+07
5-17	18" pipe	Libby La.	2.94E+06	0				0.00E+00	2.94E+06	1.47E+06	2	8	2.94E+06	0
5-22	outflow of Upper Kicki	Child St.	0	0				0.00E+00	0.00E+00	0.00E+00	2	9	***	0
											<b>Total Mean</b>	<b>2.14E+09</b>	<b>1.02E+08</b>	

Red Font = Wet Weather/Stormwater Influenced

D= Duplicate

6/2/2006 during a 0.16" and 1 day after a 0.48" rain event

6/3/2006 during a 1.32" rain event

10/11/2006 during a 0.48" rain event

10/12/2006 during a 0.34" rain event and one day after a 0.48" rain event

Shellfish Station	Description	Location	Bristol Fecal Coliform Concentration (MPN/100 ml)										Min.	Max.	Mean	n	Rank	Mean Dry Weather (MPN/100 ml)	Mean Wet Weather (MPN/100 ml)	
			2005			2006														
			9/1	9/2	9/21	5/16	5/25	6/2	6/3	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)								
17-15	36" pipe	Annawanscut Rd.				15000		23000	93000				15000	93000	43667	3	1	23000	54000	
17-16	36" pipe	Sunrise Dr.				930				NF			930	43000	21965	2	2	***	21965	
17-13	stream	Viking Dr.				15000				NF			15000	>/=24000	19500	2	3	***	19500	
17-7	stream	Bristol Landing Condos				9300	11	4600	24000				11	24000	9478	4	4	2306	16650	
17-45	stream from detention pond	Roger Williams Campus			150			4300	6400	2300			150	23000	9858	6	5	2250	17467	
17-14	stream	south of boat ramp				2300	49			2400			49	23000	8550	5	6	1225	13433	
5-1A	stream 100' from 2 pipes	Sowams Dr. upstream from 8-1				9300	33						33	9300	4667	2	7	33	9300	
5-4	18" pipe	Sherman Av								3900			2300	3900	3100	2	8	***	3100	
17-12	stream	Mt. Hope Farm (undevel.)				>/=2400	110						110	110	110	110	110	110	2400	
5-1	stream	Kicki mouth @ narrows		430		2300	46						46	2300	925	3	111	238	2300	
17-6	stream	Bristol Landing Condos	2100			430							430	2100	1265	2	11	***	1265	
17-9	stream from coastal pond	Near Mt. Hope Farm				1100	140						140	1100	620	2	12	140	1100	
17-10	stream	Near Mt. Hope Farm				930							930	930		1	13	***	930	
17-46	stream	Roger Williams Campus			240								240	240		1	14	240	***	
17-14A	stream	Hopeworth Av.					220						220	220		1	15	220	***	
17-11	stream	Near Mt. Hope Farm				150							150	150		1	16	***	150	
5-1B	stream	Narrows Rd. between 5A & 5B					49						49	49		1	17	49	***	
17-47	8" pipe underneath dock	Roger Williams Campus			15								15	15		1	18	15	***	
17-18	10" pipe	King Phillip Av.				75000												<b>Total Mean</b>	<b>2485</b>	<b>11683</b>

Red Font = Wet Weather/Stormwater Influenced  
D= Duplicate  
NF = No Flow

9/1/2005 2 days after a 2.54" rain event  
9/2/2005 3 days after a 2.54" rain event  
9/21/2005 6 days after a 3.19" rain event  
5/16/2006 during a 0.62" rainfall event, 3 days after a 2.41", and 2 days after a 1.03" rain event

5/25/2006 4 days after a 0.24 " rain event  
6/2/2006 during a 0.16" and 1 day after a 0.48" rain event  
6/3/2006 during a 1.32" rain event  
10/11/2006 during a 0.48" rain event  
10/12/2006 during a 0.34" rain event and one day after a 0.48" rain

