Total Maximum Daily Load (TMDL) Study for Bacteria in Hampton/Seabrook Harbor

Prepared by:

State of New Hampshire
Department of Environmental Services
Water Division
Watershed Management Bureau

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Total Maximum Daily Load (TMDL) Study for Bacteria in Hampton/Seabrook Harbor

STATE OF NEW HAMPSHIRE
DEPARTMENT OF ENVIRONMENTAL SERVICES
6 HAZEN DRIVE
CONCORD, NEW HAMPSHIRE 03301

MICHAEL P. NOLIN
COMMISSIONER

HARRY T. STEWART
DIRECTOR
WATER DIVISION

PREPARED BY:
PHIL TROWBRIDGE
WATERSHED MANAGEMENT BUREAU

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1. Introduction

a. Background

Section 303(d) of the Clean Water Act (CWA) and EPA's Water Quality Planning Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water quality limited segments that are not meeting designated uses under technology-based controls for pollution. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollutant sources and instream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources.

b. Purpose of this study

The purpose of this study is to develop a TMDL for bacteria in Hampton/Seabrook Harbor located in the towns of Hampton, Seabrook, and Hampton Falls, New Hampshire. The goal is to reduce bacteria loads to the harbor so that water quality standards for all the designated uses affected by bacteria pollution are met in all areas of the harbor.

The 1,047 acres of estuarine waters in Hampton/Seabrook Harbor are divided into 14 assessment units for New Hampshire's 305(b) and 303(d) reporting. The 14 assessment units are shown in Figure 1 and are listed in Table 1 and Table 2.

Ten of the 14 assessment units are on New Hampshire's 303(d) list, which is the list of impaired waters that require a TMDL. These assessment units are shown on Table 1**.** Six assessment units within Hampton/Seabrook Harbor are listed because measurements of bacteria concentrations in the assessment unit exceed State surface water quality standards for shellfish consumption. These six assessment units are listed at the top of Table 1. Two of these six assessment units are also listed as impaired for primary contact recreation (e.g., swimming). However, the primary contact recreation impairments are based on reports of discharges of untreated sewage and not actual measured violations of enterococci (the bacteria indicator for swimming in tidal waters). In fact, water quality measurements in the harbor indicate that State standards for swimming are being met.

The four assessment units on the bottom of Table 1 are closed for shellfishing for primarily administrative reasons. Additional information, such as sanitary surveys, are needed to satisfy National Shellfish Sanitation Program (NSSP) protocols before the beds can be classified. In the meantime, shellfishing is prohibited in the unclassified areas. Though officially closed for administrative reasons, these assessment units were included on New Hampshire's 303(d) list because there is some water quality data which suggests that shellfishing water quality standards may not be met in these areas (USGS/DES, 2002).

The last four assessment units in the harbor are listed as impaired by bacteria pollution on New Hampshire's 2002 305(b) list (Table 2). These four assessment units are closed for shellfishing for purely administrative reasons, not because of water quality measurements showing exceedances of standards. The NSSP requires the establishment of safety zones around municipal wastewater treatment plant discharges and the prohibition of shellfishing in the safety zones. The prohibition of shellfishing near wastewater treatment discharges is a precautionary measure to protect harvesters in the event of a wastewater treatment plant failure. These four assessment units have been included in this TMDL because the goal is to meet water quality standards throughout the harbor (these four assessment units plus the 10 units on Table 1 constitute the entire harbor area) and reductions of bacteria loads to the harbor will results in water quality improvements in all assessment units.

It is worth noting that bacteria is not the only pollutant of concern in the Hampton/Seabrook Harbor. All 14 of the assessment units for New Hampshire's coastal waters are also listed as impaired for fish and shellfish consumption due to polychlorinated biphenyl, dioxin, and mercury concentrations in fish tissue and lobster tomalley. Because of the levels of pollutants found in New Hampshire and neighboring states, the N.H. Department of Health and Human Services has issued state-wide advisories against consumption of certain species of fish and lobster tomalley. The sources of the contaminants in the fish tissue and lobster tomalley are thought to be more regional (e.g., atmospheric deposition) than local.

Table 1: 303(d)-listed waters in Hampton/Seabrook Harbor (2002)

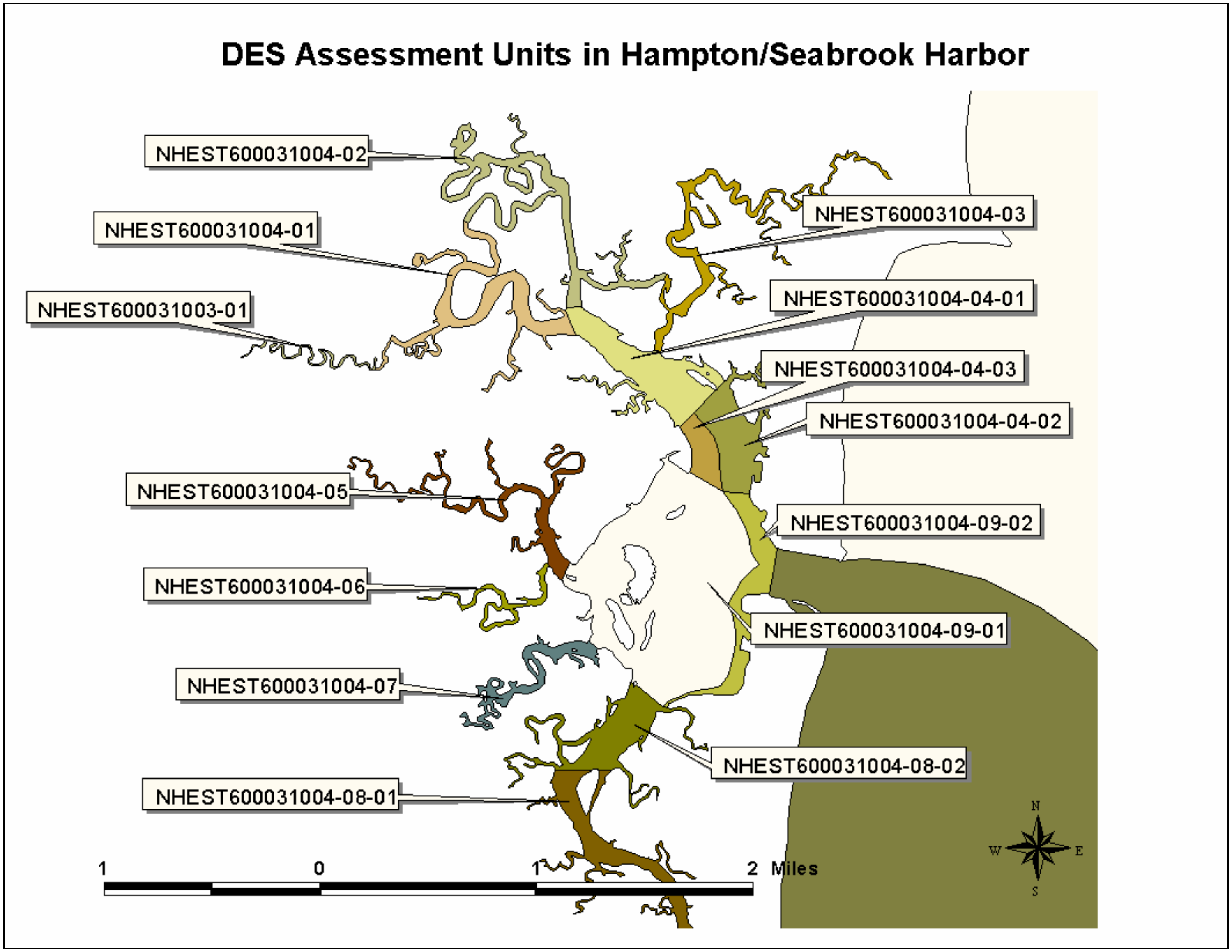
Assessment Unit ID	Name	Acres	Impaired Use	Classification (2001)	Impairment	Source(s)
NHEST600031004-04-02	Hampton River 2	65.60	Shellfishing	Restricted	Total Fecal Coliform	Source Unknown; Sanitary Sewer Overflows (Collection System Failures); Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO)
NHEST600031004-04-03	Hampton River 3	23.04	Shellfishing	Conditionally Approved	Total Fecal Coliform	Source Unknown; Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO)
NHEST600031004-08-01	Blackwater River 1	69.47	Shellfishing	Restricted	Total Fecal Coliform	Source Unknown; Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO)
NHEST600031004-08-02	Blackwater River 2	71.07	Shellfishing	Restricted	Total Fecal Coliform	Source Unknown; Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO)
NHEST600031004-09-01	Hampton/Seabrook Harbor 1	363.88	Shellfishing	Conditionally Approved	Total Fecal Coliform	Source Unknown; Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO)
NHEST600031004-09-02	Hampton/Seabrook Harbor 2	58.23	Shellfishing	Restricted	Total Fecal Coliform	Source Unknown; Sanitary Sewer Overflows (Collection System Failures); Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO)
NHEST600031003-01	Hampton Falls River	7.09	Shellfishing	Prohibited/Unclassified	Total Fecal Coliform	Source Unknown
NHEST600031004-05	Browns River	46.15	Shellfishing	Prohibited/Unclassified	Total Fecal Coliform	Source Unknown
NHEST600031004-06	Hunts Island Creek	15.99	Shellfishing	Prohibited/Unclassified	Total Fecal Coliform	Source Unknown
NHEST600031004-07	Mill Creek	31.35	Shellfishing	Prohibited/Unclassified	Total Fecal Coliform	Source Unknown

*All AU's are also listed as "Not Supporting" for fish consumption and shellfishing because of state-wide advisories issued by the N.H. Department of Health and Human Services for PCB, dioxin, and Hg contamination. Assessment Units NHEST600031004-04-02 and NHEST600031004-09-02 are also listed as "Not Supporting" for primary contact recreation because of known discharges of untreated sewage to these AU's, but monitoring data from the harbor does not indicate an impairment for primary contact recreation.

