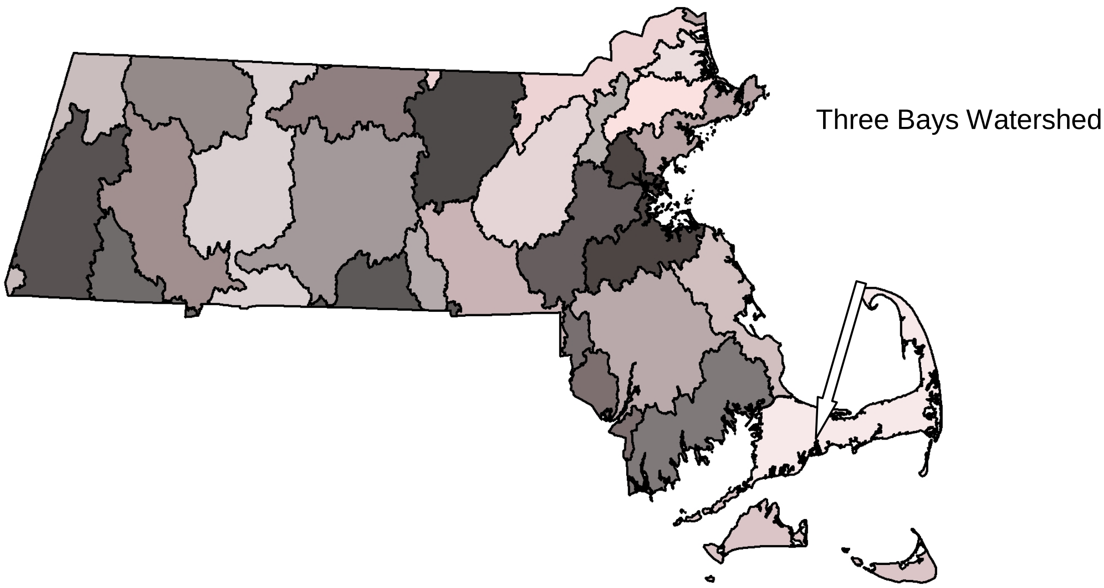
Final Pathogen TMDL for
Three Bays Watershed, Barnstable, MA
July 2009

(Report Number MA96-TMDL-19, Control Number: CN: 309.0)



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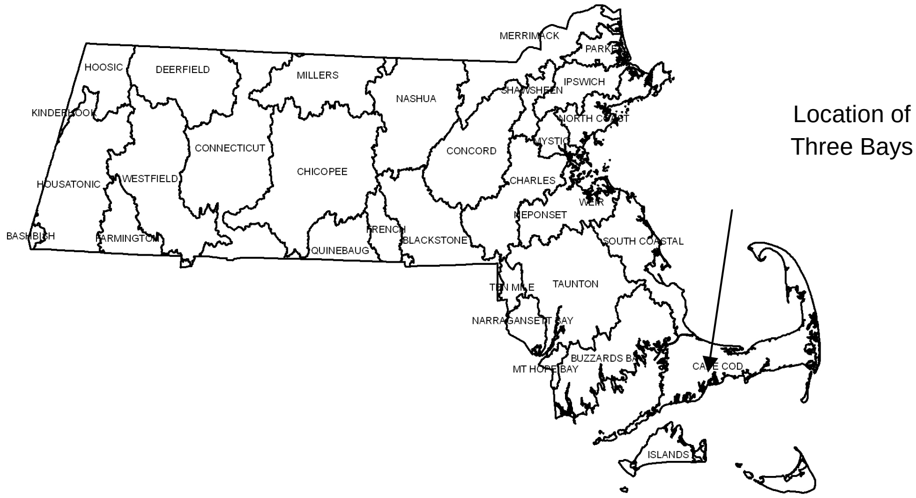
Total Maximum Daily Loads for Pathogens within the Three Bays Watershed



Key Features: Pathogen TMDL for Three Bays
Location: EPA Region 1
Land Type: New England Coastal
303(d) Listings: Pathogens

Cotuit Bay (MA96-63)
Seapuit River (MA96-64)
North Bay (Ma96-66)
Prince Cove (MA-96-07)
West Bay (MA96-65)*

*Note that West Bay is not listed for Pathogen Impairment and therefore is not included in Category 5 of the "Massachusetts Year 2006 Integrated List of Water: Part 2- Final Listing of Individual Categories of Waters" (2006 List; MassDEP 2006a). However, West Bay is included in this TMDL because it is part of the Three Bays Estuary. All other pathogen impaired segments on Cape Cod will be addressed in the Final Pathogen TMDL for Cape Cod.

Data Sources:

- University of Massachusetts – Dartmouth/School for Marine Science and Technology (SMAST)
- Massachusetts Division of Marine Fisheries
- Three Bays Preservation, Inc.

Data Mechanism: Massachusetts Surface Water Quality Standards for Pathogens; Ambient Data and Best Professional Judgment

Monitoring Plan: Massachusetts Watershed Five-Year Cycle, Division of Marine Fisheries (DMF) Shellfish Sanitation Program; Three Bays Preservation, Inc.

Control Measures: Watershed Management; Stormwater Management (e.g., illicit discharge removals, public education/behavior modification); Elimination of Boat Discharges, and Investigation for Source Identification

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1.0 Introduction

Section 303(d) of the Federal Clean Water Act (CWA) and Environmental Protection Agencies (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies (commonly referred to as the "303d List") and to develop Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant(s) contributing to the impairment. In Massachusetts, impaired waterbodies are included in Category 5 of the "Massachusetts Year 2006 Integrated List of Water: Part 2- Final Listing of Individual Categories of Waters" (2006 List; MassDEP 2006a).

TMDLs are to be developed for water bodies that are not meeting designated uses under technology-based controls only. TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating water quality standards. The TMDL process establishes the maximum allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollutant sources and instream conditions. The TMDL process is designed to assist states and watershed stakeholders in the implementation of water quality-based controls specifically targeted to identify sources of pollution in order to restore and maintain the quality of their water resources (USEPA 1999). TMDLs allow watershed stewards to establish measurable water quality goals based on the difference between site-specific instream conditions and state water quality standards.

A major goal of this TMDL is to achieve meaningful environmental results with regard to the designated uses of the Three Bays waterbodies. These include, shellfish harvesting, fishing, boating, and swimming. This TMDL establishes the necessary pollutant load to achieve designated uses and water quality standard and the companion document entitled; "Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts" provides guidance for the implementation of this TMDL.

Historically, water and sediment quality studies have focused on the control of point sources of pollutants (i.e., discharges from pipes and other structural conveyances) that discharge directly into well-defined hydrologic resources, such as lakes, ponds, or river segments. While this localized approach may be appropriate under certain situations, it typically fails to characterize the more subtle and chronic sources of pollutants that are widely scattered throughout a broad geographic region such as a watershed (e.g., roadway runoff, failing septic systems in high groundwater, areas of concentrated wildfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These so called nonpoint sources of pollution often contribute significantly to the decline of water quality through their cumulative impacts. A watershed-level approach that uses the surface drainage area as the basic study unit enables managers to gain a more complete understanding of the potential pollutant sources impacting a waterbody and increases the precision of identifying local problem areas or “hot spots” which may detrimentally affect water and sediment quality. It is within this watershed-level framework that the Massachusetts Department of Environmental Protection (MassDEP) commissioned the development of watershed based TMDLs.

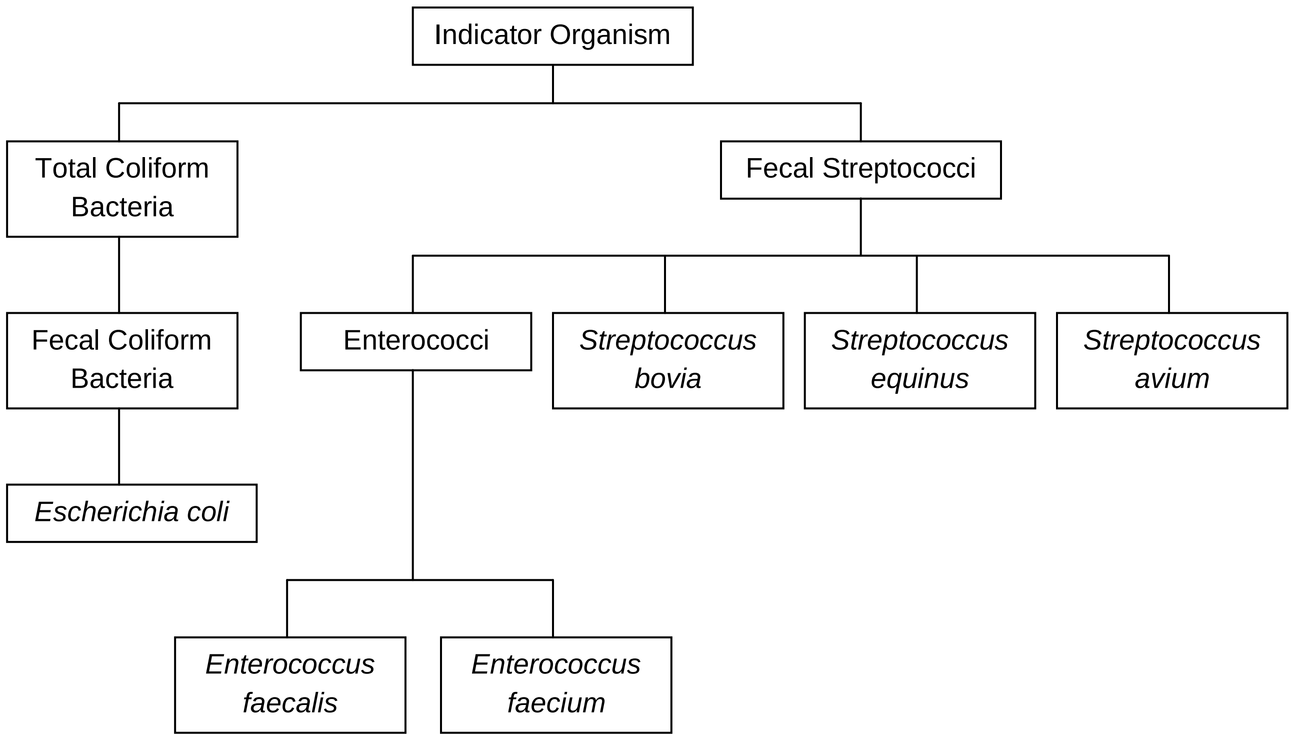
1.1 Pathogens and Indicator Bacteria

Waterborne pathogens include a broad range of bacteria and viruses that are difficult to identify and isolate. Thus, specific nonpathogenic bacteria have been identified that are typically associated with harmful pathogens in fecal contamination. These associated nonpathogenic bacteria are used as indicator bacteria as they are easier to identify and measure in the environment. High densities of indicator bacteria increase the likelihood of the presence of pathogenic organisms.

Selection of indicator bacteria is difficult as new technologies challenge current methods of detection and the strength of correlation of indicator bacteria and human illness. Currently, coliform and fecal streptococci bacteria are commonly used as indicators of potential pathogens (i.e., indicator bacteria). Coliform bacteria include total coliforms, fecal coliform and *Escherichia coli* (*E. coli*). Fecal coliform (a subset of total coliform) and *E. coli* (a subset of fecal coliform) bacteria are present in the intestinal tracts of warm blooded animals. Presence of coliform bacteria in water indicates fecal contamination and the possible presence of pathogens. Fecal streptococci bacteria are also used as indicator bacteria, specifically enterococci a subgroup of fecal streptococci. These bacteria also live in the intestinal tract of animals, but their presence is a better predictor of human gastrointestinal illness than fecal coliform since the die-off rate of enterococci is much lower (i.e., enterococci bacteria remain in the environment longer) (USEPA 2001). The relationship of indicator organisms is provided in Figure 1-1. The EPA, in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document, recommends the use of *E. coli* or enterococci as potential pathogen indicators in fresh water and enterococci in marine waters (USEPA 1986).

Massachusetts uses fecal coliform as an indicator organism of potential harmful pathogens in salt water (MassDEP 2007). View the Water Quality Standards at http://www.mass.gov/dep/service/regulations/314cmr04.pdf. The Three Bays watershed pathogen TMDLs have been developed using fecal coliform as an indicator bacterium for shellfish areas. Any future changes in the Massachusetts pathogen water quality standard will apply to this TMDL at the time of the standard change. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

Figure 1-1. Relationships Among Indicator Organisms (USEPA 2001).



1.2 Comprehensive Watershed-based Approach to TMDL Development

Consistent with Section 303(d) of the CWA, MassDEP has chosen to complete pathogen TMDLs for all waterbodies in the Three Bays watershed at this time, regardless of current impairment status (i.e., for all waterbody categories in the *2006 Integrated List*). MassDEP believes a comprehensive management approach carried out by watershed communities is needed to address the ubiquitous nature of pathogen sources present in Three Bays and the Cape Cod watershed. Watershed-wide implementation is needed to meet WQS and restore designated uses in impaired segments while providing protection of desirable water quality in waters that are not currently impaired or not assessed.

As discussed below, this TMDL applies to the 4 pathogen impaired segments of the Three Bays watershed that are currently listed on the CWA § 303(d) list of impaired waters and determined to be pathogen impaired through the Massachusetts Estuaries Program.

The watershed based approach applied to complete the Three Bays watershed pathogen TMDL is straightforward. The approach is focused on identification of sources, source reduction, and stepwise implementation of appropriate management plans. Once identified, sources are required to meet applicable WQS for indicator bacteria or be eliminated.

For pathogens and indicator bacteria, water quality analyses are generally resource intensive and provide results with large degrees of uncertainty. This approach focuses on sources and required load reductions, proceeding efficiently toward water quality restoration activities.

The implementation strategy for reducing indicator bacteria is an iterative process where data are gathered on an ongoing basis, sources are identified and eliminated if possible, and control measures including Best Management Practices (BMPs) are implemented, assessed and modified as needed. Measures to abate probable sources of waterborne pathogens include everything from public education, to improved stormwater management, to reducing the influence from inadequate and/or failing sanitary sewer infrastructure.