Shellfish Station	Description	Location	Bristol Fecal Coliform Loading (fc/day)											Mean Dry Weather (fc/day)	Mean Wet Weather (fc/day)	
			2006									n	Rank			
			5/25	6/2	6/3	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)	Min.	Max.	Mean					
17-7	stream	Bristol Landing Condos	2.59E+08	1.35E+11	1.10E+12				2.59E+08	1.10E+12	4.12E+11	3	1	6.76E+10	1.10E+12	
17-14	stream	south of boat ramp	5.00E+09			5.87E+08	5.63E+11	3.30E+11	5.87E+08	5.63E+11	2.25E+11	4	2	2.79E+09	4.47E+11	
17-45	stream from detention pond	Roger Williams Campus		1.46E+09	5.87E+10	1.25E+08	5.63E+11	1.13E+11	1.25E+08	5.63E+11	1.47E+11	5	3	7.93E+08	2.45E+11	
17-15	36" pipe	Annawamscutt Rd.		2.26E+10	4.56E+11				2.26E+10	4.56E+11	2.39E+11	2	4	2.26E+10	4.56E+11	
17-16	36" pipe	Sunrise Dr.				NF	2.10E+11	NF	2.10E+11	2.10E+11		1	5	***	2.10E+11	
5-4	18" pipe	Sherman Av				1.06E+09	1.69E+10	NF	1.06E+09	1.69E+10	8.98E+09	2	6	***	8.98E+09	
17-14A	stream	Hopeworth Av.	4.61E+09						4.61E+09	4.61E+09		1	7	4.61E+09	***	
17-13	stream	Viking Dr.				NF	3.18E+09	NF	3.18E+09	>=3.18E+09		1	8	***	3.18E+09	
5-1B	stream	Narrows Rd. between 5A & 5B	2.25E+09						2.25E+09	2.25E+09		1	9	2.25E+09	***	
5-1	stream	Kicki mouth @ narrows	1.17E+09						1.17E+09	1.17E+09		1	10	1.17E+09	***	
17-9	stream from coastal pond	Near Mt. Hope Farm	1.07E+09						1.07E+09	1.07E+09		1	11	1.07E+09	***	
17-12	stream	Mt. Hope Farm (undevel.)	6.41E+08						6.41E+08	6.41E+08		1	12	6.41E+08	***	
5-1A	stream 100' from 2 pipes	Sowams Dr. upstream from 8-1	8.07E+07						8.07E+07	8.07E+07		1	13	8.07E+07	***	
												<b>Total Mean</b>			<b>1.04E+10</b>	<b>3.53E+11</b>

Red Font = Wet Weather/Stormwater Influenced  
D= Duplicate  
NF = No Flow

5/25/2006 4 days after a 0.24 " rain event  
6/2/2006 during a 0.16" and 1 day after a 0.48" rain event  
6/3/2006 during a 1.32" rain event  
10/11/2006 during a 0.48" rain event  
10/12/2006 during a 0.34" rain event and one day after a 0.48" rain

Shellfish Station	Description	Location	Bristol M.S. Bacteriophage Concentration (pfu/100 ml)												Mean Dry Weather (pfu/100ml)	Mean Wet Weather (pfu/100ml)
			2006							Min.	Max.	Mean	n	Rank		
			5/16	5/25	6/2	6/3	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)							
17-14	stream	south of boatramp	522	29			4	0	4530	0	4530	1017	5	1	17	1684
17-45	stream from detention pond	Roger Williams Campus			5	2054	2270	119	92	5	2270	908	5	2	1138	755
17-13	stream	Viking Dr.	>800				NF	150	NF	150	>800	475	2	3	***	475
17-7	stream	Bristol Landing Condos	297	7	1	0				0	297	76	4	4	4	149
5-1	stream	Kicki mouth @ narrows	232	1						1	232	117	2	5	1	232
5-1A	stream 100' from 2 pipes	Sowams Dr. upstream from 8-1	107	107						107	107	107	2	6	107	107
17-9	stream from coastal pond	Near Mt. Hope Farm	89	10						10	89	50	2	7	10	89
17-14A	stream	Hopeworth Av.		9						9	9		1	8	9	***
17-15	36" pipe	Annawamscutt Rd.	7		0	0				0	7	2	3	9	0	4
5-4	18" pipe	Sherman Av					7	2	NF	2	7	5	2	10	***	5
17-12	stream	Mt. Hope Farm (undevel.)	0	6						0	6	3	2	10	6	0
17-16	36" pipe	Sunrise Dr.	3				NF	6	NF	3	6	5	2	11	***	5
17-10	stream	Near Mt. Hope Farm	0							0	0		1	11	***	0
17-11	stream	Near Mt. Hope Farm	0							0	0		1	11	***	0
17-6	stream	Bristol Landing Condos	0							0	0		1	11	***	0
5-1B	stream	Narrows Rd. between 5A & 5B		0						0	0		1	11	0	***
17-18	10" pipe	King Phillip Av.	1													1
												<b>Total Mean</b>	<b>129</b>	<b>234</b>		