Table 2: 305(b)-listed assessment units in Hampton/Seabrook Harbor

Assessment Unit ID	Name	Acres	Impaired Use	Classification (2001)	Impairment	Source(s)
NHEST600031004-04-01	Hampton River 1	89.06	Shellfishing	Prohibited/Safety Zone	Total Fecal Coliform	Municipal Point Source Discharges
NHEST600031004-03	Tide Mill Creek	55.97	Shellfishing	Prohibited/Safety Zone	Total Fecal Coliform	Municipal Point Source Discharges
NHEST600031004-02	Taylor River	76.81	Shellfishing	Prohibited/Safety Zone	Total Fecal Coliform	Municipal Point Source Discharges
NHEST600031004-01	Hampton Falls River	73.4	Shellfishing	Prohibited/Safety Zone	Total Fecal Coliform	Municipal Point Source Discharges

Figure 1: DES assessment units in Hampton/Seabrook Harbor



2. Problem Statement

a. Waterbody Description

Hampton/Seabrook Harbor is in the coastal drainage watershed of New Hampshire. The land cover in the subwatersheds draining to Hampton/Seabrook Harbor is shown in the following table.

Table 3: Land use categories in the watersheds draining to Hampton/Seabrook Harbor (HUC12 010600031004 and HUC12 010600031003)

Category	Acres	Percent	Comments
Developed Land	8,248	31%	Sum of "Residential-Commercial-Industrial," "Transportation," "Disturbed," and "Cleared/Other Open".
Agriculture	2,049	8%	Sum of "Row Crops," "Fruit Orchards," and "Hay-Rotation-Permanent Pasture".
Forest	11,897	44%	Sum of all forest types
Wetlands	4,714	18%	Sum of "Forested Wetland," "Non-forested Wetland," and "Tidal Wetland".
Total	26,907	100%	Does not include land in the "Open Water" or "Sand Dunes" categories.

Data Source: New Hampshire Land Cover Assessment (2001) UNH Complex Systems Research Center.

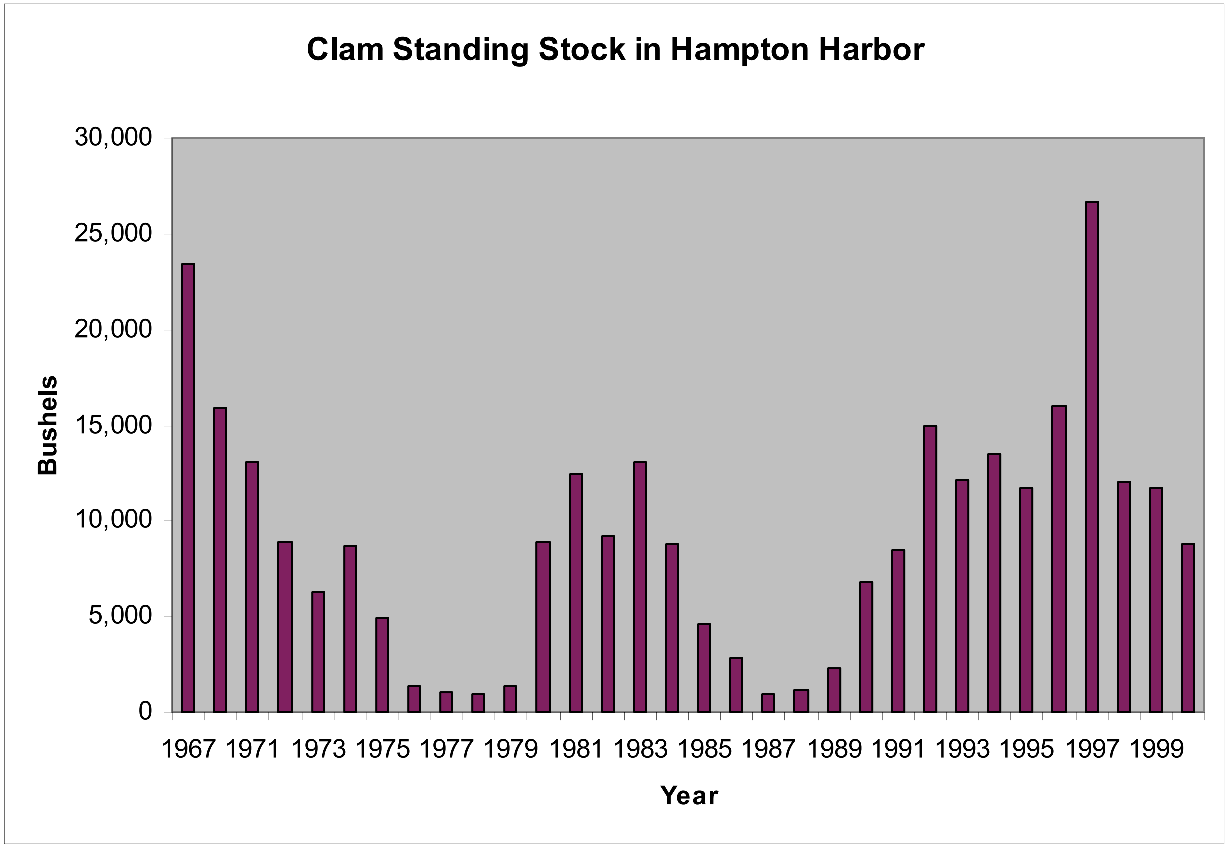
Hampton/Seabrook Harbor experiences strong tidal flushing. Approximately 88 percent of the water in the harbor is exchanged on each tide. The low tide volume of the estuary is 500 million gallons while the high tide volume is 4,200 million gallons (NAI, 1977). Another distinguishing characteristic of the harbor is that it is surrounded on three sides by 5,000 acres of salt marshes. At its eastern edge, the harbor is separated from the ocean by a narrow spit of land that is heavily developed. The northern portion of the spit is the Hampton Beach area. The southern portion is the Seabrook Beach area. There is a small gap in the spit between the towns which is spanned by a bridge and through which the tidal exchange of the estuary occurs. The Seabrook Station nuclear power plant is located on the edge of the salt marshes on the western side of the harbor. Figure 2 is an aerial photograph of the Hampton/Seabrook Harbor region from 2000.

Figure 2: The Hampton/Seabrook Harbor Area

Photo courtesy of Seabrook Station.

Hampton/Seabrook Harbor is the most popular, and most productive, area for recreational harvesting of soft shell clams in New Hampshire. Soft shell clams (*Mya arenaria*) are harvested from three large clam flats in the middle of Hampton/Seabrook Harbor as well as from other smaller flats in the harbor. The resource fluctuates over time. The most recent information from clam surveys indicates a standing crop of nearly 9,000 bushels of clams (NHEP, 2002a).

Figure 3: Clam standing stock in Hampton/Seabrook Harbor



Data courtesy of Seabrook Station

Despite being New Hampshire's primary clam resource, the clam flats in Hampton/Seabrook Harbor are often closed due to bacteria pollution. The DES Shellfish Program is responsible for classifying shellfish growing areas in New Hampshire. DES uses a set of guidelines and standards known as the National Shellfish Sanitation Program (NSSP) for classifying shellfish growing areas. The latest classifications for the waters in Hampton/Seabrook Harbor are shown in the following table.

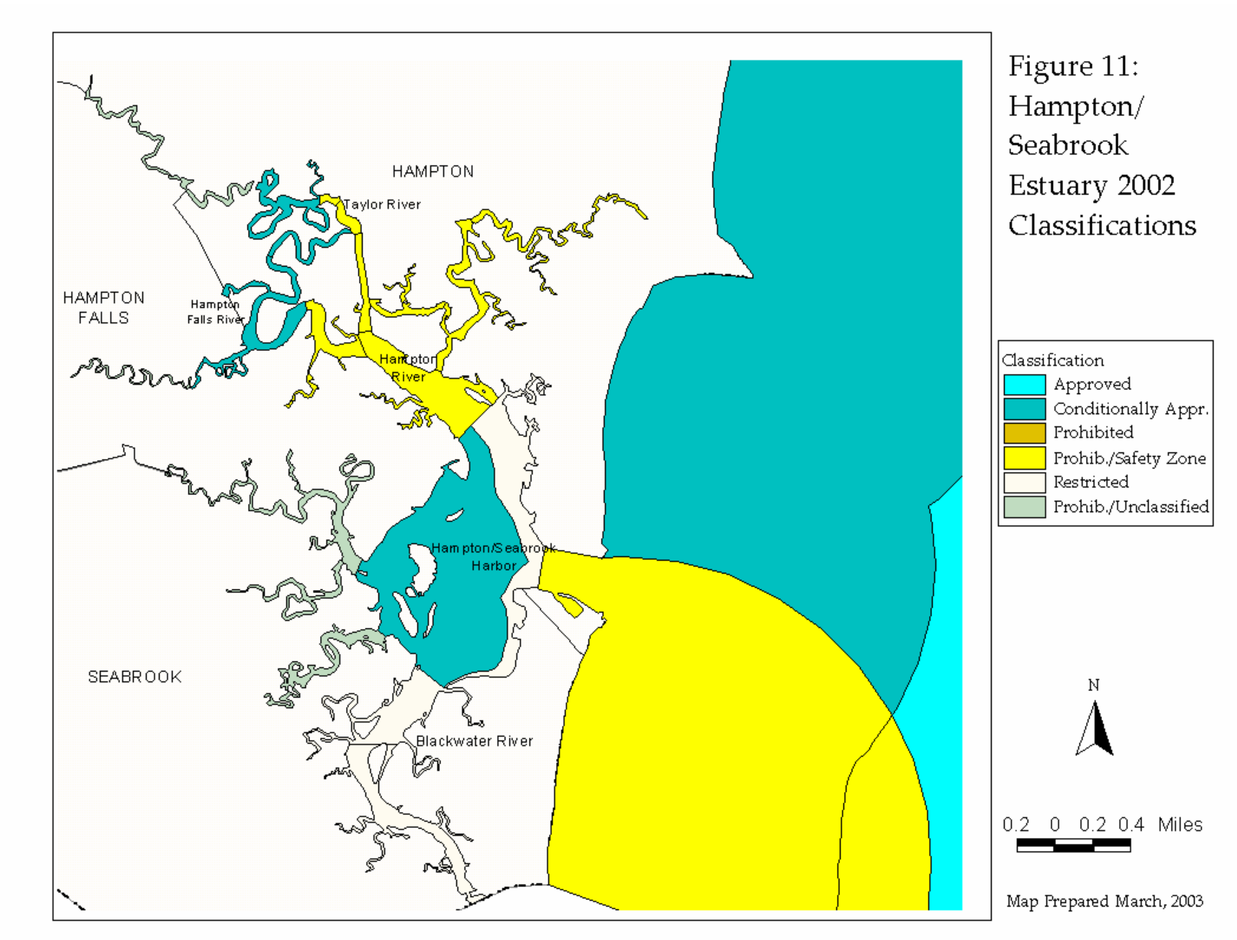
Table 4: Classification of growing areas in Hampton/Seabrook Harbor in 2002

Classification	Area	Location
Conditionally Approved	474 acres	Central harbor around Middle Ground, Common Island, and Confluence flats; portions of Hampton Falls River and Taylor River.
Prohibited/Safety Zone	208 acres	Hampton River and tributaries; portions of Hampton Falls River and Taylor River; Tide Mill Creek
Prohibited/Unclassified	101 acres	Browns River, Hampton Falls River, Hunts Island Creek, Mill Creek
Restricted	264 acres	Blackwater River, buffer between Harbor and Hampton Beach development.
Total	1,047 acres	

Source: DES Shellfish Program
Note: Table does not contain the tidal portion of the Taylor River upstream of the railroad bridge.