1.3 TMDL Report Format

This document contains the following sections:

- Watershed Description (Section 2) – provides watershed specific information
- Water Quality Standards (Section 3) – provides a summary of current Massachusetts WQS as they relate to indicator bacteria
- Problem Assessment (Section 4) – provides an overview of indicator bacteria measurements collected in the Three Bays watershed
- TMDL Development (Section 5) – specifies required TMDL development components including:
    - Definitions and Equation
    - Load and Waste Load Allocations
    - Margin of Safety
    - Seasonal Variability
- Implementation Plan (Section 6) – describes specific implementation activities designed to remove pathogen impairment. This section and the companion "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" document should be used together to support implementing management actions.
- Monitoring Plan (Section 7) – describes recommended monitoring activities
- Reasonable Assurances (Section 8) – describes reasonable assurances the TMDL will be implemented
- Public Participation (Section 9) – describes the public participation process, and
- References (Section 10)

2.0 Watershed Description

Three Bays is one of the major estuaries along the south coast of Cape Cod. It is located in Barnstable, Massachusetts and is comprised of the following waterbodies:

- **Cotuit Bay**, the southwest embayment, which exchanges water directly with Nantucket Sound (water body segment #MA96-63);
- **West Bay**, the southeast embayment, which has a tidal inlet to Nantucket Sound (water body segment #MA96-65);
- **North Bay**, the embayment north of Cotuit and West Bays, which receives tidal waters from both bays through navigable channels (water body segment #MA96-66);
- **Prince Cove**, the most northern of the sub-embayment which extends to the west of the Marstons Mills River and includes Warren's Cove to the east of Prince Cove and extends to North Bay at Fox Island (water body segment #MA96-07).
- **Seapuit River,** south of Osterville Grand Island to Cotuit Bay and West Bay, Barnstable (water body segment #96-64).

The two predominant land use types in the Three Bays watershed are forestland (36%) and residential (42%). The land area surrounding Prince Cove is the most heavily developed of the Three Bays watershed. Numerous roadways circle all of the bays with tangential residential streets connecting to these roadways.

Cotuit Bay, North Bay, Prince Cove and the Seapuit River have priority ranking as a component of the Massachusetts Estuary Project and because they exceeded water quality standards for fecal coliform bacteria in historical samplings and analyses. Due to these elevated concentrations of fecal coliform bacteria, all of these waterbodies are listed on the Massachusetts Integrated List of Waters as Category 5 waters requiring a TMDL. Additionally, the Division of Marine Fisheries has classified certain areas as Conditionally Approved for shell fishing due to high bacteria counts. Currently all of North Bay, including Areas SC 23.2 and SC 23.21, is classified as Conditionally Approved for shell fishing. In Cotuit Bay, Areas SC21.1 and SC21.2 were classified as Conditionally Approved in 1999. The Conditionally Approved Area SC21.1 also extends into a portion of the Seapuit River. Prince Cove has been classified as Conditionally Approved for shell fishing since 1988.

The Cape Cod drainage area is home to many rare, threatened or endangered species. There are eight Areas of Critical Environmental Concern (ACEC) within the watershed (EEA 2003). Four towns on Cape Cod are in the "top 10" in Massachusetts for the largest number of state-listed rare species records. The Town of Barnstable is one of only five towns in the state with more than 100 records of rare species (EEA 2003).

Several areas on Cape Cod including Three Bays are considered "No Discharge Areas" (NDAs). NDAs are waterbodies in which a state, with EPA approval, has determined to be important ecological or recreational areas worthy of special protection against the release of raw or treated sewage in navigable waters. Vessels are banned from discharging both raw and treated sewage in a NDA.

To track and evaluate sources of bacteria in Three Bays a bacteria database was constructed. Among the data sources was a Sanitary Survey in Prince Cove conducted by the Massachusetts Division of Marine Fisheries (DMF) and the Three Bays Preservation, Inc. in 2001. Other existing data that was utilized in the technical analysis included sanitary surveys conducted in North Bay in 1990; a Triennial Sanitary Survey conducted in February of 2000; water quality samples collected from 1985 to 2003; a source identity study using DNA analysis in 2000; and sampling by Massachusetts Estuaries Project at the Marstons Mill River Route 28 culvert in 2002 and 2003.

The technical analysis shows that the most likely sources of fecal coliform bacteria that need to be evaluated are: stormwater inflows from paved areas; boat discharges in the cove; waterfowl/wildlife within Prince and the adjacent Warren's Cove with their associated wetlands; and transport of fecal coliform via the Marstons Mills River into the Coves via tidal exchange.

More detailed information on the description of Three Bays, the pollutant of concern (fecal coliform bacteria), pollutant sources and priority ranking is presented in the accompanying technical report entitled "Basis for Development of Total Maximum Daily Load of Bacteria – Prince Cove/Three Bays Watershed, Town of Barnstable", dated August 2005, and authored by University of Massachusetts Dartmouth – School of Marine Science and Technology (SMAST). This information can be found in the Executive Summary and Sections II, III and V of the technical report.

3.0 Water Quality Standards

The Surface Water Quality Standards (WQS) for the Commonwealth of Massachusetts establish chemical, physical, and biological standards for the restoration and maintenance of the most sensitive uses (MassDEP 2000a). The WQS limit the discharge of pollutants to surface waters for the protection of existing uses and attainment of designated uses in downstream and adjacent segments.

The Massachusetts Water Quality Standards call for all water classes to be good or excellent "… habitat for fish, other aquatic life and wildlife …" Coastal waters, such as Three Bays, that are classified as SA waters shall have a fecal coliform bacteria concentration not exceeding a geometric mean of 14 CFU/100 ml, nor shall more than 10 percent of the samples exceed a Most Probable Number (MPN) of 28/CFU/100 ml. It should be noted that Massachusetts revised its freshwater WQS in late 2006. The standard was revised by changing the MPN that should not be exceeded by 10 percent of the samples from 43 CFU/100 ml to 28 CFU/100 ml http://www.mass.gov/dep/service/regulations/314cmr04.pdf.

For the protection of shellfish resources, fecal coliform bacteria is the pathogenic indicator utilized by the Commonwealth of Massachusetts as the measure to determine if a coastal marine water body is in compliance with bacteria based Water Quality Standards. The goal of this TMDL report will be to decrease or eliminate fecal coliform bacterial contamination or determine that it is not wastewater derived (i.e. from wildlife) in order to protect human health and return these waters to their most beneficial use as a shellfish resource.

Fecal coliform, enterococci, and *E. coli* bacteria are found in the intestinal tract of warm-blooded animals, soil, water, and certain food and wood processing wastes. "Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems" (USEPA 2004b). These bacteria are often used as indicator bacteria since it is expensive and sometimes difficult to test for the presence of individual pathogenic organisms.

4.0 Problem Assessment

Pathogen impairment has been documented within the Three Bays Estuary including Cotuit Bay, North Bay, Prince Cove and the Seapuit River. Excessive concentrations of indicator bacteria (e.g., fecal coliform) can indicate the possible presence of pathogenic organisms. The amount of indicator bacteria and potential pathogens entering waterbodies is dependent on several factors including watershed characteristics and meteorological conditions. Indicator bacteria levels generally increase with increasing development activities, including increased impervious cover, illicit sewer connections, and failed septic systems.

Indicator bacteria levels also tend to increase with wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated to the waterbodies via overland flow and stormwater conduits. In some cases, dry weather bacteria concentrations can be higher when there is a constant source that becomes diluted during periods of precipitation, such as with illicit connections. The magnitude of these relationships is variable, however, and can be substantially different temporally and spatially throughout the United States or within each watershed.

Studies have been carried out to evaluate the ranges of fecal coliform concentrations in stormwater associated with various land use types. In general, pristine areas are observed to have low indicator bacteria levels and residential areas are observed to have elevated indicator bacteria levels. Development activity generally leads to decreased water quality (e.g., pathogen impairment) in a watershed. Development-related watershed modification includes increased impervious surface area which can (USEPA 1997):

- Increase flow volume,
- Increase peak flow,
- Increase peak flow duration,
- Increase stream temperature,
- Decrease base flow, and
- Change sediment loading rates

Many of the impacts associated with increased impervious surface area also result in changes in pathogen loading (e.g., increased sediment loading can result in increased pathogen loading). In addition to increased impervious surface impacts, increased human and pet densities in developed areas increase potential fecal contamination.

An overview of the Three Bays pathogen impairment is provided in this section to illustrate the nature and extent of the impairment. Since pathogen impairment has been previously established and documented on the Integrated List, it is not necessary to provide detailed documentation of pathogen impairment herein. Data from Three Bays Preservation Inc. was reviewed and are summarized by segment below.

The following sections provide a summary of available water quality information for the four listed segments (Cotuit Bay, North Bay, Prince Cove and Seapuit River) as well as West Bay since it is part of the Three Bays embayment. In addition, water quality data collected by Three Bays Preservation Inc. for the entre area is summarized. Each section summarizes data on fecal coliform bacteria that was collected and complied by DMF for the 1985-1995 and 1996-2003 time periods. For this TMDL the data collected through the 1985-1995 period is presented to provide a historical perspective on water quality conditions. Although percent reductions are presented for the 1985-1995 time period, the more recent data are considered to better represent current conditions.

Although not required for approval of the TMDL, each section also provides an estimate of the magnitude of the pollutant reductions needed to attain the goals of the TMDL. This data is helpful to set priorities for further investigation and/or remediation efforts. Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For illicit sources such as failing septic systems or illegal tie-ins to the storm drains, the goal is complete elimination (100% reduction). Source categories representing discharges of stormwater from distinct point sources are set equal to the fecal coliform standard for SA waters in order to ensure that standards for shellfish harvesting can be met in the waterbody.

Overall reductions needed to attain water quality standards are estimated using ambient fecal coliform data. Using ambient data is beneficial because it provides a realistic estimate of existing conditions and the magnitude of cumulative loading to the surface waters. Reductions are calculated using data that was collected in the summer (May through October) and winter (November through April) during both wet and dry weather conditions. Less than 0.25 inches of precipitation was considered to be a dry weather sample and greater than 0.25 inches was considered a wet weather sample. Percent reductions to attain the water quality standard of 14 organisms per 100 mL are presented in Tables 4-1, 4-3, 4-5, 4-7, and 4-9. Tables 4-2, 4-4, 4-6, 4-8, and 4-10 list the 90% observation and percent reductions necessary to attain the water quality standard which states that no more than 10% of the samples exceed 28 organisms per 100 mL. The 90% observation indicates that within the range of data collected for each station, 90% of the samples collected at that station must fall below the stated value. As an example, for data collected during the 1985-1995 summer period at Station #1 for Prince Cove, 90% of the samples had a concentration below 128 per 100/mL (Table 4-6). To meet the water quality standard, the 90% observation would have to be reduced to 28 organisms per 100 mL; therefore, a 78.1% reduction is necessary at that station. Data for individual segments within Three Bays is described in more detail below.

Cotuit Bay (MA96-63)

This 0.16 square mile Class SA segment extends from North Bay at Point Isabella ocean ward to a line extended along Oyster Harbors Beach, Barnstable. The DMF sampling stations for Cotuit Bay are presented in Figure 4-1. Geometric means and the 90th percentile observation are summarized in Table 4-1 and 4-2, respectively.

Figure 4-1. Cotuit Bay and Seapuit River Sampling Stations

Table 4-1. Estimates of Fecal Coliform Load Reductions to Cotuit Bay and Seapuit River Necessary to meet WQS[a].

	Analysis Period 1985 – 1995				Analysis Period 1996-2003							
	SUMMER		WINTER		SUMMER				WINTER			
Station#	Geometric Mean/ (Percent Reduction)	N	Geometric Mean/ (Percent Reduction)	N	Wet Geometric Mean/ (Percent Reduction)	N	Dry Geometric Mean/ (Percent Reduction)	N	Wet Geometric Mean/ (Percent Reduction)	N	Dry Geometric Mean/ (Percent Reduction)	N
Cotuit Bay												
1	4/ (0%)	25	4/ (0%)	22	2/(0%)	8	2/(0%)	12	3/(0%)	9	2/(0%)	5
2	3/(0%)	25	2/(0%)	20	3/(0%)	8	4/(0%)	12	3/(0%)	9	2/(0%)	6
3	2/(0%)	17	2/(0%)	15	ND	ND	ND	ND	ND	ND	ND	ND
3A	8/(0%)	8	2/(0%)	7	ND	ND	ND	ND	ND	ND	2/(0%)**	1
4	4/(0%)	25	2/(0%)	20	5/(0%)	8	5/(0%)	12	2/(0%)	9	2/(0%)	6
5	6/(0%)	18	2/(0%)	15	13/(0%)	6	12/(0%)	10	3/(0%)	13	3/(0%)	13
6	3/(0%)	20	1/(0%)	16	ND	ND	8/(0%)**	1	2/(0%)**	1	ND	ND
6B	10/(0%)	11	9/(0%)	11	4/(0%)	6	2/(0%)	8	4/(0%)	12	2/(0%)	12
7	3/(0%)	10	2/(0%)	13	3/(0%)	8	2/(0%)	12	2/(0%)	9	3/(0%)	6
9A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	ND	ND	ND		5/(0%)*	4	6/(0%)*	3	2/(0%)	7	3/(0%)	8
Seapuit River												
8	7/(0%)	24	6/(0%)	22	3/(0%)	8	2/(0%)	12	5/(0%)	11	2/(0%)	9
9	6/(0%)	19	5/(0%)	17	ND	ND	ND	ND	2/(0%)**	1	2/(0%)**	1
10	4/(0%)*	4	3/(0%)*	2	ND	ND	ND	ND	ND	ND	ND	ND

[a] WQS= Fecal Coliform shall not exceed a geometric mean Most Probable Number of 14 organisms per 100 ml

*Too few data for accurate geometric mean to be calculated (less than five samples collected). Value is presented for comparative/informational purposes only.

** Value represented is only one data point and is presented for comparative/informational purposes only.

ND= No Data

N = Number of samples

Table 4-2. 90th Percentile Observation and Estimates of Fecal Coliform Loading Reductions to Cotuit Bay and Seapuit River Necessary to Meet WQS[a].

	Analysis Period 1985 – 1995		Analysis Period 1996-2003	
	SUMMER	**WINTER**	**SUMMER**	**WINTER**
Station	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation/ (%Reduction)**
Cotuit Bay				
1	11/(0%)	36/(22.2%)	4/(0%)	8/(0%)
2	14/(0%)	23/(0%)	8/(0%)	6/(0%)
3	5.8/(0%)	5.8/(0%)	ND	ND
3A	128/(78.1%)	5.8/(0%)	ND	**
4	14/(0%)	5.8/(0%)	22/(0%)	2/(0%)
5	23/(0%)	2/(0%)	50/(44.0%)	8/(0%)
6	8.2/(0%)	1.7/(0%)	**	**
6B	128/(78.1%)	30/(6.7%)	8/(0%)	8/(0%)
7	5.8/(0%)	5.8/(0%)	4/(0%)	8/(0%)
9A	ND	8.2/(0%)	ND	ND
11	ND	ND	50/(44.0%)	6/(0%)
Seapuit River				
8	41/(31.7%)	128/(78.1%)	6/(0%)	14/(0%)
9	23/(0%)	64/(56.3%)	ND	2/(0%)
10	9.1/(0%)	2/(0%)	ND	ND

[a] WQS = Fecal Coliform shall not exceed a geometric mean Most Probable Number of 14 organisms per 100 ml
** Value not calculated since there was only one data point
ND= No Data

As can be seen in Table 4-1 all the summer and winter fecal coliform geometric means during both dry and wet weather in Cotuit Bays were below the water quality standard of 14 CFU/100 mL. Table 4-2 indicates that in Cotuit Bay during the historical 1985-1995 period, more than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL in both the summer and winter and reductions of up to 78.1% were required. Subsequent sampling in the more recent 1996-2003 time period, however, indicated elevated fecal coliform counts only at Stations# 5 and 11 in the summer both of which require a 44% reduction.