Red Font = Wet Weather/Stormwater Influenced  
D= Duplicate  
NF = No Flow

5/16/2006 during a 0.62" rainfall event, 3 days after a 2.41", and 2 days after a 1.03" rain event  
5/25/2006 4 days after a 0.24 " rain event  
6/2/2006 during a 0.16" and 1 day after a 0.48" rain event

6/3/2006 during a 1.32" rain event  
10/11/2006 during a 0.48" rain event  
10/12/2006 during a 0.34" rain event and one day after a 0.48" rain event

Shellfish Station	Description	Location	Bristol M.S. Bacteriophage Loading (pfu/day)										n	Rank	Mean Dry Weather (pfu/day)	Mean Wet Weather (pfu/day)
			2006							Min.	Max.	Mean				
			5/25	6/2	6/3	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)								
17-14	stream	south of boatramp	2.96E+09			9.97E+05	0	9.98E+10	0.00E+00	9.98E+10	2.57E+10	4	1	1.48E+09	4.99E+10	
17-45	stream from detention pond	Roger Williams Campus		1.70E+06	1.88E+10	1.24E+08	2.91E+09	4.50E+08	1.70E+06	1.88E+10	4.46E+09	5	2	2.26E+08	7.28E+09	
5-1A	stream 100' from 2 pipes	Sowams Dr. upstream from 8-1	2.62E+08						2.62E+08	2.62E+08		1	3	2.62E+08	***	
17-14A	stream	Hopeworth Av.	1.89E+08						1.89E+08	1.89E+08		1	4	1.89E+08	***	
17-7	stream	Bristol Landing Condos	1.65E+08	2.94E+07	0				0.00E+00	1.65E+08	6.48E+07	3	5	9.72E+07	0	
17-9	stream from coastal pond	Near Mt. Hope Farm	7.65E+07						7.65E+07	7.65E+07		1	6	7.65E+07	***	
17-12	stream	Mt. Hope Farm (undevel.)	3.50E+07						3.50E+07	3.50E+07		1	7	3.50E+07	***	
17-16	36" pipe	Sunrise Dr.				NF	2.94E+07	NF	2.94E+07	2.94E+07		1	8	***	2.94E+07	
5-1	stream	Kicki mouth @ narrows	2.55E+07						2.55E+07	2.55E+07		1	9	2.55E+07	***	
17-13	stream	Viking Dr.				NF	1.99E+07	NF	1.99E+07	1.99E+07		1	10	***	1.99E+07	
5-4	18" pipe	Sherman Av				1.91E+06	1.07E+07	NF	1.91E+06	1.07E+07	6.31E+06	2	11	***	6.31E+06	
17-15	36" pipe	Annawanscut Rd.		0	0				0.00E+00	0.00E+00	0.00E+00	2	12	0	0	
5-1B	stream	Narrows Rd. between 5A & 5B	0						0.00E+00	0.00E+00		1	12	0	***	
17-18	10" pipe	King Phillip Av.										<b>Total Mean</b>		<b>2.39E+08</b>	<b>8.18E+09</b>	

Red Font = Wet Weather/Stormwater Influenced  
D= Duplicate  
NF = No Flow

5/25/2006 4 days after a 0.24 " rain event  
6/2/2006 during a 0.16" and 1 day after a 0.48" rain event  
6/3/2006 during a 1.32" rain event  
10/11/2006 during a 0.48" rain event  
10/12/2006 during a 0.34" rain event and one day after a 0.48" rain

Shellfish Station	Description	Location	Tiverton Fecal Coliform Concentration (MPN/100 ml)														n	Rank	Mean Dry Weather (MPN/100 ml)	Mean Wet Weather (MPN/100 ml)	
			2005		2006										Min.	Max.					Mean
			9/2	9/21	5/16	5/25	6/2	6/3	8/29	9/8	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)								
17-27	stream	Summerfield La.	930		4300	79	>/=240000	9300	4600			210	9300	4300	79	>/=240000	30335	9	1	36060	7633
17-27D	stream	Summerfield La.												2300							
17-28	stream	Robert Gray Av.							>/=24000		9300	93000	4300	4300	93000	32650	4	2	16650	48650	
17-40	24" pipe	State Av.								21000	4300	9300	39000	4300	39000	17533	3	3	12650	24150	
17-29	stream	Brackett Av.							2400					2400	2400		1	4	2400	***	
17-32	10' x 4' concrete structure	Villages @ Mt. Hope Bay		930			>/=2400	230						230	>/=2400	1187	3	5	1665	230	
17-44	36" pipe	Canonicus St.								930				930	930		1	6	930	***	
17-26	stream	North of Summerfield La.							930					930	930		1	6	930	***	
17-23	30" pipe	Judson St.							150					150	150	150	1	7	150	***	
17-23D	30" pipe	Judson St.							93												
17-27A	stream	Craig Av. upstream of 17-27				130								130	130		1	8	130	***	
17-25	stream	Horizon Dr.							93					93	93		1	9	93	***	
17-24	stream	Lepes Rd.							93					93	93		1	10	93	***	
17-42	8" pipe	Chase Av.								23				23	23		1	11	23	***	
17-43	30" pipe	Chase Av.								4				4	4		1	12	4	***	
																	<b>Total Mean</b>	<b>5521</b>	<b>20166</b>		