The following map illustrates which portions of Hampton/Seabrook Harbor are classified in the different categories.

Figure 4: Shellfishing Classifications for Hampton/Seabrook Harbor in 2002



Source: DES Shellfish Program

The "conditionally approved" classification for the central harbor area and the upper reaches of the Hampton Falls and Taylor rivers means that these areas are open during dry weather but closed after a rainfall of a specified magnitude for the period of November through May. The current rainfall closure threshold is 0.25 inches. Depending on the weather in a given year, the clam flats are closed due to rainfall for 40-70 percent of the weekends available for harvest.

The "prohibited/safety zone" area covering Hampton River and a portion of its tributaries is closed to shellfishing because this area could be affected by a failure of the Hampton WWTF before managers have time to close the area to harvesting. Designation of such areas is a standard requirement of the NSSP.

The areas classified as "restricted" constitute a buffer between the clam flats and the Hampton Beach development. The Blackwater River to the south is also considered restricted. In restricted areas, shellfish may be harvested only if permitted and subjected to a suitable and effective purification process (typically implemented by commercial operations). But because the area is harvested only by recreational diggers, the “restricted” designation effectively closes the area to all harvesting.

The remaining sections of the harbor are closed to shellfishing because they have not yet been classified.

The flats are closed by the N.H. Fish & Game Department in June, July, and August for resource conservation reasons. DES keeps the flats closed in September and October because the bacteria concentrations are typically elevated even though there tends to be little rainfall during this period. Additionally, a closure of this area during the months of September and October would also be appropriate because of the unacceptably large risk of boat sewage contamination present during this time.

Therefore, although Hampton/Seabrook Harbor is New Hampshire’s major clam resource, the use of this resource is significantly restricted due to bacterial pollution. The central portion of the harbor with the greatest clam resource is closed to shellfishing after nearly every rainfall between November to May, and is closed in September and October due to dry weather impacts. Other areas of the harbor are currently closed throughout the year.

b. Applicable Water Quality Standards and Water Quality Numeric Targets

i. Overview

Water Quality Standards determine the baseline water quality that all surface waters of the State must meet in order to protect their intended uses. They are the "yardstick" for identifying where water quality violations exist and for determining the effectiveness of regulatory pollution control and prevention programs. The standards are composed of three parts: classification, criteria, and antidegradation regulations.

Classification of surface waters is accomplished by state legislation under the authority of RSA 485-A:9 and RSA 485-A:10. By definition, (RSA 485-A:2, XIV), "surface waters of the state means streams, lakes, ponds, and tidal waters within the jurisdiction of the state, including all streams, lakes, or ponds, bordering on the state, marshes, water courses and other bodies of water, natural or artificial."

All State surface waters are either classified as Class A or Class B, with the majority of waters being Class B. DES maintains a list which includes a narrative description of all the legislative classified waters. Designated uses for each classification may be found in State statute RSA 485-A:8 and are summarized below.

Classification	Designated Uses
Class A -	These are generally of the highest quality and are considered potentially usable for water supply after adequate treatment.

Discharge of sewage or wastes is prohibited to waters of this classification.

Class B - Of the second highest quality, these waters are considered acceptable for fishing, swimming and other recreational purposes, and, after adequate treatment, for use as water supplies.

Tidal waters, such as in Hampton/Seabrook Harbor, are Class B waters.

DES has developed a Comprehensive Assessment and Listing Methodology (DES, 2002c) in which the specific designated uses for New Hampshire waters have been defined as shown in the following table.

Table 5: Designated uses for New Hampshire waters

Designated Use	DES Definition	Applicability
Aquatic Life	Waters that provide suitable chemical and physical conditions for supporting a balanced, integrated and adaptive community of aquatic organisms.	All surface waters
Fish Consumption	Waters that support fish free from contamination at levels that pose a human health risk to consumers.	All surface waters
Shellfish Consumption	Waters that support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers	All tidal surface waters
Drinking Water Supply	Waters that with conventional treatment will be suitable for human intake and meet state/federal drinking water regulations.	All fresh surface waters
Primary Contact Recreation (i.e. swimming)	Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water	All surface waters
Secondary Contact Recreation	Waters that support recreational uses that involve minor contact with the water.	All surface waters
Wildlife	Waters that provide suitable physical and chemical conditions in the water and the riparian corridor to support wildlife as well as aquatic life.	All surface waters

The second major component of the water quality standards is the "criteria." These are numerical or narrative criteria which define the water quality requirements for Class A or Class B waters. Criteria assigned to each classification are designed to protect the legislative designated uses for each classification. A waterbody that meets the criteria for its assigned classification is considered to meet its intended use. Water quality criteria for each classification may be found in RSA 485-A:8, I-V and in the State of New Hampshire Surface Water Quality Regulations (Env-Ws 1700).

The third component of water quality standards are antidegradation provisions which are designed to preserve and protect the existing beneficial uses of the State's surface waters and to limit the degradation allowed in receiving waters. Antidegradation regulations are included in Part Env-Ws 1708 of the New Hampshire Surface Water Quality Regulations. According to Env-Ws 1708.02, antidegradation applies to the following:

* All new or increased activity, including point and nonpoint source discharges of pollutants that would lower water quality or affect the existing or designated uses.
* A proposed increase in loadings to a waterbody when the proposal is associated with existing activities.
* An increase in flow alteration over an existing alteration.
* All hydrologic modifications, such as dam construction and water withdrawals.

ii. Water Quality Standards Most Applicable to Pollutant of Concern

There are three designated uses for tidal waters that are relevant to bacteria pollution: shellfishing, primary contact recreation, and secondary contact recreation (e.g., boating). The water quality standards applicable to these three designated uses are provided below.

The water quality standards for shellfishing waters are the NSSP standards for "approved" shellfish harvesting areas: a geometric mean for fecal coliforms of less than 14 MPN/100ml and a 90th percentile of less than 43 MPN/100ml as determined using NSSP protocols (RSA 485-A:8, V; ISSC, 1999). The NSSP guidelines include other factors besides attainment of these standards for growing area classifications (e.g., completion of sanitary surveys).

The water quality standards for primary contact recreation are: tidal waters used for swimming purposes shall contain not more than either the geometric mean based on at least three samples obtained over a 60 day period of 35 enterococci per 100 mL, or greater than 104 enterococci per 100 mL in any one sample, unless naturally occurring (RSA 485-A:8, V).

There are no water quality standards for secondary contact recreation. However, for the purposes of determining impaired waters for the 305b/303d lists, DES uses enterococci concentrations greater than five times the primary contact recreation standards to determine secondary contact recreation use support (DES, 2002c).

iii. Targeted Water Quality Goals

The goal for this TMDL is for the bacteria concentrations throughout Hampton/Seabrook Harbor to meet all the water quality standards for all the designated uses affected by bacteria pollution: shellfishing, primary contact recreation, and secondary contact recreation. Of these three designated uses, the water quality standards for shellfishing are the most stringent. Therefore, the targeted goal for this TMDL is for the water quality in Hampton/Seabrook Harbor to meet both aspects of the NSSP shellfishing standard (geomean and 90th percentile concentrations) as measured in accordance with NSSP protocols. It is expected that bacteria loading reductions needed to meet the NSSP standards will also cause primary and secondary contact recreation standards to be met. Follow-up monitoring, discussed in Section 6(b)(ii), will include measurements of both fecal coliforms and enterococci so that the water quality standards for all the designated uses can be assessed.

3.

Hampton/Seabrook Harbor Receiving Water Quality Characterization

Data from the DES Shellfish Program monitoring program from 1993-2002 were used to characterize the baseline concentrations of fecal coliforms (FC) in Hampton/Seabrook Harbor. Fecal coliform measurements were compiled from the ten stations that surround and overlay the major clam flats in the harbor (see Figure 5 from the QAPP in Appendix A). Data from June, July, and August were excluded because the clam flats are closed by NHF&G during this period for resource conservation reasons. Only low tide samples (from three hours before low tide to 0.5 hours after low tide) were used because most of the samples collected during this period were from this tide stage. The FC results from the DES Shellfish Program are expressed as "most probable number per 100ml (MPN/100ml)." The precipitation value for each sample is the precipitation recorded at Seabrook Station on the day of sample collection (if the storm occurred before the sample was collected) plus the total precipitation recorded during the preceding three days. All data used for these calculations have passed the QA protocols of the DES Shellfish Program.

In addition to the fecal coliform data from the DES Shellfish Program, information on the results of two microbial source tracking studies and measurements of enterococci concentrations at the harbor stations are also presented in Sections 3(e) and 3(f), respectively.

a. Representativeness of Water Quality Stations

The Hampton/Seabrook Harbor study area consists of three different environments: the central harbor area where the main clam flats are located, the tidal tributaries flowing into the central harbor area, and the shoreline area between the developed portions of Hampton and Seabrook and the central harbor area. The NSSP stations are representative of the central harbor area where most people harvest shellfish because the stations are located around the perimeter of this area and are between any sources and this area. NSSP stations are also located at the points where tidal tributaries merge with the central harbor. For tidal river systems, the instream sampling locations are considered representative of river water quality because mixing carries bacteria past the sampling point with little time for die off. (In fact, the central harbor area also resembles a tidal river at low tide because it becomes a series of channels with the stations located in the middle of them.) Therefore, the only portion of the study area where the representativeness of the NSSP stations may be in question is the shoreline area between the developed portions of Hampton and Seabrook and the central harbor area. Most of the discrete stormwater pipes and all the marinas are located in this area so there is the potential for higher bacteria concentrations near the shore than out in the harbor. However, in accordance with NSSP guidance, this area is classified as "restricted" for shellfishing as a precaution against releases from the marinas. A restricted classification requires that any shellfish harvested in these areas be purified, which is typically only implemented by commercial operations. But because the area is harvested only by recreational diggers, the restricted designation effectively closes the area to all harvesting.