Seapuit River (MA96-64)

This 0.06 square mile Class SA segment of tidally influenced river extends from the south of Osterville Grand Island to Cotuit Bay and West Bay, Barnstable. The DMF sampling stations for the Seapuit River are presented in Figure 4-1. Geometric means and the 90th percentile observation are summarized in Tables 4-1 and 4-2, respectively.

Table 4-1 indicates that all the summer and winter fecal coliform geometric means during both dry and wet weather in the Seapuit River were below the water quality standard of 14 CFU/100 mL. Table 4-2 indicates that during the historical 1985-1995 period, more than 10% of the samples collected in the Seapuit River exceeded the water quality standard of 28 CFU/100 mL in both the summer and winter and reductions of up to 78.1% were required.

North Bay (MA96-66)

This 0.47 square mile Class SA segment extends from Fox Island to just south of Bridge Street and is separated from Cotuit Bay at a line from Point Isabella southward to the opposite shore (including Dam Pond, Barnstable, MA). The DMF sampling stations for North Bay are presented in Figure 4-2. Geometric means and the 90th percentile observation are summarized in Tables 4-3 and 4-4 respectively.

Figure 4-2. North Bay Sampling Stations

Table 4-3. Estimates of Fecal Coliform Load Reductions to North Bay Necessary to Meet WQS[a].

	Analysis Period 1985 – 1995				Analysis Period 1996-2003							
	SUMMER		WINTER		SUMMER				WINTER			
Station/Location	**Geometric Mean/ (Percent Reduction)**	**N**	**Geometric Mean/ (Percent Reduction)**	**N**	**Wet Geometric Mean/ (Percent Reduction)**	**N**	**Dry Geometric Mean/ (Percent Reduction)**	**N**	**Wet Geometric Mean/ (Percent Reduction)**	**N**	**Dry Geometric Mean/ (Percent Reduction)**	**N**
4	19/(26.3%)	17	2/(0%)	24	8/(0%)*	2	6/(0%)*	4	3/(0%)	20	3/(0%)	20
4A	ND	ND	6/(0%)*	2	ND	ND	ND	ND	ND	ND	ND	ND
5	11/(0%)	13	2/(0%)	21	ND	ND	ND	ND	2/(0%)**	1	ND	ND
5S	ND	ND	4/(0%)**	1	ND	ND	ND	ND	ND	ND	ND	ND
6	5/(0%)	15	2/(0%)	25	3/(0%)*	2	3/(0%)*	4	3/(0%)	21	2/(0%)	20
6S	ND	ND	6/(0%)*	2	ND	ND	ND	ND	ND	ND	ND	ND
7	5/(0%)	8	2/(0%)	22	7/(0%)*	2	2/(0%)*	4	3/(0%)	19	2/(0%)	20
7B	ND	ND	1/(0%)*	4	ND	ND	ND	ND	ND	ND	ND	ND
8	15/(6.6%)	16	2/(0%)	27	30/(53.3%)*	2	6/(0%)*	4	3/(0%)	19	3/(0%)	20
8B	ND	ND	2/(0%)*	4	ND	ND	ND	ND	ND	ND	ND	ND
9	10/(0%)	16	2/(0%)	27	17/(17.6%)*	2	3/(0%)*	4	3/(0%)	20	2/(0%)	20
9B	ND	ND	2/(0%)	5	ND	ND	ND	ND	ND	ND	ND	ND
SM - Route 28 Culvert[1]	ND	ND	ND	ND	197/(92.9%)	19	10/(0%)**	1	27/(48.1%)	8	5/(0%)	6

[a] WQS= Fecal Coliform shall not exceed a geometric mean Most Probable Number of 14 organisms per 100 ml

*Too few data for accurate geometric mean to be calculated (less than five samples collected). Value is presented for comparative/informational purposes only.

** Value represented is only one data point and is presented for comparative/informational purposes only.

[1]Data collected is for the 2002-2003 period only

ND= No Data

N = Number of samples

Table 4-4. 90th Percentile Observation and Estimates of Fecal Coliform Loading Reductions to North Bay Necessary to Meet WQS [a]

	Analysis Period 1985 – 1995		Analysis Period 1996 - 2003	
	SUMMER	**WINTER**	**SUMMER**	**WINTER**
Station #	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation / (%Reduction)**
4	128/(78.1%)	14/(0%)	8/(0%)	11/(0%)
4A	ND	5.8/(0%)	ND	ND
5	128/(78.1%)	8.2/(0%)	ND	*
5S	ND	*	ND	ND
6	18/(0%)	5.8/(0%)	6/(0%)	6/(0%)
6S	ND	18/(0%)	ND	ND
7	23/(0%)	3.6/(0%)	1.9/(0%)	6/(0%)
7B	ND	1.7/(0%)	ND	ND
8	128/(78.1%)	8.2/(0%)	18/(0%)	8(0%)
8B	ND	11/(0%)	ND	ND
9	128/(78.1%)	30/(6.7%)	8/(0%)	6/(0%)
9B	ND	5.8/(0%)	ND	ND
SM[1] Route 28 Culvert	ND	ND	460/(93.9%)	<100/(72%)

[a] WQS = More than 10% of the Fecal Coliform samples shall not exceed a MPN of 28 organisms per 100 ml

* Value not calculated since there was only one data point

ND= No Data

[1]Data collected is for the 2002-2003 period only

Limited data exists for the 1996-2003 summer sampling period so it was not possible to calculate accurate geometric means for most locations in North Bay. Based on the limited data that was available, it was shown that Station 8 and 9 exceeded the water quality standard of 14 CFU/100 mL during wet weather sampling (Table 4-3). In North Bay, the historical 1985-1995 data indicated that more than 10% of the samples exceeded the water quality standard of 28 CFU/l00 mL at several stations during the summer (Table 4-4). For the 1996-2003 period the stations that were sampled met this water quality standard and no reductions were needed.

At station SM, which is the Route 28 culvert on the Marstons Mills River, data collected by SMAST during 2002 and 2003 indicated that wet geometric means exceeded the water quality standard of 14 CFU/100 mL in both the summer and winter requiring reductions of up to 92.9% and 48.1% respectively (Table 4-3). More than 10% of the samples exceed the water quality standard of 28 CFU/100 mL during both the summer and winter with reductions between 72% and 93.9% necessary to attain this water quality standard (Table 4-4).

Prince Cove (MA-96-07)

This 0.14 square mile Class SA, segment extends from Prince Cove including the adjacent unnamed cove [referred to as Warren's Cove] east of Prince Cove to North Bay at Fox Island, Barnstable, MA. The DMF sampling stations for West Bay is presented in Figure 4-3. Geometric means and the 90th percentile observation are summarized in Table 4-5 and 4-6 respectively.

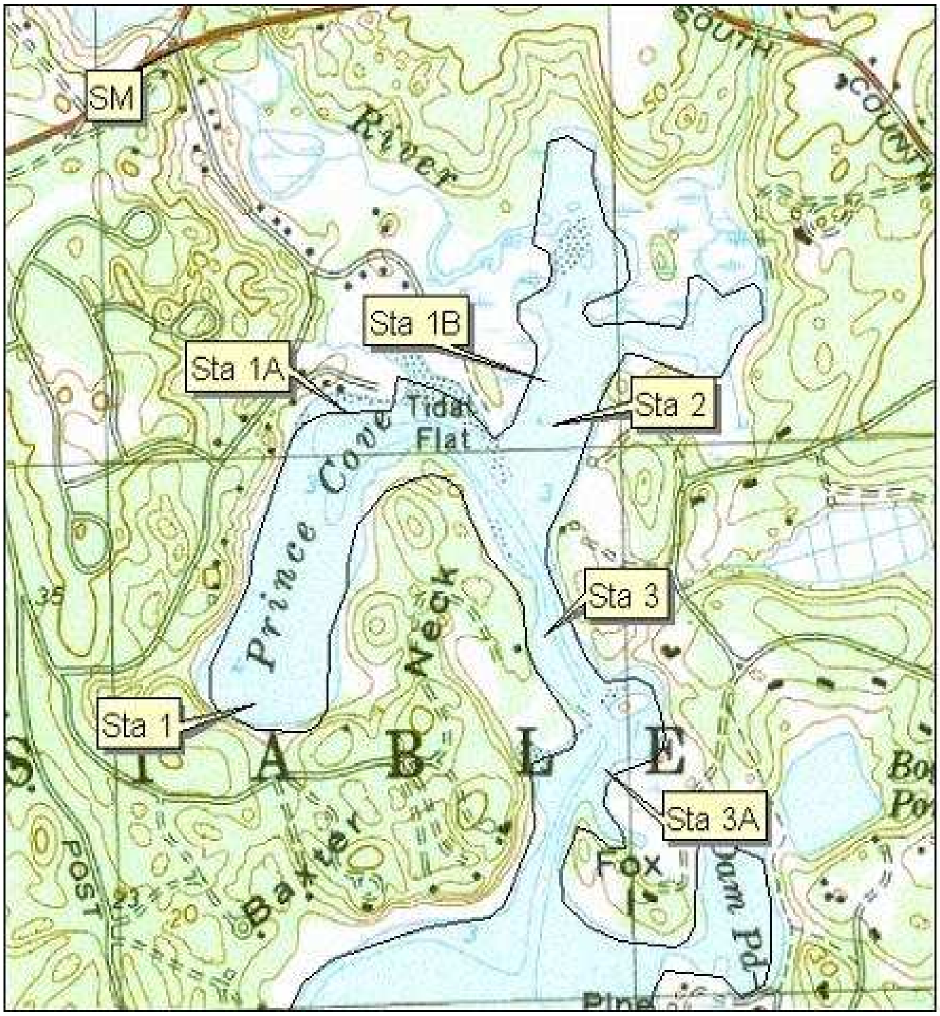


Figure 4-3. Prince Cove Sampling Stations

Table 4-5. Estimates of Fecal Coliform Load Reductions to Prince Cove Necessary to Meet WQS [a].

	Analysis Period 1985 – 1995				Analysis Period 1996-2003							
	SUMMER		WINTER		SUMMER				WINTER			
Station#/ Location	Geometric Mean/ (Percent Reduction)	N	Geometric Mean/ (Percent Reduction)	N	Wet Geometric Mean/ (Percent Reduction)	N	Dry Geometric Mean/ (Percent Reduction)	N	Wet Geometric Mean/ (Percent Reduction	N	Dry Geometric Mean/ (Percent Reduction)	N
1 - Prince Cove	14/(0%)	9	2/(0%)	26	14/(0%)*	2	27/(48.1%)*	4	4/(0%)	13	3/(0%)	18
1A - Prince Cove	19/(26.3%)	9	3/(0%)	31	43/(67.4%)*	2	15/6.6%)*	4	3/(0%)	14	3/(0%)	19
1B - Warren's Cove	33/(57.5%)	5	4/(0%)	18	51(72.5%)*	2	42/(66.6%)*	3	8/(0%)	13	7/(0%)	18
2 - Warren's Cove	50/(72%)	10	8/(0%)	29	43/67.4%)*	2	50/(72%)*	4	11/(0%)	14	9/(0%)	19
3 - Prince Cove	51/(72.5%)	9	5/(0%)	30	51/(72.5%)*	2	40/(65%)*	4	9/(0%)	14	7/(0%)	19
3A - Prince Cove	31/(54.8%)*	3	4/(0%)	18	ND	ND	ND	ND	ND/(0%)	ND	ND	ND

[a] WQS = Fecal Coliform shall not exceed a geometric mean Most Probable Number of 14 organisms per 100 ml

* Too few data for accurate geometric mean to be calculated (less than five samples collected). Value is presented for comparative/informational purposes only.

ND = No Data

N = Number of samples

Table 4-6. 90th Percentile Observation and Estimates of Fecal Coliform Load Reductions to Prince Cove Necessary WQS[a].

		Analysis Period 1985 – 1995		**Analysis Period 1996 - 2003**	
STATION		**SUMMER**	**WINTER**	**SUMMER**	**WINTER**
Station	**Location**	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation / (%Reduction)**
1	Prince Cove	128 / (78.1%)	6 / (0%)	50 / (44.0%)	11 / (0%)
1A	Prince Cove	30 / (6.7%)	14 / (0%)	36 / (22.2%)	14 / (0%)
1B	Warren's Cove	65 / (56.9%)	14 / (0%)	51 / (45.1%)	51 / (45.1%)
2	Warren's Cove	128 / (78.1%)	64 / (56.3%)	51 / (45.1%)	51 / (45.1%)
3	Prince Cove	128 / (78.1%)	30 / (6.7%)	51 / (45.1%)	51 / (45.1%)
3A	Prince Cove	128 / (78.1%)	14 / (0%)	ND	ND

[a] WQS = More than 10% of the Fecal Coliform samples shall not exceed a MPN of 28 organisms per 100 ml
ND= No Data

Table 4-5 indicates that the summer data for Prince is representative of the worst-case scenario requiring the greatest reduction in bacterial levels. Reductions in fecal coliform are required in Prince and Warren's Coves throughout the summer during both wet and dry weather in order to meet the water quality standard of 14 CFU/100 mL. In contrast, fecal coliform counts throughout the winter at both coves consistently met this standard. More than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL in Prince and Warren's Coves and the 1996-2003 data indicate that reductions of up to 78.1% are required in both the summer and winter (Table 4-6).

West Bay (MA96-65)

This 0.52 square mile Class SA, embayment has a tidal inlet fixed by two jetties to Nantucket Sound. The segment extends form South of the Bridge Street bridge to Nantucket Sound including Eel River, Barnstable, MA . The DMF sampling stations for West Bay is presented in Figure 4-4. Geometric means and the 90th percentile observation are summarized in Table 4-7and 4-8, respectively.