Red Font = Wet Weather/Stormwater Influenced  
D= Duplicate  
9/2/2005 3 days after a 2.54" rain event  
9/21/2005 6 days after a 3.19" rain event  
5/16/2006 during a 0.62" rainfall event, 3 days after a 2.41". and 2 days after a 1.03" rain event

5/25/2006 4 days after a 0.24 " rain event  
6/2/2006 during a 0.16" and 1 day after a 0.48" rain event  
6/3/2006 during a 1.32" rain event  
8/29/2006 during a 0.12" rain event and 1 and 2 days after 0.42" and 0.19" rain events

9/8/2006 4 days after a 0.43 rain event  
10/11/2006 during a 0.48" rain event  
10/12/2006 during a 0.34" rain event and one day after a 0.48" rain event

Location	Tiverton Fecal Coliform Loading (fc/day)											n	Rank	Mean Dry Weather (fc/day)	Mean Wet Weather (fc/day)
	2006								Min.	Max.	Mean				
	5/25	6/2	6/3	8/29	9/8	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)							
Summerfield La.	5.80E+09	>=1.37E+13	9.96E+11	1.35E+12		5.14E+06	5.69E+11	5.26E+10	5.14E+06	>=1.37E+13	2.09E+12	8	1	2.52E+12	7.83E+11
								2.81E+10							
Robert Gray Av.				>=1.18E+10		6.83E+10	1.82E+12	5.26E+10	>=1.18E+10	1.82E+12	4.88E+11	4	2	4.01E+10	9.36E+11
State Av.					4.32E+10	1.14E+09	4.55E+11	1.91E+11	1.14E+09	4.55E+11	2.16E+11	3	3	1.14E+09	3.23E+11
Villages @ Mt. Hope Bay		>=4.08E+10	1.95E+09						1.95E+09	>=4.08E+10	2.14E+10	2	4	4.08E+10	1.95E+09
North of Summerfield La.				1.42E+10					1.42E+10	1.42E+10		1	5	1.42E+10	***
Craig Av. upstream of 17-27	9.54E+09								9.54E+09	9.54E+09		1	6	9.54E+09	***
Brackett Av.				1.53E+09					1.53E+09	1.53E+09		1	7	1.53E+09	***
Lepes Rd.				1.14E+09					1.14E+09	1.14E+09		1	8	1.14E+09	***
Canonicus St.					9.42E+08				9.42E+08	9.42E+08		1	9	9.42E+08	***
Judson St.				6.12E+08					6.12E+08	6.12E+08	6.12E+08	1	10	6.12E+08	***
Judson St.				3.79E+08											
Horizon Dr.				3.79E+07					3.79E+07	3.79E+07		1	11	3.79E+07	***
Chase Av.					3.20E+06				3.20E+06	3.20E+06		1	12	3.20E+06	***
Chase Av.					4.97E+05				4.97E+05	4.97E+05		1	13	4.97E+05	***
												<b>Total Mean</b>		<b>2.03E+11</b>	<b>5.11E+11</b>

Red Font = Wet Weather/Stormwater Influenced  
D= Duplicate

5/25/2006 4 days after a 0.24 " rain event  
6/2/2006 during a 0.16" and 1 day after a 0.48" rain event  
6/3/2006 during a 1.32" rain event  
8/29/2006 during a 0.12" rain event and 1 and 2 days after 0.42" and 0.19" rain events

9/8/2006 4 days after a 0.43 rain event  
10/11/2006 during a 0.48" rain event  
10/12/2006 during a 0.34" rain event and one day after a 0.48" rain event