NSSP stations were established in certain locations to serve one of three purposes: (1) monitor the effect of known pollution source; (2) justify a boundary between two different classifications; or (3) monitor ambient water quality. The DES Shellfish Program monitors these stations using a "systematic random sampling design" in accordance with NSSP protocols.

Specifically, approximately eight to ten sampling dates during the open season (September to May) are chosen in advance for each station. While these dates are not chosen at random, the weather patterns are random so the samples are effectively randomized across a range of possible weather conditions.

Therefore, the NSSP stations in Hampton/Seabrook Harbor should be considered representative of all areas except for near the shoreline of the developed areas of Hampton and Seabrook. However, in accordance with NSSP guidance, recreational shellfishing will always be prohibited in these near shore areas, regardless of water quality, because of the proximity of potential pollution sources. Consequently, exposure to bacteria via eating shellfish from this area should not occur. In certain areas where parking lots and other public places are near stormwater drains, there is the potential for public health risks from exposure to high bacteria concentrations in stormwater. DES does not have any measurements of enterococci concentrations in stormwater samples to evaluate the significance of this risk. The follow-up monitoring plan for this TMDL (Section 6(b)(ii)) includes some enterococci monitoring at easily accessible pipes to evaluate this exposure pathway. As discussed in Section 2(b)(iii), the goal for this TMDL is to meet bacteria water quality standards for shellfishing as well as primary and secondary contact recreation throughout Hampton/Seabrook Harbor. However, the targeted goal is attainment of shellfishing standards since these are the most stringent bacteria standards of the three designated uses.

b. Methods for Geometric Mean Fecal Coliform Calculations

For the NSSP, the geomean concentration is simply the geometric mean of the most recent 30 routine samples. Routine samples are collected using a systematic random sampling design so that these samples are representative of the conditions in the harbor. The DES Shellfish Program database contains 977 routine samples from the harbor stations over the past 10 years. In addition, the DES Shellfish Program has conducted many sampling runs targeted at specific conditions of interest, particularly wet weather events and autumn dry weather events. This work added an additional 694 samples to the database. More importantly, the sampling targeted at wet weather events has produced a sizeable collection of measurements during different size storms which is important for estimating the effect of different size storms on the harbor water quality. Therefore, rather than excluding the non-routine samples from the geomean calculation (as would be required under NSSP protocols), a weighted geometric mean (WGM) will be calculated using all the data in the DES Shellfish Program database with weighting factors to prevent bias due to the overabundance of wet weather samples.

For the WGM calculation, geometric mean concentrations were determined for each station for groups of samples collected after different size rainfalls. These geometric mean FC concentrations were combined through a weighted average based on the percentage of the year for which each size rainstorm typically occurs. The equation of the WGM calculation is:

$$WGM = \sum_i f_i \cdot GM_i$$

where:
WGM = Weighted Geometric Mean (MPN/100ml)
f_i = frequency of days per year between September and May of stormsize *i*.

GM_i = Geomean FC concentration for stormsize i.

A ten year record of rainfall for Portsmouth (1992-2001) was used determine the frequency of different storm sizes. Snowfall events were removed from this dataset so the frequencies only reflect liquid precipitation. After a rainstorm, elevated concentrations typically persist in the harbor for three days due to continued bacteria loading from the watershed (DPHS, 1994). Therefore, the frequency of days when the water quality in the harbor reflects wet weather conditions was calculated by multiplying the number of storm events per year by three. While three days was the typical amount of time that the poor water quality lasted, the duration of poor water quality was highly variable. Some large storms cause closures for four or more days, while the bacteria concentrations return to normal within one or two days for others. How long the high bacteria concentrations actually last depend on the amount of rainfall, the storm duration, the rate at which bacteria loads pass through the watershed, and the timing of the storm relative to the tidal cycle. For this TMDL report, three days was an approximation of the duration of water quality impairments for modeling purposes.

The number of rainfall events and their frequencies are summarized in the following table. The frequencies in the last column of this table were used for the f_i values in the WGM calculation.

Table 6: Frequency of rainstorms during September through May in Hampton/Seabrook Harbor

Storm Size Class	Average Number of Storms/Year	Average Number of Days Affected	Average Fraction of Year Affected
Dry	NA	152	0.553
0.01-0.10	9.5	28.5	0.104
0.11-0.25	5.1	15.3	0.056
0.26-0.50	7.5	22.5	0.082
0.51-0.75	5.7	17.1	0.062
0.76-1.00	4.3	12.9	0.047
1.01-2.00	6.5	19.5	0.071
>2.00	2.4	7.2	0.026

Data source: Daily precipitation records for Portsmouth, NH.

c. Methods for 90th Percentile Fecal Coliform Calculations

The second component of the NSSP standard is the 90th percentile fecal coliform concentration. NSSP protocols call for the 90th percentile concentration to be calculated by:

$$90th\%ile = 10^{(x+1.28 \cdot s_x)}$$

where
90th%ile = the 90th percentile FC concentration
x = the mean value of log transformed FC concentrations (base 10)
s_x = the standard deviation of the log transformed FC concentrations (base 10)

This equation was used to estimate the 90th percentile concentrations for the TMDL. However, implicit in this equation is the assumption that the FC data used to calculate x and s_x are a random sample of the water quality in the harbor. Therefore, only data collected during the routine (systematic random) sampling program can be used to estimate the 90th percentile concentrations. The samples were not split into different storm sizes because the 90th percentile concentration is based on the distribution of FC concentrations under all conditions.

d. Hampton/Seabrook Harbor Water Quality Statistics

The following table summarizes the WGM and 90th percentile FC concentrations for the ten harbor stations. These statistics were calculated using the methods described in the previous sections.

Table 7: Characterization of Fecal Coliform Concentrations in Hampton/Seabrook Harbor

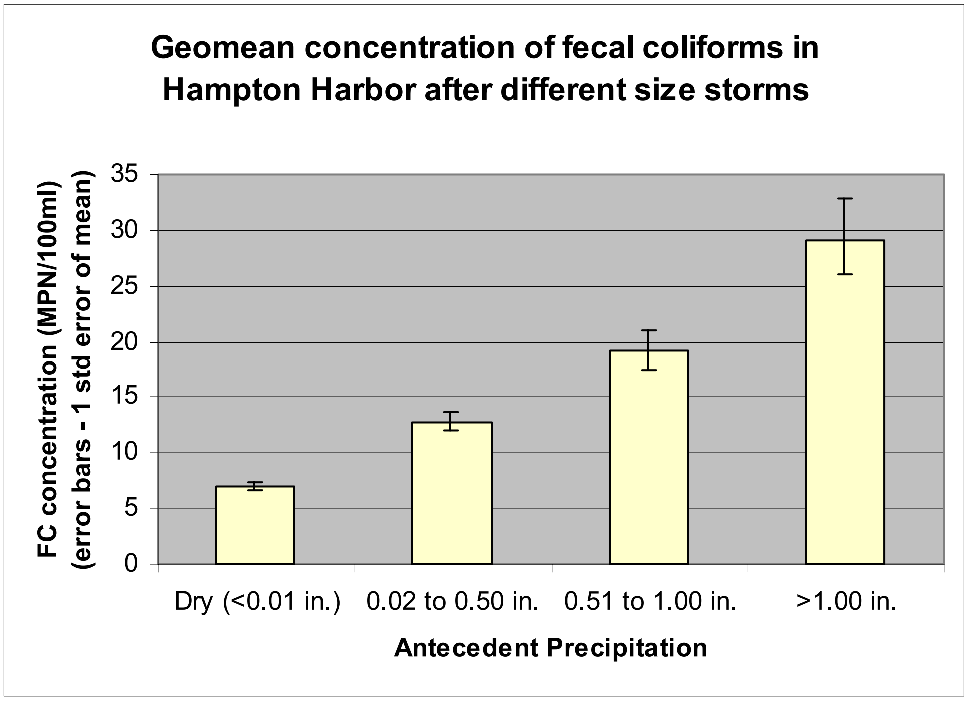
Station	Weighted Geomean (MPN/100ml)	90th %ile Concentration (MPN/100ml)
HH10	12	48
HH11	11	53
HH12	13	79
HH17	13	78
HH18	10	40
HH19	17	109
HH1A	14	75
HH2B	13	69
HH5B	13	58
HH5C	14	44
Average	**13**	**65**
NSSP Standard	**14**	**43**

Data Source: DES Shellfish Program, records from 1993-2002

These statistics illustrate that the weighted geomean concentrations are close to the water quality standard but that the 90th percentile concentrations are consistently higher than the standard. High 90th percentile concentrations indicate unacceptably high variability in FC due to periodic spikes, as opposed to chronically poor water quality. The most obvious source of periodic loading spikes is wet weather runoff. Another possible episodic source is boat discharge. The only portion of the estuary where the geomean standard is not met is the mouth of Mill Creek (HH19) which may indicate a chronic source of bacteria from this tributary.

The following figures illustrate the effect of wet weather runoff on FC concentrations in the harbor. In Figure 5, the geomean FC concentrations during different size storms are shown to increase steadily with increasing rainfall amount.

Figure 5: Geomean concentration of fecal coliforms in Hampton/Seabrook Harbor after different size storms



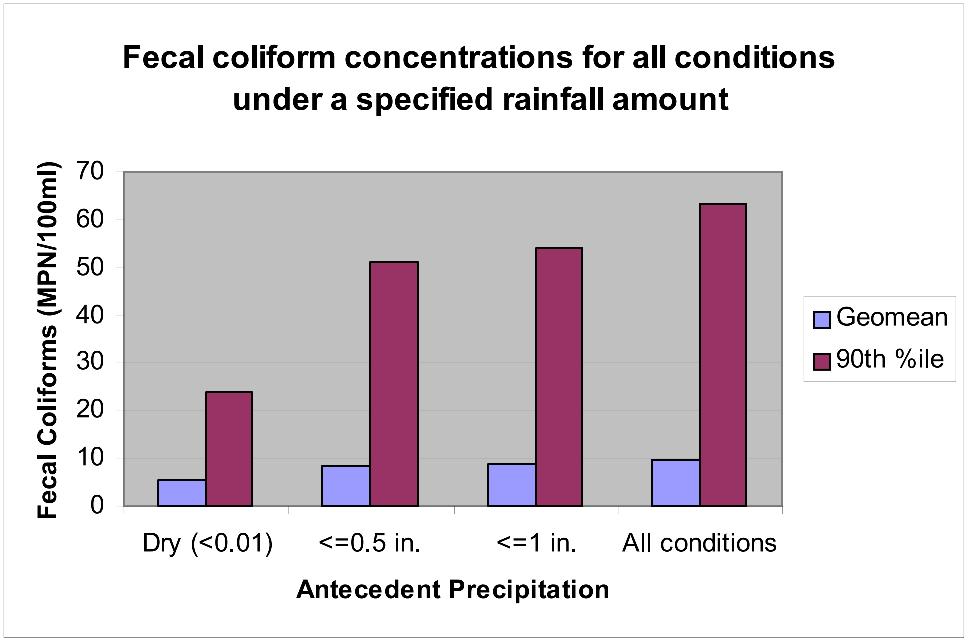
Data Source: DES Shellfish Program, 1993-2002, all low tide data, September to May

The elevated FC concentrations during wet weather events cause the geomean and 90th percentile concentration to increase as larger storms are included in the statistic calculation. To illustrate this, the geomean and 90th percentile FC concentrations were calculated for subsets of the routine samples:

- Only samples collected with antecedent precipitation <0.01 inches (n=437)
- Only samples collected with antecedent precipitation ≤0.50 inches (n=746)
- Only samples collected with antecedent precipitation ≤1 inches (n=873)
- All routine samples (n=977)

The following figure illustrates how the 90th percentile statistic increases more rapidly than the geomean statistic as more samples from larger rainfall events are added to the calculation.