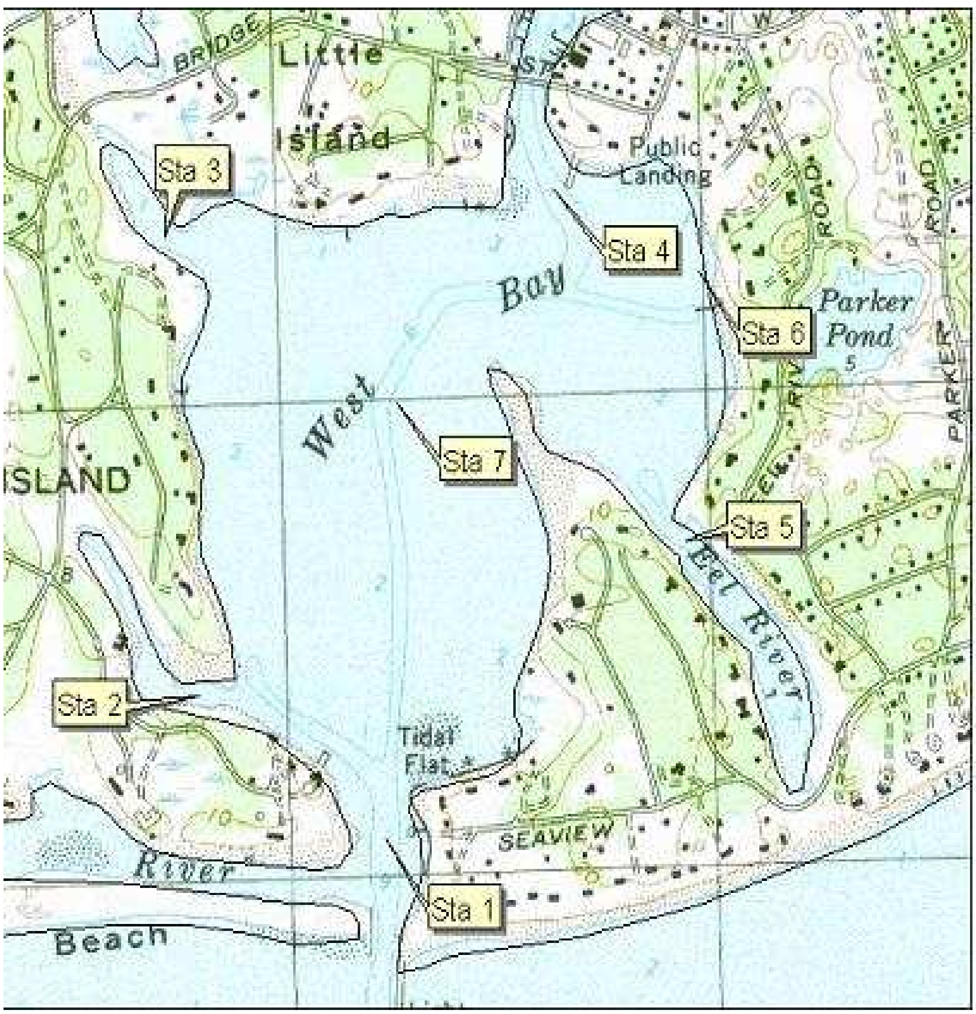


Figure 4-4. West Bay Sampling Locations

Table 4-7. Estimates of Fecal Coliform Load Reductions to West Bay Necessary to Meet WQS [a].

	Analysis Period 1985 – 1995				Analysis Period 1996-2003							
	SUMMER		WINTER		SUMMER				WINTER			
Station	Geometric Mean	N	Geometric Mean	N	Wet Geometric Mean	N	Dry Geometric Mean	N	Wet Geometric Mean	N	Dry Geometric Mean	N
1	3/(0%)	26	4/(0%)	22	2/(0%)	8	2/(0%)	13	2/(0%)	8	2/(0%)	6
2	4/(0%)	27	2/(0%)	22	4/(0%)	8	2/(0%)	12	2/(0%)	8	2/(0%)	6
3	8/(0%)	27	2/(0%)	22	6/(0%)	8	3/(0%)	12	2/(0%)	8	2/(0%)	5
4	10/(0%)	27	2/(0%)	22	7/(0%)	8	3/(0%)	12	2/(0%)	8	2/(0%)	6
5	4/(0%)	27	1/(0%)	22	4/(0%)	8	3/(0%)	13	2/(0%)	8	2/(0%)	5
6	6/(0%)	5	2/(0%)*	4	ND	ND	ND	ND	ND	ND	ND	ND
7	3/(0%)	5	2/(0%)	5	3/(0%)	8	3/(0%)	12	2/(0%)	8	2/(0%)	6

[a] WQS= Fecal Coliform shall not exceed a geometric mean Most Probable Number of 14 organisms per 100 ml

*Too few data for accurate geometric mean to be calculated (less than five samples collected). Value is presented for comparative/informational purposes only.

ND= No Data

N = Number of samples

Table 4-8. 90th Percentile Observation and Estimates of Fecal Coliform Loading Reductions to West Bay Necessary to meet WQS[a].

	Analysis Period 1985 – 1995		Analysis Period 1996-2003	
	SUMMER	**WINTER**	**SUMMER**	**WINTER**
Station	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation/ (%Reduction)**	**90th Percentile Observation/ (%Reduction)**
1	11/(0%)	30/(6.7%)	4/(0%)	2/(0%)
2	11/(0%)	14/(0%)	8/(0%)	2/(0%)
3	41/(31.7%)	3.6/(0%)	8/(0%)	1.9/(0%)
4	41/(31.7%)	3.6/(0%)	14/(0%)	2/(0%)
5	18/(0%)	1.9/(0%)	8/(0%)	4/(0%)
6	23/(0%)	1.9/(0%)	ND	ND
7	11/(0%)	1.9/(0%)	8/(0%)	2/(0%)

[a] WQS = More than 10% of the Fecal Coliform samples shall not exceed a MPN of 28 organisms per 100 ml
ND = No Data

As can be seen in Table 4-7, all the summer and winter fecal coliform geometric means during both dry and wet weather in West Bay were below the water quality standard of 14 CFU/100 mL. More than 10% of the samples collected in West Bay did not exceed the water quality standard of 28 CFU/100 mL and no reductions are needed for the 1996-2003 period (Table 4-8).

Three Bays Preservation Inc. Data (all segments)

The Three Bays Preservation, Inc. sampling stations are indicated on Figure 4-5. As can be seen in Tables 4-9 and 4-10, data collected by the Three Bays Preservation Inc. was consistent with the findings of the DMF dataset both in the coliform levels and the spatial and seasonal pattern of bacterial contamination. Following is a brief summary of those results.

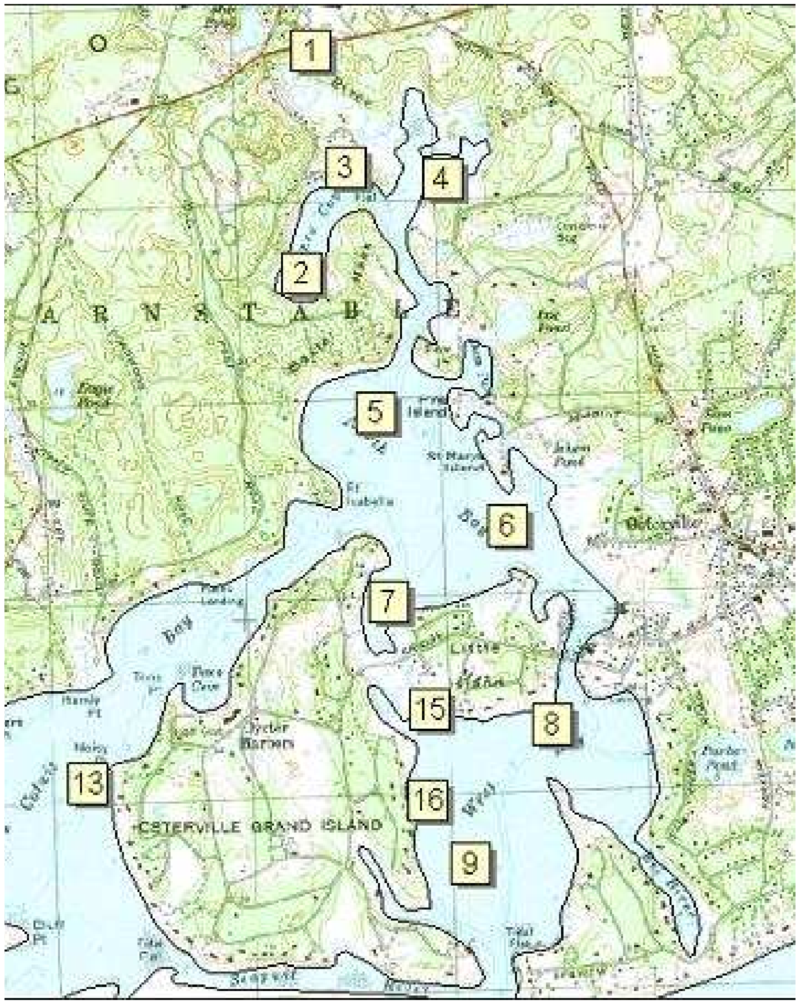


Figure 4-5. Three Bays Preservation, Inc. Sampling Stations.

Table 4-9. Estimates of Fecal Coliform Load Reductions to Three Bays Necessary to meet WQS[a].

Station# & Location	Analysis Period 1999-2003							
	SUMMER				WINTER			
	Wet Geometric Mean/ (Percent Reduction)	N	Dry Geometric Mean/ (Percent Reduction)	N	Wet Geometric Mean/ (Percent Reduction	N	Dry Geometric Mean/ (Percent Reduction)	N
1 – Marstons Mills River	73/(80.8%)	7	70/(80%)	22	240/(0%)**	1	21/(33.3%)*	4
2 - Prince Cove	75/(81.3%)	8	29/(51.7%)	23	5/(0%)**	1	6/(0%)*	4
3 - Prince Cove	84/(83.3%)	8	48/(70.8%)	23	5/(0%)**	1	10/(0%)**	1
4 - Warren's Cove	515/(97.3%)	8	156/91.0%)	23	30/(53.3%)**	1	40/(65%)**	1
5 - North Bay	21/(33.3%)	8	12/(0%)	23	5/(0%)**	1	5/(0%)*	4
6 - North Bay	18/(22.2%)	8	11/(0%)	23	ND	ND	5/(0%)*	4
7 - North Bay	16/(12.5%)	8	9/(0%)	23	ND	ND	5/(0%)**	1
8 - West Bay	5/(0%)	8	7/(0%)	23	5/(0%)**	1	5/(0%)**	1
9 - West Bay	7/(0%)	8	6/(0%)	23	5/(0%)**	1	5/(0%)*	4
11 – Seapuit River	9/(0%)	8	6/(0%)	23	5/(0%)**	1	5/(0%)**	1
13 - Cotuit Bay	6/(0%)	8	6/(0%)	23	5/(0%)**	1	5/(0%)*	4
15 - West Bay	5/(0%)	6	7/(0%)	19	ND	ND	5/(0%)**	1
16 - West Bay	8/(0%)	6	5/(0%)	16	ND	ND	5/(0%)**	1

[a]Fecal Coliform shall not exceed a geometric mean Most Probable Number of 14 organisms per 100 ml
*Too few data for accurate geometric mean (less than five samples collected)
** Value represented is one data point
ND= No Data
N = Number of samples

Table 4-10. 90th Percentile Observation and Estimates of Fecal Coliform Load Reductions to Three Bays Necessary to meet WQS[a].

Analysis Period 1999 - 2003			
		SUMMER	**WINTER**
Station#/Location		**90th Percentile Observation/(%Reduction)**	**90th Percentile Observation/(%Reduction)**
1	Marstons Mills River	140/(80%)	40/(30%)
2	Prince Cove	190/(85.3%)	<10/(0%)
3	Prince Cove	410/(93.2%)	10/(0%)
4	Warren's Cove	1160/ 97.6%)	40/(30%)
5	North Bay	80/(65%)	<10/(0%)
6	North Bay	40/30%)	<10/(0%)
7	North Bay	40/(30%)	**
8	West Bay	10/(0%)	<10/(0%)
9	West Bay	10/(0%)	<10/(0%)
11	Seapuit River	20/(0%)	<10/(0%)
13	Cotuit Bay	10/(0%)	<10/(0%)
15	West Bay	10/(0%)	**
16	West Bay	<10/(0%)	**

[a]More than 10% of the Fecal Coliform samples shall not exceed a MPN of 28 organisms per 100 ml

** Value not calculated since there was only one data point

There were no exceedences in West Bay for the 14 organisms per 100 mL water quality standard and 10% of the samples did not exceed the water quality standard of 28 CFU/100 mL.

As Table 4-9 indicates Prince Cove requires up to an 83.3% reduction in the summer to meet the 14 organisms per 100 mL water quality standard. Based on the limited data that was available no reductions were necessary in the winter. More than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL during the summer requiring reductions of up to 93.2% (Table 4-10). This water quality standard was met during winter weather.

In Warren's Cove in order to meet the 14 organisms per 100 mL water quality standard a 97.3% reduction is required in the summer (Table 4-9). The limited samples that were collected during the winter (only two samples) indicate that this water quality standard may not be met during the winter. More than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL in Warren's Cove in the summer with reductions of 97.6% required (Table 4-10).

The 14 organisms per 100 mL water quality standard was met in North Bay with the exception of the summer wet data which required a reduction up to 33.3% (Table 4-9). More than 10% of the samples exceeded the water quality standard of 28 CFU/100 mL in the summer requiring reductions up to 65% (Table 4-10).

The Marstons Mills River station exceeded the 14 organisms per 100 mL standard in the summer during both wet and dry conditions requiring reductions of up to 80.8%. The limited data that was collected during the winter season indicates that this water quality standard was also exceeded in the winter. More than 10% of the samples at this Marstons Mills River station exceeded the water quality standard of 28 CFU/100 mL with reductions of 80% required in the summer.

There were no exceedences in the Seapuit River for the 14 organisms per 100 mL water quality standard and more than 10% of the samples did not exceed the water quality standard of 28 CFU/100 mL.

Data Conclusions

In summary, the data indicates that West and Cotuit Bays contain low concentrations of fecal coliform bacteria while levels of fecal coliform bacteria in excess of the water quality standards frequently occur in Prince Cove, Warren's Cove and the tidal channel to North Bay. Analysis of the bacterial loads in the Marstons Mills River indicates that the river is an important source of bacterial contamination. Further detailed information and analysis of the bacteria data can be found in Section V of the technical report, “Basis for Development of Total Maximum Daily Load of Bacteria – Prince Cove/Three Bays Watershed, Town of Barnstable”.

5.0 Pathogen TMDL Development

Section 303 (d) of the Federal Clean Water Act (CWA) requires states to place water bodies that do not meet the water quality standards on a list of impaired waterbodies. The most recent approved impairment list, *Final Massachusetts Year 2006 Integrated List of Waters*, identifies Cotuit Bay, North Bay, Prince Cove and the Seapuit River for use impairment caused by excessive indicator bacteria concentrations.

The CWA requires each state to establish Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant contributing to the impairment(s). TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating the water quality standards. Both point and nonpoint pollution sources are accounted for in a TMDL analysis. EPA regulations require that point sources of pollution (those discharges from discrete pipes or conveyances) subject to NPDES permits receive a wasteload allocation (WLA) specifying the amount of pollutant each point source can release to the waterbody. Nonpoint sources of pollution (and point sources not subject to NPDES permits) receive load allocations (LA) specifying the amount of a pollutant that can be released to the waterbody by this source. In the case of stormwater, it is often difficult to identify and distinguish between point source discharges that are subject to NPDES regulation and those that are not. Therefore, EPA has stated that it is permissible to include all point source stormwater discharges in the WLA portion of the TMDL. MassDEP has taken this approach. In accordance with the CWA, a TMDL must account for seasonal variations and a margin of safety, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Thus:

TMDL = WLAs + LAs + Margin of Safety

Where:
WLA = Waste Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future point source of pollution.
LA = Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future nonpoint source (and point sources not subject to NPDES permits).