Shellfish Station	Description	Location	Tiverton M.S. Bacteriophage Concentration (pfu/100 ml)											n	Rank	Mean Dry Weather (pfu/100ml)	Mean Wet Weather (pfu/100ml)		
			2006																
			5/16	5/25	6/2	6/3	8/29	9/08/06	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)	Min.	Max.						
17-28	stream	Robert Gray Av.					6120			138	TNTC	TNTC	138	TNTC	2	1	3129	TNTC	
17-40	24" pipe	State Av.						TNTC		7060	146	1250	146	TNTC	3	2	7060	698	
17-27	stream	Summerfield La.	34	3	3	0	0			30	4150	1280	0	4150	8	3	263	1395	
17-27D	stream	Summerfield La.										108							
17-43	30" pipe	Chase Av.						3					3	3	1	4	3	***	
17-44	36" pipe	Canonicus St.						2					2	2	1	5	2	***	
17-23	30" pipe	Judson St.					0						0	0	1	6	0	***	
17-23D	30" pipe	Judson St.					0												
17-24	stream	Lepes Rd.					0						0	0	1	6	0	***	
17-25	stream	Horizon Dr.					0						0	0	1	6	0	***	
17-26	stream	North of Summerfield La.					0						0	0	1	6	0	***	
17-27A	stream	Craig Av. upstream of 17-27		0									0	0	1	6	0	***	
17-29	stream	Brackett Av.					0						0	0	1	6	0	***	
17-42	8" pipe	Chase Av.						0					0	0	1	6	0	0	
17-32	10' x 4' concrete structure	Villages @ Mt. Hope Bay			0	0											<b>Total Mean</b>	<b>871</b>	<b>698</b>

**Red Font** = Wet Weather/Stormwater Influenced  
 D= Duplicate  
 TNTC=Too Numerous to Count  
 5/16/2006 during a 0.62" rainfall event, 3 days after a 2.41", and 2 days after a 1.03" rain event  
 5/25/2006 4 days after a 0.24 " rain event

6/2/2006 during a 0.16" and 1 day after a 0.48" rain event  
 6/3/2006 during a 1.32" rain event  
 8/29/2006 during a 0.12" rain event and 1 and 2 days after 0.42" and 0.19" rain events

9/8/2006 4 days after a 0.43 rain event  
 10/11/2006 during a 0.48" rain event  
 10/12/2006 during a 0.34" rain event and one day after a 0.48" rain event

Shellfish Station	TMDL Station	Description	Location	Tiverton M.S. Bacteriophage Loading (pfu/day)											Min.	Max.	n	Rank	Mean Dry Weather (pfu/day)	Mean Wet Weather (pfu/day)
				2006																
				5/25	6/2	6/3	8/29	9/8	10/11 (10 P.M.)	10/12 (12 A.M.)	10/12 (9 A.M.)									
17-28		stream	Robert Gray Av.				3.02E+09			1.01E+09	TNTC	TNTC	1.01E+09	TNTC	2	1	2.02E+09	TNTC		
17-40		24" pipe	State Av.					TNTC		1.87E+09	7.14E+09	6.12E+09	1.87E+09	TNTC	3	2	1.87E+09	6.63E+09		
17-27	MHBS5	stream	Summerfield La.	2.20E+08	1.71E+08	0	0			7.34E+08	2.54E+11	1.57E+10	0	2.54E+11	7	3	2.80E+09	2.54E+11		
17-27D		stream	Summerfield La.									1.32E+09								
17-43		30" pipe	Chase Av.					2.40E+06					2.40E+06	2.40E+06	1	4	2.40E+06	***		
17-44		36" pipe	Canonicus St.					2.03E+06					2.03E+06	2.03E+06	1	5	2.03E+06	***		
17-23		30" pipe	Judson St.				0						0	0	1	6	0	***		
17-23D		30" pipe	Judson St.				0													
17-24		stream	Lepes Rd.				0						0	0	1	6	0	***		
17-25		stream	Horizon Dr.				0						0	0	1	6	0	***		
17-26		stream	North of Summerfield La.				0						0	0	1	6	0	***		
17-27A		stream	Craig Av. upstream of 17-27	0									0	0	1	6	0	***		
17-29		stream	Brackett Av.				0						0	0	1	6	0	***		
17-32	MHBS6	10' x 4' concrete structure	Villages @ Mt. Hope Bay		0	0							0	0	2	6	0	***		
17-42		8" pipe	Chase Av.					0					0	0	1	6	0	***		
															<b>Total Mean</b>		<b>5.15E+08</b>	<b>1.30E+11</b>		

Red Font = Wet Weather/Stormwater Influenced  
D= Duplicate  
TNTC=Too Numerous to Count

5/25/2006 4 days after a 0.24 " rain event  
6/2/2006 during a 0.16" and 1 day after a 0.48" rain event  
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