Figure 6: Fecal coliform concentrations for all conditions under a specified rainfall amount



While wet weather loads are clearly important, a persistent trend of unacceptably high FC concentrations during dry weather in the autumn has also been noted by the DES Shellfish Program (DES, 2002a). The following table illustrates how geomean and 90th percentile FC concentrations during dry weather are much higher during the September-October period compared to the rest of the year.

Table 8: Yearly and autumn dry weather FC concentrations

Period	Sample Size	Geomean (MPN/100ml)	90th %ile (MPN/100ml)
September through May	437	5.56	24.05
September and October	97	16.87	80.77
November through May	340	4.05	12.80

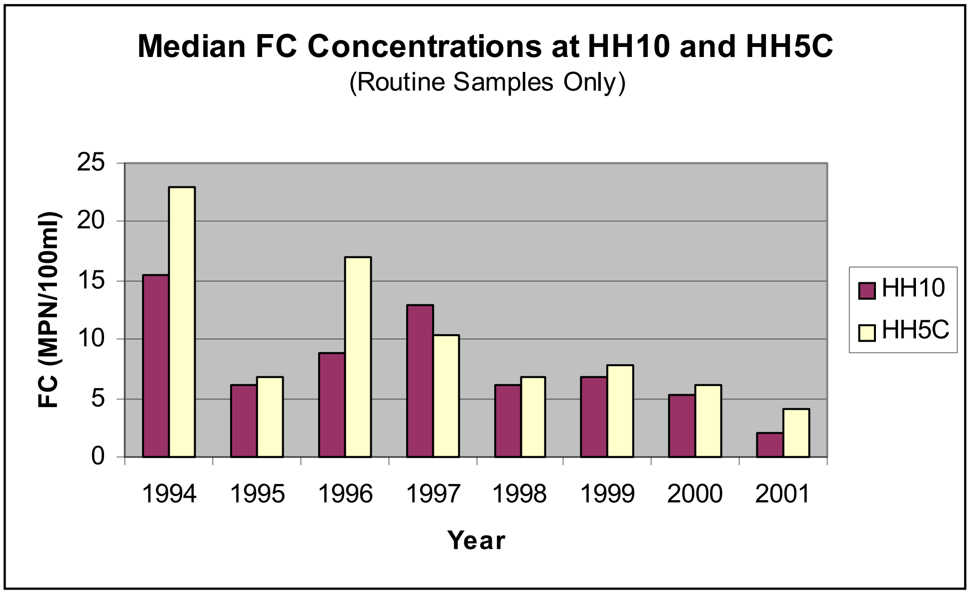
Data Source: DES Shellfish Program, 1993-2002, low tide, routine samples

The DES Shellfish Program keeps the clam flats closed in September and October due to these elevated FC concentrations and the unacceptably high risk of boat sewage contamination during this time.

e. Water Quality Trends

Trends in FC concentrations over time were assessed using the nonparametric Mann-Kendall Test on the yearly median FC concentrations. The yearly medians from 1994 through 2001 were used for this assessment because at least 5 routine samples were collected from each station during each of these years. Eight of the ten stations exhibited no significant trend. At HH10 and HH5C, downward trends were statistically significant at $p<0.1$ level. Figure 7 illustrates the trends in median FC concentrations at these two stations.

Figure 7: Median FC concentrations at HH10 and HH5C, 1994-2001



Based on this trend analysis, there do not appear to be any global trends in FC concentrations in Hampton/Seabrook Harbor over the past ten years. In the Hampton River (where HH10 and HH5C are located), there is evidence for a local trend of decreasing concentrations.

f. Microbial Source Tracking Results

Source species for *Escherichia coli* strains in Hampton/Seabrook Harbor were identified using a genetic fingerprinting technique called ribotyping. Ten sampling stations were monitored at least every two weeks from September 2000 through October 2001. Ribotyping analyses matched 60 percent of the ribotypes for *E. coli* isolates found in the water samples to the ribotypes for strains housed in the source species database at the University of New Hampshire. Sixty percent of the isolates were matched, with 15 percent identified as wildlife sources, 7 percent as avian sources, 26 percent as human sources, 4 percent as pets and the remaining 8 percent as livestock.

The ribotyping analyses showed that roughly one-quarter of the sources were wild animal sources (wildlife and avian) during both wet and dry weather conditions. These data show that the percentage of *E. coli* isolate types found in the harbor are relatively consistent with regard to weather conditions (Table 9). The combined wildlife and avian types were identified in 21 percent and 24 percent of the isolates during wet and dry weather, respectively.

Table 9: Relative percent of source species for E. coli strains in Hampton/Seabrook Harbor for various weather conditions: 2000-2001

Source Species	All weather	Wet weather	Dry weather	Autumn Dry weather
Wildlife	15%	14%	17%	14%
Avian	7%	7%	7%	8%
Human	26%	26%	26%	27%
Pets	4%	2%	5%	4%
Livestock	8%	7%	9%	8%
Unidentified	40%	43%	36%	39%

Data Source: UNH/DES Ribotyping Project (Jones and Landry, 2003)

As discussed above, 40 percent of the ribotypes for isolates were not matched to known source species strains. This deficiency makes it difficult to draw firm conclusions about the relative proportions of different bacteria sources to the harbor. The percent of strains from human-related sources (human, pets, livestock) could be between 38 percent (if none of the unmatched strains were from human related sources) and 78 percent (if all the unmatched strains were from human related sources). Likewise for wild animal sources, the relative percent of strains could range from 22 percent (if none of the unmatched strains were from wildlife or avian sources) to 62 percent (if all of the unmatched strains were from wildlife or avian sources). The ranges shown above represent extremes because it is unlikely that all of the unmatched strains would be just human-related or just wild animal related. In reality, the relative proportions of the human-related and wild animal sources will probably be toward the middle their possible ranges. Therefore, in the absence of more information, it will be assumed that the ratio of human-related sources to wild animal sources is approximately 60:40.

DES collected samples from two stormwater sources for ribotyping analysis during the TMDL study. One of the pipes chosen for this study was HHPS069 which is in Hampton, and drains multiple catch basins along Ashworth Avenue. The other source was HHPS182 which receives stormwater from the River Street pump station in Seabrook. Five samples from each source were collected at hourly intervals during a large rainstorm on October 16, 2002. The results from these samples are shown in the following table.

Table 10: Relative percent of source species for E. coli strains in stormwater from two stormwater pipes, 2002

Source Species	HHPS069	HHPS182	Both Pipes
Wildlife	13%	17%	15%
Avian	46%	29%	36%
Human	13%	26%	20%
Pets	4%	9%	7%
Livestock	0%	0%	0%
Unidentified	25%	20%	22%

Data Source: UNH/DES Ribotyping Project (Jones, 2003)

At both pipes, birds were the largest relative source of bacteria, followed by humans and wildlife. Human related sources (human, pets, livestock) accounted for 17 percent and 35 percent of the isolates in HHPS069 and HHPS182, respectively. These results differ from the relative source strengths determined from the samples collected in the harbor. However, the harbor results are based on sampling data collected throughout the year at ten stations. The data for the pipes is from two pipes sampled during one storm. The relative distribution of sources for the pipes may change during the year due to large changes in the population of the beach areas during the summer. Therefore, the data from the harbor study should be more representative of the cumulative bacteria pollution to the harbor. The data from the two pipes is still useful for designing remediation plans for these two sources and, importantly, for identifying the presence of human-sourced bacteria in stormwater.

g. Water Quality Relative to Swimming Standards

During 2001, four stations in central portion of Hampton/Seabrook Harbor were monitored for enterococci monthly between May and September. The data from these samples are shown in the following table.

Table 11: Enterococci data for Hampton/Seabrook Harbor, 2001

Station	Date	Enterococci (cts/100ml)	Geomean* (cts/100ml)	Comments
HH10	5/21/2001	4		
HH10	6/12/2001	30	6.2	
HH10	7/16/2001	2		
HH10	8/23/2001	50		
HH10	9/25/2001	10		Ave of dupes (10 and <10)
HH19	5/21/2001	1		
HH19	6/12/2001	240	9.0	
HH19	7/16/2001	3		
HH19	8/23/2001	60		
HH19	9/25/2001	10		
HH1A	5/21/2001	5		
HH1A	6/12/2001	20	4.6	
HH1A	7/16/2001	1		
HH1A	8/23/2001	40		
HH1A	9/25/2001	10		
HH2B	5/21/2001	10		
HH2B	6/12/2001	80	4.3	
HH2B	7/16/2001	0.1		Result was 0 but set to 0.1 to allow for geomean calc.
HH2B	8/23/2001	40		
HH2B	9/25/2001	10		

Shaded cells denote >104/100ml single sample standard or >35/100ml 60-day geomean standard.
* Geomean of the 3 samples collected within the 60 day period between 5/21/01 and 7/16/01at each station.

The results of this monitoring program show that the water quality in the harbor met the water quality standards for swimming (primary contact recreation) during this period. The sample collected from station HH19 on June 12, 2001 was higher than the single sample standard of 104 counts/100ml. However, following the procedure for determining impairments in New Hampshire's Consolidated Assessment and Listing Methodology (DES, 2002c), the frequency of exceedences was too low to consider the waterbody to be impaired for the designated use.