For this TMDL three methods were used to calculate daily TMDL targets: daily concentration TMDL targets, percent reductions needed to attain water quality standards, and load based on volume of runoff entering the Three Bays system from stormwater.

5.1 Wasteload Allocations (WLAs) and Load Allocations (LAs) as Daily Concentrations

WLAs and LAs to Three Bays have been identified for all suspected source categories including both dry and wet weather sources. The most likely sources of fecal coliform bacteria that were identified are stormwater inflows, waterfowl/wildlife and boat discharges.

Although there are no permitted discharges of fecal coliform to Three Bays, direct stormwater discharges from storm drainage systems occur. Discharges from stormwater conveyances (including pipes, channels, roads with drainage systems and municipal streets) are by definition point sources and are subject to the requirements of NPDES Phase II stormwater permits. Therefore, the goal will be to achieve the fecal coliform standard at the end of pipe for all stormwater sources but compliance with the standard will be determined by an appropriate number of samples collected in the ambient water.

Table 5-1 presents the fecal coliform bacteria WLAs and LAs for the various potential source categories as daily concentration targets for the Three Bays Watershed. WLAs (to address point sources of pollution) and LAs (to address non-point sources of pollution) are presented by applying the fecal coliform standard. All piped discharges are, by definition, point sources regardless of whether they are currently subject to the requirements of NPDES permits. Therefore a WLA set equal to the WQS criteria will be assigned to the portion of the stormwater that discharges to surface waters via storm drains. For any illicit sources including illicit discharges to stormwater systems and sewer system overflows (SSO's) the goal is complete elimination (100% reduction). Source categories representing discharges of untreated sanitary sewage to receiving waters are prohibited, and therefore, assigned WLAs and LAs equal to zero.

It is recommended that these concentration targets be used to guide implementation. The goal to attain WQS at the point of discharge is environmentally protective, and offers a practical means to identify and evaluate the effectiveness of control measures. In addition, this approach establishes clear objectives that can be easily understood by the public and others responsible for monitoring activities. As previously noted, success of the control efforts and subsequent conformance with the TMDL can be determined by documenting that a sufficient number of valid bacteria samples from the receiving water meet the appropriate indicator criteria (WQS) for the water body.

Table 5-1. Concentration Based Fecal Coliform Wasteload Allocations (WLAs) and Load Allocations (LAs) for Three Bays Watershed.

Surface Water Classification	Pathogen Source Category	Waste Load Allocation (CFU/100 ml)	Load Allocation (CFU/100 ml)[2]
SA	Illicit discharges to Storm drains	0	Not applicable
SA	Failing Septic Systems	Not applicable	0
SA	Stormwater Runoff Phase II	Geometric Mean $\leq$ 14 Nor shall 10% of samples be $\geq$ 28	Not applicable
SA	Nonpoint Source Stormwater Runoff	Not applicable	Geometric Mean $\leq$ 14 Nor shall 10% of samples be $\geq$ 28
SA	Wildlife[1]	None	None
SA	Boat Discharges	0	Not applicable

[1]Given that sources of fecal coliform from wildlife are naturally occurring no allocation has been assigned.

[2]A concentration-based load allocation has been included for completeness in the Three Bays TMDL. Due to the moderate to high permeability of soils in the Three Bays System there is a limited potential for net runoff on an annualized basis to occur beyond the 200 foot buffer included in the WLA. Therefore, a load allocation will not be assigned to currently listed segments nor is it anticipated that a load allocation will be assigned to future listed segments in the Three Bays System.

5.2 TMDL Expressed as Daily Load

The pollutant loading that a waterbody can safely assimilate is expressed as either mass-per-time, toxicity or some other appropriate measure (40 C.F.R. § 130.2(i)). Typically, TMDLs are expressed as total maximum daily loads. Expressing the bacteria TMDL in terms of daily loads is difficult to interpret given the very high numbers of indicator bacteria and the magnitude of the allowable load which is dependent on flow conditions. Therefore the magnitude of the bacteria load that is allowable within water quality standards will vary as flow rates change. For example, a very high number of indicator bacteria are allowable if the volume of water that transports the bacteria is also high provided water quality standards are still met. Conversely, a relatively low number of bacteria may exceed the water quality standards if flow rates are low.

For embayments such as Three Bays, the allowable loading was based on the volume of runoff entering the waterbody from stormwater. No other direct discharges have been authorized. The amount of precipitation that falls and actually reaches the embayment as surface water is a function of how much precipitation recharges directly to groundwater and the amount of evapotranspiration (the amount that evaporates and/or gets taken up by trees, crops and other vegetation). The difference between the amount of precipitation and these factors is a good approximation of how much actually runs off. Another major component that affects runoff is the amount of impervious area that provides direct runoff into each embayment.

To better define the above factors some knowledge is necessary of the type of soils and their permeability on Cape Cod. According to the U.S. Geological Survey (USGS) by far the most extensive type of glacial deposit at the land surface consists of mostly coarse sand and gravel outwash. Outwash consists predominantly of coarse sand and gravel but contains fine sand in places. In addition, beach and dune deposits, which consist of fine to coarse sand, are also dispersed around the periphery of the peninsula but have only a small areal extent (http://pubs.usgs.gov/ha/ha730/ch_m/M-text2.html). These types of soils have moderate to high permeability and therefore a limited potential to result in runoff into the Three Bay System. As a result runoff, where it occurs will likely be more associated with local impervious areas close to the Bay.

In order to estimate a runoff value for the Three Bays TMDL, USGS hydrology data for Cape Cod were employed. Walter and Whealan (2005; Figure 6) report precipitation results covering a time period from 1941-1995 at the Hatchville weather station in Falmouth, MA. These data indicate that an annual average of 45 inches/year (3.75 feet/year) typically falls on Cape Cod varying from a low of about 25 inches (1965) to a high of 73 inches (1972). Rates of natural surface runoff on Cape Cod are generally very low to zero, because of the medium-to-coarse sandy soils (Walter and Whealan, 2005). Precipitation in sandy soils in Cape Cod has essentially two fates: (1) ground-water recharge, or (2) evapotranspiration. Walter and Whealan (2005) report an annual average ground water recharge rate of 27 inches/year for Cape Cod and Desimone (2003) estimates that approximately 24 inches of precipitation on Cape Cod is lost to evapotranspiration. Based on the annual average rainfall and reported ground-water recharge and evapotranspiration rates, it was assumed that runoff from pervious areas within the 200 ft buffer zone of impaired embayments in the vicinity of Three Bays watershed is negligible on an annualized basis.

The resulting TMDL for embayments in Three Bays is reflected in the following equation:

$$TMDL = WLA + LA + MOS + NB$$

Where:

> WLA = allowable load for point source categories (including piped stormwater) within 200 ft buffer zone
> LA = allowable load for nonpoint source categories associated with pervious areas within 200 ft buffer zone = 0
> MOS = margin of safety
> NB = natural background conditions

It should be noted that a buffer area of 200 feet was chosen as a reasonable estimate of the area which is likely to contribute stormwater discharges directly to each embayment. Within this area it is assumed that all 45 inches per year of precipitation runs directly off any impervious area within this buffer zone. It was conservatively assumed that all runoff from impervious surfaces is collected and piped directly to the embayment through stormdrain infrastructure. For pervious areas, it was assumed that runoff is negligible on an annual basis (e.g., 0 inches per year) because of the medium-to-coarse sandy soils on the Cape.

Hence, the allowable total bacteria load on an annualized basis was calculated as the water quality standard (14 CFU/100 ml of fecal coliform for Class SA shellfishing) times the estimated annual runoff associated with impervious areas within the 200 foot buffer zone once conversions for the various units are applied. The daily load in CFU/day is then calculated by dividing the allowable annual load by the number of days, on average, that it rains. Since it rains once every three to four days, this equates to approximately 105 days per year with rainfall and runoff (based on information interpreted from http://cdo.ncdc.noaa.gov/ancsum/ACS). It should be noted that an approximate average was taken between the total number of days with >0.01inch of precipitation. The resulting equations are provided below:

Annual Waste Load Allocation for Impaired Segment (CFU/Year) =

(200 ft buffer area in acres) x (43,560 ft^2/acre) x (fraction impervious area in 200 foot buffer area) x (3.75 ft/year annual precipitation) x (14 CFU/100 ml) x (1000 ml/l) x (28.32 l/ft^3) = CFU/Year

Daily Waste Load Allocation (WLA) for Impaired Segment (CFU/Day) =

(CFU/Year) x (year/105 precipitation days) = CFU/day

It should be noted that the load allocation (LA) for each segment in the Three Bays watershed is zero since the runoff from pervious areas is assumed to be negligible on an annual basis.

In conformance with the requirements that maximum daily loads be explicit, MassDEP has calculated the daily bacteria loads associated with each impaired segment. The TMDL in CFU/day for each impaired segment contributing to runoff to the three Bays system is summarized in Table 5-2.

5.3 Margin of Safety

This section addresses the incorporation of a Margin of Safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either be implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted below the water quality standard, provided that the receiving water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

Table 5-2. Waste Load Allocation and Total Maximum Daily Load (TMDL) by Segment.

Segment	**Applicable Water Quality Standard**	**200 ft Buffer Area**	**WLA (Impervious Buffer Area)**		**TMDL (WLA + LA[1])**
	SA - Shellfishing	Acres	Percent of Impervious Area within 200 ft buffer	Daily Load (CFU/day)	Daily Load (CFU/day)
MA96-63 Cotuit Bay	14 fecal coliform/100ml	154	11.4	1.08E+08	1.08E+08
MA96-64 Seapuit River	14 fecal coliform/100ml	40	9.2	5.67+05	5.67+05
MA96-65 West Bay[2]	14 fecal coliform/100ml	101	10.8	6.73E+07	6.73E+07
MA96-66 North Bay	14 fecal coliform/100ml	107	10.9	7.19E+07	7.19E+07
MA96-07 Prince Cove	14 fecal coliform/100ml	123	6.5	4.93E+07	4.93E+07

[1] Load Allocation (LA) equals zero since runoff from the pervious area is assumed to be negligible because high soil permeability makes direct discharge unlikely except within the 200 foot buffer area of a water body.

[2] West Bay is included in this TMDL document although it is not currently impaired by pathogens, nor listed on the Massachusetts 2006 303(d) list of impaired waters.

5.4 Seasonal Variability

In addition to a Margin of Safety, TMDLs must also account for seasonal variability. This TMDL recognizes that the concentration of bacteria, the pollutant of concern, is greater during the summer season, however, this TMDL has set WLAs and LAs for all known and suspected source categories equal to the Massachusetts WQS independent of seasonal and climatic conditions. This will ensure the attainment of water quality standards regardless of seasonal and climatic conditions. Controls that are necessary will be in place throughout the year, protecting water quality at all times. However, for discharges that do not affect shellfish beds or intakes for water supplies and in areas when primary contact recreation is not taking place (i.e., during the winter months) seasonal disinfection is permitted for NPDES point source discharges.

6.0 TMDL Implementation Plan

The objective of this TMDL is to specify reductions in bacterial pollutant loads so that water quality standards for aquatic life and shellfish harvesting can be met. The detailed discussion for this topic is presented in the Executive Summary and Section VI of the accompanying technical report. The following presents a summary of the specific measures that should be taken:

The first priority should be given to all sources that result in water quality standards violations during dry weather conditions. Potential sources such as illicit sewer connections, failed Title 5 systems and/or other sanitary sources should, if applicable, be given the highest priority, identified and eliminated if necessary to meet standards.

Wet weather exceedances should be targeted as a secondary priority once dry weather sources are reduced or eliminated. Potential sources to wet weather discharges should be identified and appropriate (non-structural BMPs) applied to reduce or eliminate sources if possible.

The data indicates that the Marstons Mills River is one of the main contributors of the bacterial contamination in Prince Cove. A sanitary survey should be undertaken by the town of Barnstable to identify the bacterial sources to the Marstons Mills River.

The Massachusetts Highway Department (MHD) must meet the requirements of EPA's NPDES General Permit for Stormwater Discharges from small Municipal Separate Storm Sewer Systems (MS4s) (Phase II), Part I D(1-4), as it pertains to approved TMDLs. Infiltration structures and devices that have been installed to control the road runoff from Route 28 into the Martstons Mills River should be inspected to determine their performance and condition. MHD should also continue to identify and implement to the maximum extent practicable best management practices so that the water quality standard for bacteria in SA waters is met.

In 2000 the Three Bays Preservation, Inc. conducted a fecal coliform source identity study throughout the Thee Bays System. As a part of this study, DNA testing was done which showed most bacterial contamination comes from wildlife sources, however, human sources to Prince and Warren’s Coves are indicated. The Board of Health should continue to focus on finding the sources of bacteria with a “human DNA” signature within these coves. The potential for an isolated failing on-site septic system should be a part of this investigation.

In Prince Cove higher levels of bacteria are found at the well-flushed entrance and lower levels are present at the more poorly flushed upper station indicating a source near the entrance. The tidal inflows from Warren’s Cove may be one of the potential sources. The extent to which bacterial contaminants from Warren’s Cove contribute to the contamination in Prince Cove should be quantified by the Town of Barnstable.

The Three Bays System recently received designation as a “No Discharge Zone” making direct discharge of wastewater from boats illegal. However, greywater and illegal blackwater discharges from moored boats particularly in Prince Cove may still occur periodically during the summer. The Town of Barnstable should ensure that strict enforcement of the “No Discharge Zone” is carried out. A sampling program that evaluates the effectiveness of its enforcement program in eliminating the bacterial impacts of these types of discharges should be instituted as appropriate. Educational materials and information should also be provided so that the public recognizes the importance of this problem.

The land areas surrounding Prince Cove are the most heavily developed in the entire Three Bays watershed. There are numerous roadways circling all of the bays with tangential residential roads connecting to those. Stormwater runoff from roads is a likely source of contamination in some regions. The Town of Barnstable should continue to work toward compliance with its Stormwater Management Program established under the NPDES Phase II Stormwater Program to implement the six minimum control measures.

Any bacterial testing that is done to determine sources of contamination should consider analytical testing to differentiate anthropogenic versus non-anthropogenic sources to rule out waterfowl/wildlife as the source.

The salt marsh at Station 8 in the southeast quadrant of North Bay should be investigated by the Board of Health for human sources of fecal coliforms.