In Section 2(a), it was discussed that two of the 14 assessment units that constitute the harbor are listed as impaired for primary contact recreation (e.g., swimming) on New Hampshire's 2002 303(d) list. However, the primary contact recreation impairments are based on reports of discharges of untreated sewage (e.g., sanitary sewer overflows, wastewater treatment bypasses) in these assessment units. In contrast, as shown in this section, water quality measurements in the harbor indicate that State standards for swimming are being met.

4.

Source Characterization

a. Existing Point Source Loads

Point source discharges include discernible, confined, and discrete conveyances such as the discharge from the effluent pipes of wastewater treatment plants. In addition, discrete stormwater discharges from municipal separate storm sewer systems (MS4) covered by the Phase II stormwater program regulations are considered point sources for this TMDL (EPA, 2002b). All point source discharges must have a State Surface Water Discharge permit and a federal National Pollutant Discharge Elimination System (NPDES) discharge permit.

i. Wastewater Discharges

The only significant bacteria point source discharging to Hampton/Seabrook Harbor is the Hampton municipal wastewater treatment facility (WWTF). There are two other permitted sources for bacteria discharges to the estuary, EnviroSystems, Inc. (NPDES # NH0022055) and Aquatic Research Organisms, Inc. (NPDES # NH0022985), but their discharges are negligible.

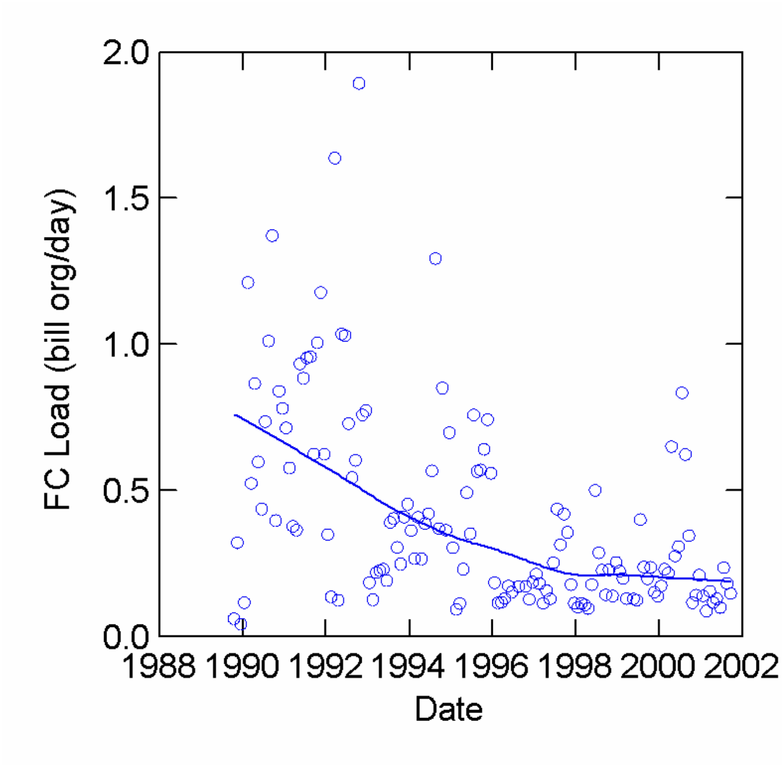
Bacteria loads from the Hampton WWTF were estimated using Discharge Monitoring Reports from 1989 to 2001 that reported total coliform concentration in the effluent and the average effluent discharge rate for each month. The geometric mean loading rate from the facility is 0.3 billion fecal coliform organisms per day (bill org/day). The fecal coliform loading rate was estimated from the total coliform data by assuming that 20 percent of total coliform bacteria are fecal coliforms. This assumption is based on the ratio between the fecal coliform and total coliform NSSP geomean standards (14 MPN/100ml for FC, 70 MPN/100ml for TC). Moreover, TC to FC ratios from effluent sampling at other WWTFs support this conversion factor. The Dover WWTF and Durham WWTF recently switched from measuring total coliforms in effluent samples to fecal coliforms. The ratio of the median TC concentration before the switch to the median FC concentration after the switch ranged from 16-26 percent for these two plants.

The following figure illustrates the trend in bacteria loading from the Hampton WWTF. Over the period of 1989-2001, the loading has decreased by 91 percent. Most of the decrease was due to decreasing bacteria concentrations in the effluent, not decreasing flows (NHEP, 2002b).

According to its permit for 2002-2006, the Hampton WWTF is permitted to discharge effluent with a monthly average FC concentration of 14 MPN/100ml and a daily maximum FC concentration of 43 MPN/100ml (EPA, 2002). The design flow for the facility is 4.7 million gallons per day (EPA/DES, 2002), although the largest possible flow through the plant is actually less than this amount due to the nitrification process (Stephanie Larson, DES, *pers. com.*). Therefore, under the existing permit, the WWTF can discharge a maximum of 7.7 billion organisms per day.

Estimates of bacteria loads from the Hampton WWTF are based on measurements of bacteria in treated effluent from discharge monitoring reports. The loading estimate does not take into account loadings from the plant due to emergency bypasses of untreated or partially treated wastewater during storm events or other temporary system failures.

Figure 8: Fecal coliform load from the Hampton WWTF, 1990-2002



ii. Stormwater Discharges from Phase II MS4 Systems

The towns of Hampton and Seabrook are covered by the EPA Phase II stormwater program regulations. Therefore, stormwater discharges from discrete pipes and conveyances in these towns are considered point sources for this TMDL. Over 100 pipes, streams, creeks, and conveyances of stormwater have been identified around Hampton/Seabrook Harbor by the DES Shellfish Program and the DES Watershed Assistance Section. During 2002, DES selected the 16 stormwater sources most likely to be large contributors of bacteria to the harbor and monitored them for bacteria loads during two storms. The locations of the monitored stormdrains are shown in Appendix A.

Bacteria loads from the 16 sources were monitored during two storms. The first storm on July 23, 2002 was a short, but intense rainstorm that dropped 0.33 inches of precipitation over four hours. The second storm on October 16, 2002 was a classic Nor'easter with soaking rain and high winds lasting over 12 hours. A total of 1.39 inches of rain fell during the second storm. Total precipitation during the two storms was taken from Seabrook Station precipitation records. Since these two storms were so different, the monitoring results from each day are assumed to bracket the range of possible loadings.

The results of the study are shown below in Table 12 containing the average fecal coliform concentration in stormwater and Table 13 containing the loading values for each source during the two storms. For more information on the individual stormdrains and the methods used to collect the stormwater samples and calculate the loads, refer to the QA Project Plan for the study

(DES, 2002b). Summary tables of the FC concentrations, flow data, and any additional methods not covered by the QA Project Plan are included in Appendix B (DES, 2003a). Appendix C contains an audit of the sampling and data handling procedures by the Project Manager. The Project QA Officer's concurrence report in attached as Appendix D.

Table 12: Average concentrations of fecal coliforms in stormwater samples from MS4 stormdrains on July 23, 2002, October 16, 2002, and October 17, 2002

Date	7/23/2002		10/16/2002		10/17/2002	
Precip	0.33 in		1.39 in		NA	
Units	(cfu/100ml)	(#)	(cfu/100ml)	(#)	(cfu/100ml)	(#)
HHPS015	1,500	n=4	2,820	n=5	700	n=1
HHPS016	1,675	n=4	4,000	n=5	2,000	n=1
HHPS055	100	n=4	2,920	n=5	No Data	NA
HHPS056	600	n=4	2,120	n=5	No Data	NA
HHPS057	No Data	NA	50	n=1	No Data	NA
HHPS061	No Data	NA	13,560	n=5	No Data	NA
HHPS062	No Data	NA	6,020	n=5	No Data	NA
HHPS063	150	n=2	4,540	n=5	No Data	NA
HHPS066	7,062	n=6	11,600	n=8	No Data	NA
HHPS067	9,450	n=4	14,150	n=6	No Data	NA
HHPS068	4,900	n=6	2,900	n=8	No Data	NA
HHPS069	4,500	n=6	8,763	n=8	No Data	NA
HHPS070	725	n=4	7,180	n=5	No Data	NA
HHPS071	1,267	n=3	1,968	n=5	No Data	NA
HHPS072	5,933	n=3	2,950	n=4	No Data	NA
HHPS182	5,375	n=4	8,600	n=5	No Data	NA
Average for Hampton Beach stormdrains (2)	3,469		6,055			

(1) Results reported as "below detection limit" were assigned a value of the detection limit to calculate the average.
(2) Hampton Beach stormdrains are all the sources on this table except HHPS015, HHPS016, and HHPS182.

Table 13: Summary of bacteria loads from stormdrain sources monitored in 2002

Source	Pipe Diameter	Bacteria Load (7/23/02) 0.33 inch rain	Bacteria Load (10/16/02) 1.39 inch rain	Percent of Total Load (7/23/02)	Percent of Total Load (10/16/02)	Comments
	(in)	(bill org)	(bill org)	(%)	(%)	
HHPS061	20	no info	0.0		0%	No Flow
HHPS062	10	no info	4.1		1%	
HHPS073	12	no info	0.0		0%	No Flow
HHPS072	18	5.2	7.7	4%	1%	
HHPS071	28	0.6	4.7	0%	1%	
HHPS070	28	0.2	14.7	0%	2%	
HHPS054	12	0.0	0.0	0%	0%	No Flow
HHPS055/056	18/36	0.0	5.0	0%	1%	No flow 7/23
HHPS057	18	0.0	0.0	0%	0%	No Flow
HHPS015	42	1.7	10.8	1%	2%	
HHPS016	60	11.1	138.4	9%	22%	
HHPS066	36	13.9	67.0	12%	11%	
HHPS067	12	1.1	10.0	1%	2%	
HHPS068	36	0.1	24.0	0%	4%	
HHPS069	36	14.2	98.2	12%	16%	
HHPS182	30	71.8	245.7	60%	39%	
Subtotal		**119.8**	**630.3**	**100%**	**100%**	

The results of the DES stormwater sampling show that the loading from monitored stormdrain sources was approximately 120 billion organisms during the storm on July 23, 2002 and 630 billion organisms on October 16, 2002. As a point of reference, the average loading from the Hampton WWTF is 0.3 billion organisms per day and its maximum permitted daily load is 7.7 billion organisms per day. Therefore, during storm events, there can be significant bacteria loads to the harbor from MS4 stormdrains.

b. Existing Non-Point Source Loads

In general, non-point sources (NPS) of pollutants include all pollutant sources other than point sources. Compared to point sources, NPSs of pollution are diffuse and more difficult to quantify. Examples of NPSs include stormwater runoff not conveyed through MS4 systems and diffuse sources such as failed septic systems. In Hampton/Seabrook Harbor, the three major non-point sources are (1) discharges from boats in mooring fields or marinas, (2) dry weather human and wildlife non-point sources, and (3) stormwater runoff (via tributaries or other non-MS4 sources).

i. Marinas/Boats

Many large boats are moored or docked in Hampton/Seabrook Harbor. Releases of untreated sewage from these boats could contribute to the FC concentrations in the harbor. On October 17, 2002, the DES Shellfish Program observed that 52 of the 143 slips at the Hampton River Marina were filled and that 15 boats were present in each of the two mooring fields (Hampton River and Seabrook Harbor). During the summer, the DES Shellfish Program observed that all the slips at the marina were filled on August 14, 2002. The number of boats in the mooring fields in August was not recorded but it will be assumed to be at least twice as many as were present in October (assume 30 boats in each field).

For a programmatic review of the DES Shellfish Program, the US Food and Drug Administration evaluated the Hampton River Marina and estimated that 50 percent of the boats in the slips discharge untreated sewage (USFDA, 2002). In the mooring fields, information from the DES Shellfish Program (Chris Nash, *pers. com.*) indicates that moored boats are mainly commercial vessels and often operate out at sea. Following DES Shellfish Program Classification Policies and Procedures (DES, 2003b), it can be conservatively assumed that only half of these moored boats have marine sanitation devices and only half of these boats would discharge in the harbor. Using these assumptions, the number of discharging boats ranged from 86 in August 2002 to 33 in October 2002 (see Table 14).

Table 14: Boats counts in Hampton/Seabrook Harbor from DES Shellfish Program

Date	Location	Number of Boats	Percent with heads	Percent discharging	Number of boats discharging
8/14/02	H.R. Marina	143	100%	50%	71
	Mooring Fields	60	50%	50%	15
10/17/92	H.R. Marina	52	100%	50%	26
	Mooring Fields	30	50%	50%	7

Following DES Shellfish Program Classification Policies and Procedures (DES, 2003b), the bacteria load from these boats can be estimated by the following equation:

$$FC\ Load = (2\ billion\ organisms/person) \times (2\ persons/boat) \times (Number\ of\ boats\ discharging)$$

Using this equation, an estimate of the bacteria loads from boat discharges would be 132-344 billion organisms per day. The average value (238 billion FC organisms per day) will be used in subsequent calculations as a central tendency estimate.

The assumptions used to arrive at this value are conservative and likely overestimate the load from boat discharges for much of the year, except possibly the fall. During the fall, it is possible that there are more discharges from marine sanitation devices as boats are hauled from the water for winter storage.

ii. Modeled Dry-Weather Non-Point Source Loads

Sources of bacteria to the harbor during dry weather are a combination of human and wildlife/natural processes. Examples of possible dry weather human sources are failing septic systems and illicit discharges of wastewater to the stormwater system. Bird and wild animal waste is an example of a non-human source of bacteria to the harbor during dry weather.

A mass balance model was used to estimate the baseline loading of bacteria to the harbor during dry weather. There are four basic premises of the model:

- During dry weather conditions, the only sources of bacteria to the harbor should be the WWTF, boat discharges, and dry-weather non-point sources (both natural/wildlife and human).
- The largest mechanism to remove bacteria from the harbor is tidal flushing. Eighty-eight percent of the water in the estuary (4.2 billion gallons) is exchanged on each tide and very little of the exported water is drawn back into the estuary on the return tide (NAI, 1977). Therefore, the export of bacteria from the harbor over one tidal cycle will be approximately equal to the tidal prism volume (3.7 billion gallons) multiplied by the average FC concentration.
- The FC concentrations in the harbor are relatively constant during dry weather periods. The majority of the dry weather observations are within one order of magnitude (i.e., 67 percent of the observations are between 2 and 25 MPN/100ml). The DES Shellfish Program has found no significant differences between FC concentrations at high tide and low tide. Therefore, it is possible to assume steady state conditions.
- Since FC concentrations remain constant in the harbor, FC bacteria must be added to the harbor at a rate equal to the removal rate from tidal flushing.

The model predicts the total FC loading that is needed to maintain the constant dry weather FC concentrations in the harbor given the rate of bacteria removal due to tidal flushing. The baseline dry weather loading is the difference between the estimated total load from the model and the estimated loadings from WWTF and boat discharges from the previous sections. The equation for the model is:

Change in Number of Bacteria in Harbor = Sources - Sinks

$$\frac{\Delta(C \cdot V)}{\Delta t} = k_b + k_w + k_d - C \cdot \frac{V_{TP}}{\Delta t} \cdot CF$$

Variable Definitions:
C = concentration of fecal coliform bacteria in the waterbody (MPN/100ml)
V = Estuary volume (gallons)
Δt = time step in increments of whole tidal cycles = 0.52 days
k_b = baseline load of NPS bacteria during dry weather conditions (billion organisms per day)
k_w = WWTF load = 0.3 billion organisms per day
k_d = Load from boat discharges = 238 billion organisms per day
V_{TP} = Tidal exchange volume, equal to the difference between high tide and low tide volumes = 3.7 billion gallons (NAI, 1977)
CF = Conversion factor = 3.785E-08 (100ml*bill org)/(gallon*MPN)

Assuming steady-state conditions ($\Delta CV/\Delta t$=0), this equation reduces to a balance of sources and sinks:

$$Total\_Sources = k_b + k_w + k_d = C \cdot \frac{V_{TP}}{\Delta t} \cdot CF = Total\_Sinks$$

which can be solved for k_b:

$$k_b = -k_w - k_d + C \cdot \frac{V_{TP}}{\Delta t} \cdot CF$$

The geomean concentration of FC in the harbor during dry weather is 7 MPN/100ml based on the 662 available dry weather records in the DES Shellfish Program database. Therefore, the total tidal flushing export of bacteria from the harbor during dry weather must be equal to 1,891 billion organisms per day (k_b= -0.3–238+7*[3.7E+09/0.52]*3.785E-08 = 1891 bill org/day). For steady state to be maintained, the sum of the sources ($k_b + k_w + k_d$) must equal this amount also. Subtracting the estimated loadings for WWTF and boat discharges (0.3 billion org/day and 238 billion org/day), the baseline dry weather NPS loads (k_b) must amount to 1,653 billion org/day.

The baseline dry weather non-point source loads have a combination of human and non-human bacteria sources. The microbial source tracking data presented in Section 3(e) show that the ratio of human-related sources to wild animal sources (wildlife and avian) during dry weather is approximately 60:40. Therefore, the baseline dry weather NPS load can be split into a dry weather human-related source load of 992 billion organisms per day and a dry weather wild animal source load of 661 billion organisms per day.

iii. Stormwater Loads from Tributaries

There are seven major tributaries that drain the watershed around Hampton/Seabrook Harbor (Figure 2). During storms, the flow in these rivers increases as stormwater throughout the watershed is funneled into the harbor. Therefore, the tributaries could be considerable sources of bacteria to the harbor.

To understand the significance of the tributaries as bacteria sources, DES monitored the seven major tributaries to the harbor during two storms in 2002 (DES, 2003a). FC concentrations in each of the tributaries was monitored approximately hourly during two storms. Using a stage discharge relationship, it was possible to estimate flow (and, therefore, load) from one of the tributaries, Mill Creek. This tributary consistently had the highest concentrations of FC. The results of the monitoring are shown in Table 15.

Table 15: Summary of fecal coliform concentrations in wet weather tributary samples (2002)

Tributary	Station	N (7/23/02)	Mean FC Conc. (7/23/02)	FC Load (7/23/02)	N (10/16/02)	Mean FC Conc. (10/16/02)	Conc. (10/17/02) (n=1)	FC Load (10/16/02)
		(#)	(cfu/100ml)	(bill org)	(#)	(cfu/100ml)	(cfu/100ml)	(bill org)
Blackwater River	HHT1	4	50	NA	5	41	40	NA
Mill Creek	HHT2	4	500	9.75	5	412	1960	25.60
Hampton Falls River	HHT4	4	88	NA	5	107	30	NA
Taylor River	HHT5	4	125	NA	5	22	980	NA
Browns River	HH35	3	22	NA	1	10	20	NA
Hampton River	HH15	3	10	NA	1	<10	40	NA
Tide Mill Creek	HHT8	3	67	NA	5	82	30	NA

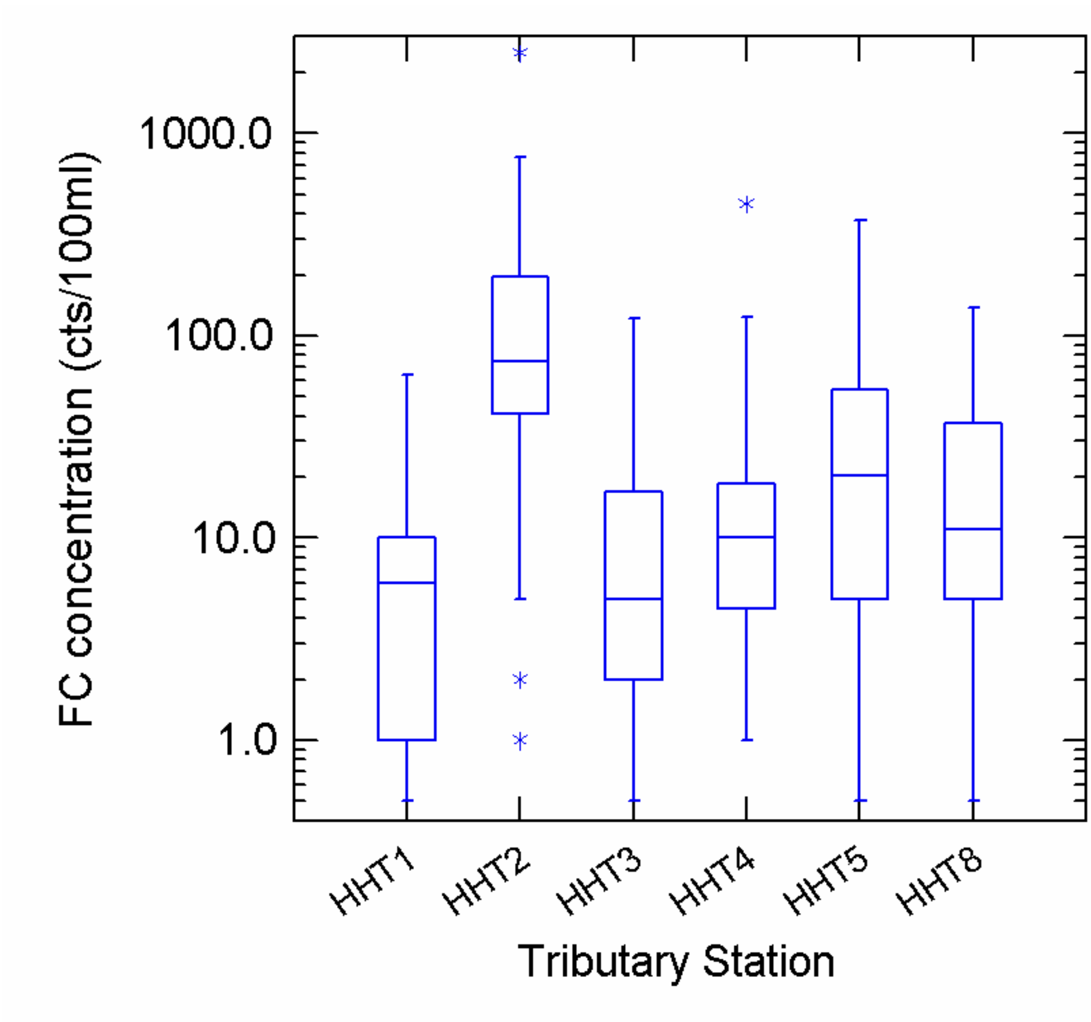
Mean values calculated using 1/2 the method detection limit (MDL) for samples reported as "<MDL" and the value for samples reported as ">value."