In addition to the Phase I and II stormwater programs described in the Reasonable Assurances of this TMDL (Section 8), the Massachusetts Department of Environmental Protection's has proposed new "Stormwater Management Regulations," to establish a statewide general permit program aimed at controlling the discharge of stormwater runoff from certain privately-owned sites containing large impervious surfaces. The proposed regulations would require private owners of land containing five or more acres of impervious surfaces to apply for and obtain coverage under a general permit; implement nonstructural best management practices (BMPs) for managing stormwater; install low impact development (LID) techniques and structural stormwater BMPs at sites undergoing development or redevelopment; and submit annual compliance certifications to the Department. Any new construction will have to comply with state stormwater standards and permits and with the antidegradation requirements of the state water quality standards.

A manual entitled, “Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts”, has been developed by ENSR in consultation with MassDEP to provide guidance for mitigating water pollution caused by pathogens. This guidance document provides a wide range of implementation techniques that may be applied to reduce bacterial pollution and achieve water quality standards. The Town of Barnstable should consult this document for guidance as it works to implement this pathogen TMDL.

7.0 Monitoring

Long term monitoring at established ambient sampling stations will be important to assess the effectiveness of efforts to reduce bacteria and determine if water quality standards are being attained. The Massachusetts Division of Marine Fisheries has a well established and effective shellfish monitoring program that provides quality assured data which can be used to assess water quality standards attainment. Each growing area must have a complete sanitary survey every twelve years, a triennial evaluation every three years and an annual review in order to maintain a shellfish harvesting classification. The National Shellfish Sanitation Program established minimum requirements for sanitary surveys, triennial evaluations, annual reviews and annual fecal coliform water quality monitoring including the identification of specific sources and the assessment of the effectiveness of controls and attainment of standards.

Efforts by groups to monitor on a frequent basis as was demonstrated by the Three Bays Preservation, Inc. should continue. MassDEP will work with any and all such groups to ensure all data are compatible and comparable. The DMF data in combination with the Three Bays Preservation, Inc. data will be used to evaluate progress and will serve as a baseline to evaluate future controls resulting from implementation activities.

8.0 Reasonable Assurances

Reasonable assurances that the TMDL will be implemented include both application and enforcement of current regulations, availability of financial incentives including low or no-interest loans to communities for wastewater treatment facilities through the State Revolving Fund (SRF), and the various local, state and federal programs for pollution control. Storm water NPDES permit coverage is designed to address discharges from municipal owned storm water drainage systems. Enforcement of regulations controlling non-point discharges includes local enforcement of the state Wetlands Protection Act and Rivers Protection Act, Title 5 regulations for septic systems and various local regulations including zoning regulations. Financial incentives include Federal monies available under the CWA Section 319 NPS program and the CWA Section 604b and 104b programs, which are provided as part of the Performance Partnership Agreement between MassDEP and the EPA. Additional financial incentives include state income tax credits for Title 5 upgrades, and low interest loans for Title 5 septic system upgrades through municipalities participating in this portion of the state revolving fund program.

A brief summary of many of MassDEP's tools and regulatory programs to address common bacterial sources is presented below.

Overarching Tools

Massachusetts Clean Water Act: The MA Clean Water Act (M.G.L. Chapter 21, sections 26-53) provides MassDEP with specific and broad authority to develop regulations to address both point and non-point sources of pollution. There are numerous regulatory and financial programs, including those identified in the preceding paragraph, that have been established to directly and indirectly address pathogen impairments throughout the state. Several of them are briefly described below. The MA Clean Water Act can be found at the following URL. http://www.mass.gov/legis/laws/mgl/21-26.htm

Surface Water Quality Standards (314 CMR 4.0): The MA Water Quality Standards (WQS) assign designated uses and establish water quality criteria to meet those uses. Water body classifications (Class A, B, and C, for freshwater and SA, SB, and SC for marine waters) are established to protect each class of designated uses. In addition, bacteria criteria are established for each individual classification. The MA Surface Water Quality Standards can be found at http://www.mass.gov/dep/water/laws/regulati.htm#wqual

Ground Water Quality Standards (314 CMR 6.0): These standards consist of groundwater classifications, which designate and assign the uses for various groundwaters of the Commonwealth that must be maintained and protected. Like the surface water quality standards the groundwater standards provide specific ground water quality criteria necessary to sustain the designated uses and/or maintain existing groundwater quality. The MA Ground Water Quality Standards can be found at http://www.mass.gov/dep/water/laws/regulati.htm#wqual

River Protection Act: In 1996 MA passed the Rivers Protection Act. The purposes of the Act were to protect the private or public water supply; to protect the ground water; to provide flood control; to prevent storm damage; to prevent pollution; to protect land containing shellfish; to protect wildlife habitat; and to protect the fisheries. The provisions of the Act are implemented through the Wetlands Protection Regulations, which establish up to a 200-foot setback from rivers in the Commonwealth to control construction activity and protect the items listed above. Although this Act does not directly reduce pathogen discharges it indirectly controls many sources of pathogens close to water bodies. More information on the Rivers Protection Act can be found on MassDEPs web site at http://www.mass.gov/dep/water/laws/laws.htm

Additional Tools to Address Failed Septic Systems

Septic System Regulations (Title 5): The MassDEP has regulations in place that require minimum standards for the design of individual septic systems. Those regulations ensure, in part, protection for nearby surface and groundwaters from bacterial contamination. The regulations also provide minimum standards for replacing failed and inadequate systems. The Department has established a mandatory requirement that all septic systems must be inspected and upgraded to meet Title 5 requirements at the time of sale or transfer of the each property.

Additional Tools to Address Stormwater

Stormwater is regulated through both federal and state programs. Those programs include, but are not limited to, the federal and state Phase I and Phase II NPDES stormwater program, and, at the state level, the Wetlands Protection Act (MGL Chapter 130, Section 40), the state water quality standards, and the various permitting programs previously identified.

Federal Phase 1 & 2 Stormwater Regulations: Existing stormwater discharges are regulated under the federal and state Phase 1 and Phase II stormwater program. In MA there are two Phase 1 communities, Boston and Worcester. Both communities have been issued individual permits to address stormwater discharges. In addition, 237 communities in MA which includes the town of Barnstable are covered by Phase II. Phase II is intended to further reduce adverse impacts to water quality and aquatic habitat by instituting use controls on the unregulated sources of stormwater discharges that have the greatest likelihood of causing continued environmental degradation including those from municipal separate storm sewer systems (MS4s) and discharges from construction activity.

The Phase II Final Rule, published in the Federal Register on December 8, 1999, requires permittees to determine whether or not stormwater discharges from any part of the MS4 contribute, either directly or indirectly, to a 303(d) listed waterbody. Operators of regulated MS4s are required to design stormwater management programs to 1) reduce the discharge of pollutants to the "maximum extent practicable" (MEP), 2) protect water quality, and 3) satisfy the appropriate water quality requirements of the Clean Water Act. Implementation of the MEP standard typically requires the development and implementation of BMPs and the achievement of measureable goals to satisfy each of the six minimum control measures.

Those measures include 1) public outreach and education, 2) public participation, 3) illicit discharge detection and elimination, 4) construction site runoff control, 5) post-construction runoff control, and 6) pollution prevention/good housekeeping. In addition, each permittee must determine if a TMDL has been developed and approved for any water body into which an MS4 discharges. If a TMDL has been approved then the permittee must comply with the TMDL including the application of BMPs or other performance requirements. The permittees must report annually on all control measures currently being implemented or planned to be implemented to control pollutants of concern identified in TMDLs. Finally, the Department has the authority to issue an individual permit to achieve water quality objectives. Links to the MA Phase II permit and other stormwater control guidance can be found at: http://www.mass.gov/dep/water/wastewater/stormwat.htm

A full list of Phase II communities in MA can be found at:
http://www.mass.gov/dep/water/laws/p2help.htm

In addition to the Phase I and II programs described above the Massachusetts Department of Environmental Protection's has proposed new "Stormwater Management Regulations," that would establish a statewide general permit program aimed at controlling the discharge of stormwater runoff from certain privately-owned sites containing large impervious surfaces.
The proposed regulations would require private owners of land containing five or more acres of impervious surfaces to apply for and obtain coverage under a general permit; implement nonstructural best management practices (BMPs) for managing stormwater; install low impact development (LID) techniques and structural stormwater BMPs at sites undergoing development or redevelopment; and submit annual compliance certifications to the Department.

Where the Department has determined that stormwater runoff is causing or contributing to violations of the Massachusetts Surface Water Quality Standards, the proposed regulations would allow MassDEP to impose the same requirements on certain private owners of land with less than five acres of impervious surfaces and require the owners of such land to design and implement the LID techniques and stormwater BMPs needed to address these violations.

The MassDEP Wetlands regulations (310 CMR 10.0) direct issuing authorities to enforce the MassDEP Stormwater Management Policy, place conditions on the quantity and quality of point source discharges, and to control erosion and sedimentation. The Stormwater Management Policy was issued under the authority of the 310 CMR 10.0. The policy and its accompanying Stormwater Performance Standards apply to new and redevelopment projects where there may be an alteration to a wetland resource area or within 100 feet of a wetland resource (buffer zone). The policy requires the application of structural and/or non-structural BMPs to control suspended solids, which have associated co-benefits for bacteria removal. A stormwater handbook was developed to promote consistent interpretation of the Stormwater Management Policy and Performance Standards: Volume 1: Stormwater Policy

Handbook and Volume 2: Stormwater Technical Handbook can be found along with the Stormwater Policy at: http://www.mass.gov/dep/water/laws/policies.htm#storm

Financial Tools

Nonpoint Source Control Program: MassDEP has established a non-point source program and grant program to address non-point source pollution sources statewide. The Department has developed a Nonpoint Source Management Plan that sets forth an integrated strategy and identifies important programs to prevent, control, and reduce pollution from nonpoint sources and more importantly to protect and restore the quality of waters in the Commonwealth. The Clean Water Act, Section 319, specifies the contents of the management plan. The plan is an implementation strategy for BMPs with attention given to funding sources and schedules. Statewide implementation of the Management Plan is being accomplished through a wide variety of federal, state, local, and non-profit programs and partnerships. It includes partnering with the Massachusetts Coastal Zone Management on the implementation of Section 6217 program. That program outlines both short and long term strategies to address urban areas and stormwater, marinas and recreational boating, agriculture, forestry, hydromodification, and wetland restoration and assessment. The CZM 6217 program also addresses TMDLs and nitrogen sensitive embayments and is crafted to reduce water quality impairments and restore segments not meeting state standards.

In addition, the state is partnering with the Natural Resource Conservation Service (NRCS) to provide implementation incentives through the national Farm Bill. As a result of this effort, NRCS now prioritizes its Environmental Quality Incentive Program (EQIP) funds based on MassDEP's list of impaired waters. The program also provides high priority points to those projects designed to address TMDL recommendations. Over the past several years EQIP funds have been used throughout the Commonwealth to address water quality goals through the application of structural and non-structural BMPs.

MA, in conjunction with EPA, also provides a grant program to implement nonpoint source BMPs that address water quality goals. The section 319 funding provided by EPA is used to apply needed implementation measures and provide high priority points for projects that are designed to address 303d listed waters and to implement TMDLs. MassDEP has funded numerous projects through 319 that were designed to address stormwater and bacteria related impairments. It is estimated that 75% of all projects funded since 2002 were designed to address bacteria related impairments.

The 319 program also provides additional assistance in the form of guidance. The Department is in the process of updating the Massachusetts' Nonpoint Source Management Manual that will provide detailed guidance in the form of BMPs by landuse to address various water quality impairments and associated pollutants.

Finally, it should be noted that the approach and process outlined for implementing this TMDL has been previously demonstrated with documented success. A previous TMDL, which utilized this approach was developed and approved by EPA for the Neponset River

Watershed. The recommendations outlined in that TMDL were similar to the current proposal. Since the time of approval, MassDEP worked closely with a local watershed group (Neponset River Watershed Association) to develop a 319 project to implement the recommendations of the TMDL. The total project cost was approximately $472,000 of which $283,000 was provided through federal 319 funds and the additional 40% provided by the watershed association and two local communities.

Other examples include the Little Harbor in Cohasset and the Shawsheen River. Similar TMDLs were developed in these areas. In Little Harbor, the TMDL was used as the primary tool to obtain local approval and funding to design and install sewers around Little Harbor and other additional areas of Town impacted by sewerage contamination. Presently, the Town is seeking additional state funding to construct the sewers. In the Shawsheen Watershed the TMDL was used to obtain a state grant to identify and prioritize specific stormwater discharges for remediation. In addition, MassDEP has received a grant to a conduct additional sampling and refine field and laboratory techniques that will allow us to differentiate between human and non-human sources that will be useful statewide. MassDEP and EPA Region 1 are also working on a compliance & enforcement strategy to address the worst sources.

Additional information related to the non-point source program, including the Management Plan can be found at: http://www.mass.gov/dep/water/resources/nonpoint.htm.

State Revolving Fund: The State Revolving Fund (SRF) Program provides low interest loans to eligible applicants for the abatement of water pollution problems across the Commonwealth. MassDEP has issued millions of dollars in loans for the planning and construction of CSO facilities and to address stormwater pollution. Loans have also been distributed to municipal governments statewide to upgrade and replace failed Title 5 systems. These programs all demonstrate the State's commitment to assist local governments in implementing the TMDL recommendations. Additional information about the SRF Program is located at: http://www.mass.gov/dep/water/wastewater/wastewat.htm#srf.

Bacteria Source Tracking Program: Over the last several years MassDEP has hired new regional staff and provided analytical capabilities in three regions (Northeast, Southeast, and West) to work with communities to track, identify and eliminate bacteria sources that contribute to water quality impairments.

In summary, MassDEP's approach and existing programs set out a wide variety of tools both MassDEP and communities can use to address pathogens, based on land use and the commonality of pathogen sources (e.g., failing septic systems, storm water and illicit connections, pet waste, etc.) Since there are only a few categories of sources of pathogens, the necessary remedial actions to address these sources are well established. MassDEP's authority combined with the programs identified above provide sufficient reasonable assurance that implementation of remedial actions will take place.

9.0 Public Participation

A public meeting was held on November 27, 2007 in the Town Council Hearing Room at the Barnstable Town Hall to present the findings and receive comments on the draft bacteria TMDL for Three Bays. A summary of the meeting, written questions and the responses to those questions is presented in Appendix A. A notice of the meeting was sent electronically to town officials in Barnstable, Mashpee and Sandwich. It also was distributed electronically to interested agencies and parties and appeared in the Massachusetts Environmental Monitor and on MassDEP's web site. Approximately 20 people were in attendance, including representatives from MassDEP-Southeast Regional Office and the Town of Barnstable. Additionally, the meeting was telecast on the local public access television cable channel for Barnstable and an interview with Alice Rojko of MassDEP and Dale Saad of the Barnstable Department of Public Works regarding the project was aired on the radio by Cape Cod Broadcasting.

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APPENDIX A

RESPONSE TO COMMENTS
FOR BACTERIA TOTAL MAXIMUM DAILY LOAD (TMDL)
FOR THREE BAYS

A public meeting was held at the Barnstable Town Hall on November 27, 2007 to present the findings and receive comments on the draft Bacteria TMDLs for Three Bays. Approximately 20 people were in attendance, including representatives from MassDEP-Southeast Regional Office and the Town of Barnstable. A copy of the attendance list for the meeting is attached. Additionally, the meeting was telecast on the local public access television cable channel for Barnstable and an interview with Alice Rojko of MassDEP and Dale Saad of the Barnstable Department of Public Works regarding the project was aired on the radio by Cape Cod Broadcasting.

The following is a brief summary of the meeting.

Presentations:

Lindsey Counsel of Three Bays Preservation, Inc. began the meeting by introducing the presenters and describing the purpose of the public meeting.

Steve Halterman, MassDEP, presented a brief overview of the project and acknowledged the work of the various parties involved.

Alice Rojko, MassDEP, presented an overview of the TMDL process and the results of the Three Bays TMDL report including a summary and analysis of the data with recommendations for future action. Information on grants and technical assistance available at the state level to assist with implementation efforts was also presented.

Handouts provided at the meeting:

Printout of power point presentation for Three Bays Report – Draft Bacteria Total Maximum Daily Load (TMDL) for Three Bays, Barnstable, Massachusetts.

Questions and Responses:

The questions that were submitted in writing and their responses are as follows.

Dale Saad, Barnstable DPW and Barnstable Technical Advisory Committee (TAC)

Comment: A map showing the sampling locations would be helpful in understanding the information in the report.

Response: Maps indicating the Division of Marine Fisheries and Three Bays Preservation sampling sites have been added to the TMDL report.

Comment: One of the goals stated in the TMDL is "to decrease or eliminate fecal coliform bacterial contamination or determine that it is not wastewater derived". Who will make the determination of wastewater or non-wastewater derived bacteria?

Response: MassDEP recommends that any bacterial testing that is conducted to determine the sources of contamination should consider analytical testing to differentiate anthropogenic versus non-anthropogenic sources. This type of testing should be included in any future studies as it will give a good indication to those conducting the study if the bacteria is wastewater or non-wastewater derived and will be instrumental in determining what future actions should be taken. MassDEP is currently working with the Wall Experiment Station to further refine the techniques used to distinguish between human and other sources of fecal bacteria. Once developed these techniques will be integrated into MassDEP's sampling programs and local monitoring programs will also be able to benefit from them.

Comment: If the bacterial contamination is found to be of wildlife origin, will the Division of Marine Fisheries (DMF) allow the opening of shellfish beds?

Response: For the protection of shellfish resources, fecal coliform bacteria are the chosen indicator to determine if a coastal marine water body is in compliance with the Massachusetts Surface Water Quality Standards (WQS). The WQS state that coastal waters, such as Three Bays that are classified as SA waters shall have a fecal coliform bacteria concentration not exceeding a geometric mean Most Probable Number (MPN) of 14 organisms per 100 mL and not more than 10% of the samples exceed a MPN of 28 per 100 mL. The WQS make no distinction between human and wildlife sources since either can be a source of contamination to shellfish beds. Shell fishing areas that exceed the WQS would have to remain closed until the bacteria levels meet water quality standards for harvesting shellfish. In addition, the Division of Marine Fisheries makes the final determination whether or not a shell fishing area can be opened independent of the state water quality standards in place. Ultimately it will be their call if the resource should be opened or not. This decision will be based on the results of sanitary surveys which include an evaluation of pollution sources that may affect an area, an evaluation of hydrographic and meteorological characteristics that may affect the distribution of pollutants and an assessment of water quality.

Comment: No dilution factor for stormwater conveyances is given. DMF often tests the discharge point and so many feet from the source to determine dilution. Determination of dilution factors helps the Towns rank systems to determine which locations have higher priority. Often money is limited to do work on pollution sources and this method gives the biggest bang for the dollar.

Response: The technical report on which the TMDL is based, The Massachusetts Estuaries Project Basis for Development of Total Maximum Daily Load of Bacteria for Prince

Cove/Three Bays Watershed, which was prepared by the School for Marine Science and Technology (SMAST) did not include any analysis of dilution from point sources. However it is safe to say that the goal is to meet standards at the end of pipe. By not using dilution an additional margin of safety is added to the analysis. It should be noted that ultimate compliance with the State water quality criteria is demonstrated by an appropriate number of samples taken from the receiving water.

Comment: On page 4, Loading Capacity, after the equation where "QR= runoff flow on any give day." Need to add an "n" to make it: "on any given day".

Response: This typo has been corrected.

Comment: How are MassDEP and the Town to handle sediment source bacterial contamination?

Response: The technical report on which the TMDL is based, The Massachusetts Estuaries Project Basis for Development of Total Maximum Daily Load of Bacteria for Prince Cove/Three Bays Watershed, which was prepared by SMAST did not include any analysis of sediment bacteria sources to these systems. Bacteria in the sediments has recently been emerging as an important issue that needs to be addressed. Generally, if there is a problem with bacteria in the water column it can be expected to impact the sediments as well. The Mystic River Watershed Association (MyRWA) conducted an assessment of bacteria in beach sand and water at eight beaches in eastern Massachusetts on Monday, July 23, 2007. MyRWA tested for the presence of the fecal indicator bacteria Enterococcus in beach sand at two freshwater beaches and six saltwater beaches. The results show that bacteria can be found in relatively high concentrations in sand even when bacteria levels in the water are low. The report, Bacteria in Beach Sand: An analysis of bacteria contamination at eight beaches in eastern Massachusetts —Technical Report 10-007, contains more information and is available from the Mystic River Watershed Association. Their website address with contact information is http://www.mysticriver.org.

Comment: Algae blooms are occurring in the Three Bay Area due to high nitrogen levels in the watershed. The algae acts as a harborage area for bacteria. The nitrogen must be addressed along with bacterial contamination in order to achieve the goal for cleaner waters. Will MassDEP take this into count when determining a timeline for implementation?

Response: The Town of Barnstable is in the process of initiating the preparation of a Comprehensive Wastewater Management Plan, which will evaluate current and future wastewater needs, compare alternate solutions and select a final plan based on cost effectiveness and environmental impact. This is a good opportunity to coordinate and address both nitrogen and bacteria issues and to set timelines for implementation.

Comment: On page 17, TMDL Implementation referred to the Executive Summary and Section VI of another report. Can a copy of these two sections be included in this report as an appendix? This will allow the report to stand-alone when it goes out to the public. A complete packaged document of this type can be useful when the Town is going for funding in front of the Town Council and/or outside funding sources. MassDEP can assist in the Towns implementation goals, by including the documents.

Response: Both the Executive Summary and Section VI from the technical report, The Massachusetts Estuaries Project Basis for Development of Total Maximum Daily Load of Bacteria for Prince Cove/Three Bays Watershed, which was prepared by SMAST will be included as appendices in the TMDL.

Comment: What are DEP's expectations of a timeline for the development of implementation plans, and what is an expected timeline for implementation?

Response: In the process of preparing a Comprehensive Wastewater Management Plan, the Town of Barnstable will be taking the lead and will be consulting with MassDEP to develop implementation plans and expected timelines.

Comment: For sections of communities that will have extended implementation schedules, due to phased implementation, is a community expected to implement interim measures, i.e. requiring septic upgrades to IA, until the final solution (i.e. sewers) is implemented to meet the TMDL?

Response: This would depend on the severity of the situation and should be addressed on a case-by-case basis by the Town of Barnstable.

Comment: How will physical changes in embayment outlets be handled in implementation? During dredging of Cotuit Lower Bay the flow regime increased from North Bay to Cotuit Bay, this resulted in elevated bacterial levels moving south resulting in a shellfish closure line in North Bay being moved into Cotuit Narrows.

Response: By identifying and removing the sources of bacterial contamination, the expectation is that problems will be eliminated and water quality standards will be met. In the event that any future implementation activity is proposed that will involve physical changes in the embayment outlets, hydrodynamic and water quality modeling should be undertaken as a part of that proposed activity to determine what the affect would be on the embayment.

Comment: What sources of funding will be available for implementation?

Response: Funding may be available through several MassDEP programs such as the 319 Nonpoint Source Grant Program, the 604b Water Quality Assessment Grant Program, the State Revolving Fund and the Community Septic Management Program. Additionally, the Office of Coastal Zone Management offers grants under its Coastal Pollution Remediation and Coastal Nonpoint Source Pollution Programs and the Department of Conservation and

Recreation provides matching grants through its River and Harbors Grant Program. A very useful document that was produced as a companion document to the statewide basin-specific pathogen TMDLs provides guidance for mitigating water pollution caused by pathogens and contains information on potential funding sources. This document, Mitigation Measures to Address Pathogen Pollution in Surface Waters: A TMDL Implementation Guidance Manual for Massachusetts, can to found at the following web site: www.mass.gov/dep/water/resources/impguide.pdf.

Lindsey Counsell, Three Bays Preservation, Inc.

Comment: Paragraph 6 page 2 lists likely sources for fecal coliform bacteria. I feel strongly that there is one other potential source. Robert Oldale of the USGS in his Cotuit Quadrangle Geologic Map #GQ-1213 lists soil types of the Three Bays area. One type Qvf, Valley-Floor Deposits, sand and gravel, is of particular interest. In reviewing this 1975 map you will see that many homes are sited in this soil type, particularly adjacent to Prince's & Warren's Cove and up and down the Marstons Mill River. More have been constructed since the publication of this map. In on going conversations with local engineers that design Title V septic systems in this area, I have inquired about the permeability of these soils and its ability to retain water in perk tests. One test performed on a home in this area that was relatively close to the river had a zero retention time for the test water. In further discussions I inquired if a soil absorption system (SAS) located in this material could contribute bacteria to the adjacent waterway. It was indicated by the engineer performing the test that the time of travel and the direct flow of water from the SAS through this sand and gravel deposit might not be sufficient to remove fecal coliforms. For this reason I believe that properly constructed and functioning Title V septic systems located in the Qvf deposits adjacent to waterways may have to be checked for a direct hydrologic connection between the SAS and the adjacent river or cove. The other soil types in this area appear to have sufficient retention time to allow for the removal of pollutant bacteria.

Response: This information on soil types should be taken into account by the Town of Barnstable in looking for potential sources of bacterial contamination. It should be noted that studies have found that greater than 99% of bacteria should be removed through the biomat and two to three feet of unsaturated soil. The four feet minimum separation to groundwater standard required since 1978 by Title 5 reflects the uncertainty of determining the high ground water level. Revisions to Title 5 in 1995 resulted in a five feet standard for sandy soils with fast perc rates. Therefore systems that are in compliance with these standards should have adequate separation to groundwater to remove most of the bacteria. Efforts by the Town of Barnstable should be focused on the identification of non-compliant systems in the vicinity of the shoreline.

Comment: Under the TMDL Implementation section, bullet two, I'm not certain if you are aware that the Massachusetts Highway Dept. (MassHighway) has already infiltrated almost all of the road run-off from Rt. 28 into the Marstons Mills River and other water bodies adjacent to the highway several years ago. Those systems undoubtedly could use a review of their performance and condition.

Response: The language in the recommendation section regarding MassHighway has been changed to reflect this. Ultimately, MassHighway must implement best management practices so that the water quality standard for bacteria in SA waters is met. Additionally, MassDEP's Southeast Regional Office has personnel that will act as a liaison with MassHighway to coordinate and work out any issues.

Comment: Where specific references and recommendations are given, it would be useful for the reader to have maps that show those points.

Response: Topographic maps indicating the Division of Marine Fisheries and Three Bays Preservation sampling sites have been added to the TMDL report.

Comment: The document may be easier to reference if the final copy had page numbers.

Response: Page numbers have been added to the final TMDL report.

Peggy H. Rowland, Three Bays Preservation, Inc.

Comment: My question about the report is regarding data on the Marstons Mills river…."requiring up to 80.8% in the summer and 94.2% in the winter" which is directly before the West Bay fecal coliform chart. It is surprising to see that the reduction needed to be greater in the winter than the summer.

Response: The 94.2% reduction needed in the winter to meet the 14 organisms per 100 mL Water Quality Standard is based on just one data point. This percentage figure has been removed and the text has been revised to indicate that data is limited and the water quality standard was exceeded during the winter season. If more samples were collected, it would give a more accurate indication of reductions needed.

EPA

In response to guidance provided by EPA and to be consistent with other bacteria TMDLs that have been prepared by the state, the draft Bacteria TMDL for Three Bays was reformatted and revised. Revisions included the addition of standard language to provide more background information and clarifying details particularly on pathogens and indicator bacteria; components required in the development of the TMDL; and the Reasonable Assurances section.

Additionally, although data was presented for the Seapuit River in the TMDL, it was not specifically identified as a separate water body segment. Data for the Seapuit River had been included under the discussion and analysis of Cotuit Bay. The TMDL was revised to present the Seapuit River as a separate segment within the Three Bays system.

Massachusetts Department of Environmental Protection
Division of Watershed Management, 627 Main Street, Worcester, MA 01608

MEETING ATTENDANCE

Meeting: Three Bays Bacteria TMDL

Date: 11-27-07 Location: Barnstable

Name	Affiliation/Address	Phone/Email
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APPENDIX B

The Massachusetts Estuaries Project Basis for Development of Total Maximum Daily Load of Bacteria for Prince Cove/Three Bays Watershed

Executive Summary

and

Section VI – Conclusions and Recommendations

Executive Summary

The Massachusetts Department of Environmental Protection (MA DEP) is responsible for monitoring and protection of the water resources of the Commonwealth, identifying those water resources that are impaired, indicating the reason for impairment, and developing restoration plans for impaired waters. The Massachusetts Year 2002 Integrated List of Waters is a list of the impaired waters of the State and is also known as the 303d list. The MA Year 2002 Integrated List of Waters identifies river, lake, and coastal waters that exhibit various forms of degradation and the reasons/types of contaminants underlying the impairment.

The DEP is required by the Federal Clean Water Act to develop a pollution budget for a water resource once it is identified as impaired and subsequently listed on the MA Year 2002 Integrated List of Waters. The pollution budget associated plan is designed to restore the health of the impaired water resource. The process of developing the pollution budget, generally referred to as a Total Maximum Daily Load (TMDL), includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water resource thus enabling it to meet water quality standards, and developing a plan for meeting the restoration goal.

This report represents the basis for the development of a TMDL for bacteria in the Prince's Cove portion of the Three Bays embayment system, Town of Barnstable, Cape Cod, Massachusetts. The goal of this report is to form the technical base for the development of a TMDL for Fecal Coliform, which was the reason for the listing of this water resource, even though limited data exists for both E. Coli and Enterococci. The area to be evaluated in this Technical Report is strictly limited to Prince's Cove and will not extend into the broader Three Bays embayment system which would include North Bay, West Bay, and Cotuit Bay, all of which receive waters from Prince's Cove to varying degrees. Limited data from North Bay, the channel from Prince's Cove to North Bay, and Warren's Cove will be considered under this analysis.

Prince's Cove (Segment ID MA96-07_2002) was selected because the system exceeded the state's Water Quality Standards for indicator bacteria, e.g. fecal coliform, in historical samplings and analyses. The Prince's Cove area (Division of Marine Fisheries growing area code SC23.3) has been "Conditionally Approved" for shell fishing since 1988 by the Division of Marine Fisheries (DMF) due to bacterial concentrations exceeding the fecal coliform criteria for SA waters as defined in the State Water Quality Standards that pertain to shell fishing growing areas. North Bay (DMF growing area code SC23) has been classified as Conditionally Approved since 1988 except for area 23.21 which was classified as Prohibited in the early 1980s due to high bacteria counts in flows from a marsh creek. It was re-classified as Conditionally Approved in 1990. Currently all of North Bay is classified as Conditionally Approved. Area 23.1 (Millers River/Prince's Cove) is closed from May 1 to February 13. Area 23.2 (North Bay) is closed from May 1 to October 31 and Area 23.3 (Warren's Cove) is closed from May 1 to February 13. According to the DMF, dates of closure in growing areas SC 23.1 (Prince's Cove) and SC 23.3 (Warren's Cove) are likely to change in 2004 to continuously closed due to consistently poor water quality.

At a regulatory level, two bacterial contamination standards must be met in order to safe guard the natural resources (shellfish) of the system and public health. The first regulatory standard (Massachusetts Surface Water Quality Standards 314 CMR 4.05(4)(a)4) is intended to protect the shell fish resources of the coastal system using fecal coliform as the indicator organism. The second is a minimum standard for bathing beaches (105 CMR

445.000) and is commonly regarded as a swimming standard aimed at protecting public health using Enterococci as the indicator organism in marine waters.

Based on the Surface Water Quality Standard (SWQS), fecal coliform criteria for coastal and marine Class SA waters specify that: a) waters approved for open shell fishing shall not exceed a geometric mean MPN of 14 organisms per 100 mL, nor shall more than 10 percent of the samples exceed a MPN of 43 per 100 mL and, b) waters not designated for shell fishing shall not exceed a geometric mean of 200 organisms in any representative set of samples, nor shall more than 10 percent of the samples exceed 400 organisms per 100 ml. With regard to safe guarding public health relative to primary and secondary contact recreation, as specified in 105 CMR 445.031(A)(1), for marine water, the indicator organism shall be Enterococci and no single Enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five (5) Enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Fecal Coliform bacteria are indicators of contamination of a water resource with sewage and/or the feces of warm blooded wildlife (mammals and birds). This type of bacterial contamination may pose risks to human health as well as limit the use of natural resources such as shellfish beds. In order to prevent further degradation in water quality and to ensure that the water resource (Prince's Cove) will meet state water quality standards, the TMDL will use the data provided herein in order to establish the bacterial limits for the water resource and will outline corrective actions to achieve the restoration goal.

Historical data was compiled from multiple agencies and was synthesized in the context of more recent weekly bacterial data collected by the Massachusetts Estuaries Project (MEP) at one location in Marstons Mill River down gradient of Mill Pond prior to discharging to the head of Prince's Cove. In addition, sampling was conducted at 15 sampling stations during one wet weather event. The sampling was conducted in Prince's Cove, Warren's Cove and the channel leading into North Bay. In order to identify likely sections of Prince's Cove responsible for highest bacterial contamination, geometric means and percent exceedances were developed for current and historical data obtained for this report.

Data on Fecal coliform bacteria in the 3 Bays system are available from The Massachusetts Department of Marine Fisheries (DMF). In North Bay including Prince's Cove, designated sampling stations are 1, 1A, 1B, 2, 3, 3A, 4, 4A, 5, 5S, 6, 6S, 7, 7B, 8, 8B, 9 and 9B (Figure V-5,V-6). Station 3A was dropped from the program in 1994, Stations 4A, 5S, 9B and 6S in 1992 and 8B in 1993. SMAST has been taking samples at its designated station at the Route 28 culvert in Marstons Mills since 2002 for Fecal Coliforms, E. coli and Enterococcus (Figure V-6).

Bacterial data from the other portions of the greater Three Bays embayment system (West bay and Cotuit Bay) were obtained for this investigation and are summarized in Section 4 along with additional sampling in all of the 3 Bays system as carried out from 1999-2003 by the Three Bays Preservation, Inc. in cooperation with SMAST. The most recent full Sanitary Survey was completed in August 2001 and data from the survey were incorporated in this investigation.

Data from the DMF, SMAST and Three Bays Preservation have been compiled and analyzed for this technical TMDL report. Data was grouped by year (1985-1995 and 1996-2003 for DMF and SMAST data, and 1999-2003 for Three Bays Preservation data) , by season (November through April for winter and May through October for summer) and by wet weather or dry weather status (1994-2003 data only, where rainfall amounts were available). Wet/Dry samplings were based on the total rainfall amount at the site over the three days prior to sampling. Less than 0.25 inches was considered to be a dry weather event and greater than 0.25 inches was designated as wet weather sampling. For each sampling station, the geometric mean, standard deviation (SD) and number of samples taken (N) were computed for winter and summer for each time interval (1985- 1995 and 1996-2003) and are presented in Tables 4-1, 4-2 and 4-3. Geometric means that exceeded the water quality standard for Class A Waters of 14 CFU/100 mls for Fecal Coliforms and E. coli, and 35 colonies/100mL for Enterococcus are highlighted. In addition, when more than 10% of the samples exceeded the water quality standard of 43 CFU/100 mL for Fecal Coliforms, or where any sample exceeded the water quality standard of 104 colonies/100mL for Enterococcus, these data were also highlighted. The ratio of the summer to winter geometric means was also determined for each sampling station as indicators of the degree of summer versus winter contamination levels.

Wet and Dry data were compiled in the same manner for each station where rainfall data were available and are presented in Figures 4-5 through 4-7 and Tables 4-8, 4-9 and 4-10. Geometric means and standard deviations were calculated seasonally for wet and dry data from each station during the years 1996-2003 (Three Bays Preservation data are from 1999-2003). Means that exceeded the water quality standards were highlighted. Data were also highlighted when more than 10% of the samples exceeded the water quality standard of 43 CFU/100 mL for Fecal Coliforms and E. coli or when any sample exceeded the water quality standard of 104 colonies/100mL for enterococcus. The ratio of wet to dry geometric means for summer and winter data were also determined for each sampling station as indicators of the degree of summer versus winter contamination levels.

The Estuaries Project recommendations are to proceed with the drafting of a TMDL using the historical data that has been collected by DMF and the Three Bays Coalition. Many potential sources have been previously pinpointed from sanitary surveys. We recommend that a sampling program be instituted as a component of the TMDL that evaluates the bacterial impacts of greywater discharges and illegal blackwater discharges from moored boats in particular in Prince's Cove.

In North Bay summer inputs create significant contamination in the upper reaches of the Bay and in Prince's Cove and Warren's Cove. Potential sources here are wildlife in Warren's Cove and failed septic systems and boat waste in Prince's Cove. Likewise, contamination from cranberry bogs via the Marstons Mills River is affecting water quality in North Bay. Winter inputs are significantly lower than summer inputs but still exceed 14 CFU/100 mL at several stations in the upper Bay and the freshwater sources to the Bay. Although Rushy Marsh has significant fecal coliform levels, it does not seem to affect the 3 Bays system to any significant degree. Wet inputs are generally higher than dry inputs in North Bay and magnify already high inputs from potential sources in the upper Bay, Prince's and Warren's Coves, and the cranberry bogs and Marstons Mills River to the north.

While Prince's Cove has been identified as not meeting relevant bacterial standards, recommendations presented herein support the need for further investigations similar in detail as a sanitary survey. The recommendations aim to focus such intense efforts to most contaminated sections of Prince's Cove as a starting point for sanitary survey level investigation of bacterial sources. Bacterial contamination most likely attributable to wildlife should be considered a natural condition unless some form of human inducement (feeding or improper trash disposal) is causing congregation of wildlife.

Authority to regulate sources of bacterial pollution and thus the successful implementation of a bacterial TMDL for Prince's Cove generally rests with local government and will therefore require cooperation from local volunteers, watershed associations, municipal government, and other entities as necessary. These cooperative activities may include but not be limited to the following:

- Expanded education
- Obtaining and/or providing funding
- Local enforcement

Federal and state funds to help implement the bacterial TMDL for Prince's Cove are available on a competitive basis and include the Non Point Source Control Grants (Section 319), Water Quality Grants (Section 604(b)), the State Revolving (Loan) Fund Program (SRF), and Coastal Pollution Remediation grants available through the Massachusetts Office of Coastal Zone Management (CZM).). Financial aid to municipalities will typically involve some degree of local match as well. These funding programs are administered through the Massachusetts Department of Environmental Protection.

VI. Conclusions and Recommendations

The Estuaries Project recommendations are to proceed with the drafting of a TMDL using the historical data that has been collected by DMF and the Three Bays Preservation Trust. All of the large and diverse data sets indicate levels of fecal coliform bacteria in excess of the water quality standard frequently occur within the upper basins to the Three Bays System, primarily in Prince's Cove, Warren's Cove and the tidal channel to North Bay. Analysis of bacterial loads discharging through the Marstons Mills River within the region of these basins indicates that the River is an important source of bacterial contamination, but that it is insufficient to account for the levels observed in these basins during the periods when they are found to exceed water quality standards. Further, examination of the spatial and temporal pattern of contamination in these estuarine basins indicates that (1) there is a "local" source of bacterial contamination to Warren's Cove, since it supports the highest bacterial levels within the entire estuarine system, (2) Warren's Cove bacterial sources are likely the result of wildlife associated with the wetlands, although an isolated watershed source cannot be ruled out at this time, (3) Prince's Cove may have local bacterial sources, but the gradient in bacterial levels (highest at the well flushed entrance and lower at the more poorly flushed upper station) indicates a "source" near the entrance, possibly associated with tidal inflows associated with Warren's Cove or the River or boats/watershed, and (4) bacterial contamination within the tidal channel to North Bay almost certainly results primarily from the transport of contaminated water from Warren's and Prince's Cove. Based upon the preliminary DNA survey data it is also clear that most of the bacterial contamination results from wildlife sources, however it is clear that human sources to Prince's and Warren's Coves are indicated. Based upon the land-use analysis, these human sources are most likely associated with illegal discharges from boats during summer and/or an isolated failed septic system. Bacterial loads in runoff appear to be important in enhancing the River load discharged to the estuary, but within the estuary are most likely associated with input from "natural" surfaces (except as noted below).

The TMDL should focus on identifying the bacterial sources to the Marstons Mills River and the sources of the bacteria with a "human DNA" signature within the estuarine basins of Warren's and Prince's Coves. To this end, many potential sources have been previously pinpointed from the August 2001 sanitary survey. We recommend that a sampling program be instituted as a component of the TMDL that evaluates the bacterial impacts of greywater discharges and illegal blackwater discharges from moored boats in particular in Prince's Cove. In reviewing the 2001 Sanitary Survey conducted by the DMF in collaboration with the US Food and Drug Administration (FDA) and a Barnstable Health Agent, this recommendation is consistent with findings of the completed shoreline survey. For the Prince's Cove/Warren's Cove sub-system to North Bay, pollution sources were identified as follows:

- Prince's Cove boat ramp: 13-foot wide concrete boat ramp to water. Small drainage area- just the ramp itself.
- Prince's Cove Marina boat ramp: 11.5 foot wide paved boat ramp to water. Small drainage area.
- Prince's Cove Marina: 1.5" PVC pipe runoff from parking lot.
- Prince's Cove Marina: Old septic system was checked by town BOH. Not
- a problem.
- Prince's Cove Marina 235 Cedar Tree Neck Road: 4" metal pipe in parking lot for a fresh water spring. Pipe tested on 6/22/01 and 6/27/01 with a result of <1 fecal coliform/100ml and a salinity of zero.
- 211 Cedar Tree Neck Road: Groundwater discharge from the beach. This is a spring, and was tested on 8/6/01 with a result of zero salinity and <100 fecal coliform.

- 15 Cove Point Road- House with pool: Possible pool discharge pipe. 2” gray PVC pipe next to pier.
- Prince Ave.: Stormwater flow off road.
- Rt 149 & Rt. 28: Stormwater flow and piped off road into Mill Pond and
- Marstons Mills River.
- Mills River: Flow is tide dependent.
- Warren Cove: Ten to twelve swans and other waterfowl in cove. 50 Fox Island Road: 1987 septic system on the road-side of home- town will check.

General sources were described as human waste from moored or docked boats primarily in the north end of Prince’s Cove.

Additionally, from the available data, it is clear that West and Cotuit Bays contain low concentrations of fecal coliform bacteria, well below the water quality standard of 14 CFU/100 mL in both summer and winter seasons. Occasional inputs from potential sources such as waterfowl, flows from North Bay, flows from a salt marsh and boat waste cause some samples to exceed the water quality standard of 43 CFU/100 mL in Cotuit Bay. Summer inputs to West and Cotuit Bays are higher than winter inputs and wet weather events result in higher inputs than dry weather but not enough to put the geometric means above the water quality standards. The only station in Cotuit Bay to show a bacterial exceedance is at the margin of North Bay.

Winter inputs are significantly lower than summer inputs but still exceed 14 CFU/100 mL at several stations in the upper Bay and the freshwater sources to the Bay. Although Rushy Marsh has significant fecal coliform levels, it does not seem to affect the 3 Bays system to any significant degree. Wet inputs are generally higher than dry inputs in North Bay and magnify already high inputs from potential sources in the upper Bay, Prince’s and Warren’s Coves, and the cranberry bogs and Marstons Mills River to the north.

DNA testing of the fecal coliform bacteria has shown significant human inputs in areas around Prince’s and Warren’s Coves, and to a lesser extent in the southeast quadrant of North Bay near a salt marsh.

Summer inputs create significant contamination in the upper reaches of North Bay and in Prince’s Cove and Warren’s Cove. Potential sources here are wildlife in Warren’s Cove and failed septic systems and boat waste in Prince’s Cove. However, a key part of the TMDL should be to quantify the extent to which bacterial contaminants from Warren’s Cove contribute to the contamination in Prince’s Cove. The existing data suggest that it is possible that much of the bacterial contamination in Prince’s Cove has its origins in the Marstons Mills River and in Warren’s Cove. Likewise discharge of bacterial contaminants by the Marstons Mills River and tidal transport from both Prince’s Cove and Warren’s Cove is almost certainly the major source of contaminants to the upper portion of North Bay. The Massachusetts Estuaries Project (MEP) recommends that future investigation focus on Warren’s Cove and the Marston’s Mills River and potential illegal discharges from boats in Prince’s Cove. In addition the salt marsh at Station 8 in the southeast quadrant of North Bay should be investigated for human sources of fecal coliforms.