The tributary sampling showed that the highest concentrations were in Mill Creek (HHT2). This pattern matches the observation that the highest weighted geomean FC concentration among the harbor stations is at HH19 at the mouth of Mill Creek.

The loading during the two storms from Mill Creek ranged from 10 to 26 billion organisms per day. These loading estimates are probably lower than the actual load from this tributary because the station was only monitored during the storm and runoff from the watershed would have continued for hours or days after the storm. For example, the concentration at HHT2 on the day after the second storm (October 17, 2002) was nearly five times higher than the average concentration measured during the storm on October 16, 2002.

In 2000, the DES Shellfish Program and the U.S. Geological Survey collected 35 samples from five of the stations monitored during the TMDL study (USGS/DES, 2002). The three-day antecedent rainfall for these samples ranged from 0 to 1.26 inches. Figure 9 shows box plots of FC concentration distribution from each station.

Figure 9: Box plots of FC concentrations at tributary stations, 2000

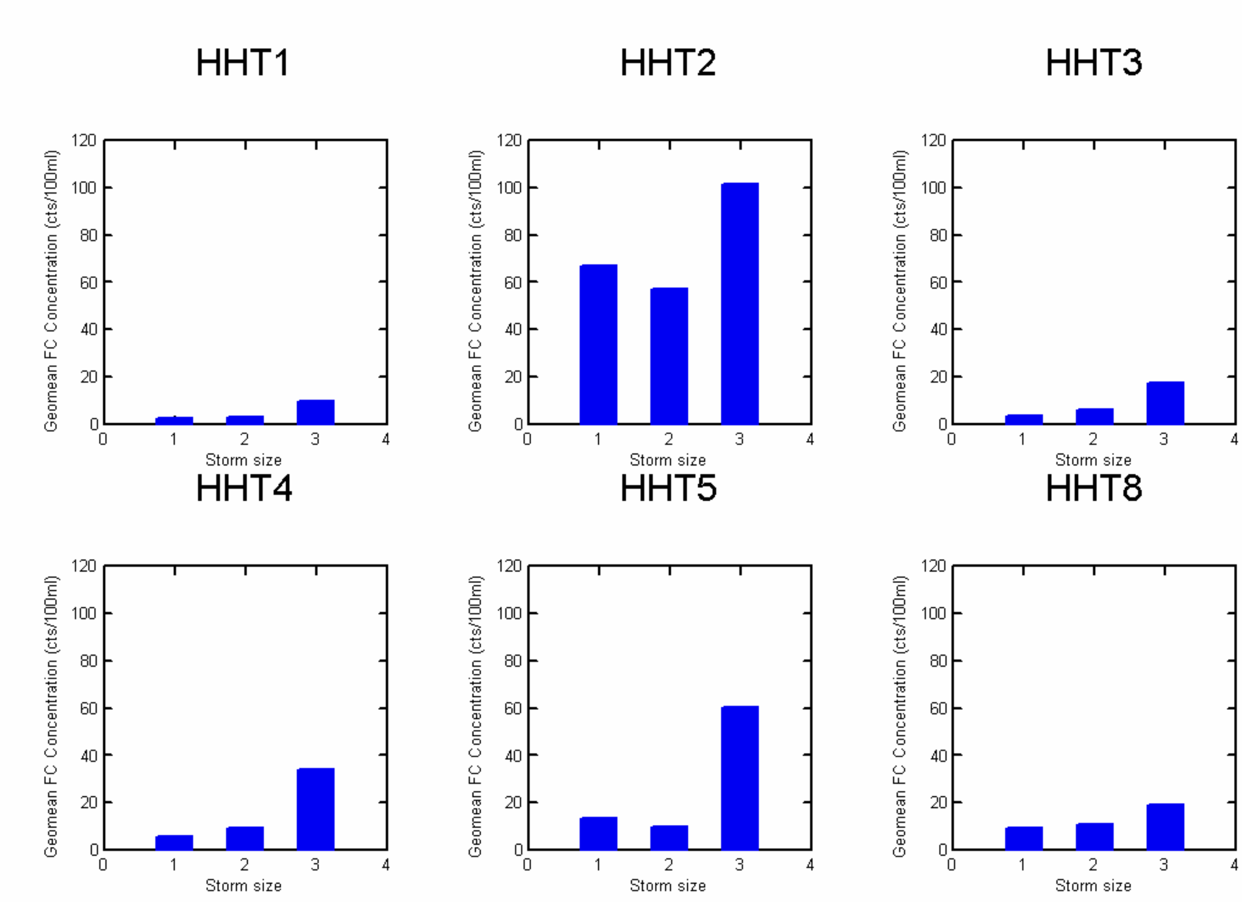


The FC concentrations at each station after different size rainfall events are summarized in the table and figure on the next page.

Table 16: Geomean FC concentration at tributary stations for different size storms, 2000

Station	Dry (<=0.01 in)		0.02 to 0.50 in		>0.50 in		All Conditions	
	N	Geomean (cfu/100ml)	N	Geomean (cfu/100ml)	N	Geomean (cfu/100ml)	N	Geomean (cfu/100ml)
HHT1	14	3	13	3	8	10	35	4
HHT2	14	67	13	57	8	101	35	69
HHT3	14	3	13	6	8	17	34	6
HHT4	14	6	13	9	8	34	35	10
HHT5	14	13	13	10	8	60	35	17
HHT8	14	9	13	11	8	19	35	12

Figure 10: Geomean FC concentrations at tributary station during different size storms, 2000



Note: Stormsize "1" is dry weather (<=0.01 inches precip)
Stormsize "2" is mild wet weather (0.02 to 0.50 inches precip)
Stormsize "3" is wet weather (>0.50 inches precip)

Note: Station HH3, located on the grounds of the Seabrook Station nuclear power plant, was not monitored during the TMDL study due to post-9/11 heightened security measures. The DES Shellfish Program data from 2000 illustrate that the FC concentrations in this tributary are similar to the other tributaries except for HHT2.

The DES Shellfish Program data confirm the observations from the TMDL tributary sampling, primarily that the concentrations at HHT2 are an order of magnitude higher than the other tributaries. As with the TMDL sampling, the tributary with the second highest concentration was the Taylor River (HHT5). Finally, the FC concentrations in the tributaries appear to respond slowly to precipitation.

Since only the flows at Mill Creek (HHT2) are known, it is only possible to estimate the load from this tributary, which ranged from 10 to 26 billion organisms per day during the two storms. In order to evaluate the significance of the loads from all tributaries relative to other sources, it would be helpful to know the total load from all the tributaries. The TMDL data and DES Shellfish Program data show that FC concentrations in the other tributaries are lower than those measured in Mill Creek. However, the other tributaries are larger than Mill Creek and have more flow and, therefore, could have sizeable loads. Therefore, as a rough, order-of-magnitude estimate, it will be assumed that the loading from each of the other tributaries is roughly equal to or less than the load from Mill Creek. Using this assumption, the total load from the seven tributaries together would be 68 to 179 billion organisms per day.

iv. Modeled Total Stormwater Load

Over 100 stormwater sources (pipes, creeks, conveyances) have been identified around Hampton/Seabrook Harbor. It was physically impossible to monitor all of these sources during the TMDL sampling rounds. Therefore, as previously mentioned, only 16 of the over 100 potential MS4 stormwater pipes, ditches, and conveyances, and only one of the seven tributaries to the harbor were monitored for bacteria loads during the DES sampling program (DES, 2003a). Overland stormwater flow directly to the harbor from developed areas and salt marshes will also contribute to NPS loading but is impossible to monitor. Therefore, two simple models were employed to provide estimates of the total stormwater load during the two storms. The modeled total loads can be compared to the monitored loads to determine what fraction of the total stormwater load was conveyed by the 16 MS4 stormdrains described in Section 4(a)(ii).

<u>Hampton Beach Runoff Model</u>

The first model is a simple infiltration-runoff model for the Hampton Beach area. The Hampton Beach area is a narrow spit of heavily developed land that runs north-south from the harbor mouth to the north end of Hampton Beach. A majority of the stormdrains monitored for the TMDL were located in this area because of its proximity to the shellfish growing areas and the large number of stormdrains. Stormwater infrastructure maps from the Hampton Department of Public Works show that the stormdrains monitored by DES should channel most of the stormwater discharged into the harbor from the area south of Ocean Boulevard. Hampton DPW staff estimated that 25-50 percent of the land surface is covered by impervious surfaces in the developed area.

The volume of stormwater runoff from the Hampton Beach area can be estimated from the following equation:

$$V_{storm} = C \cdot I \cdot A \cdot CF$$

Where
V_{storm} = volume of stormwater runoff (liters)
C = Runoff coefficient = 0.05 + 0.91× %impervious surface = 0.35 for an average %impervious surface value of 33% (equation from Schueler, 1987)
I = Rainfall intensity = 0.33 in for 7/23/02 storm and 1.39 for 10/16/02 storm
A = Area = 156 acres (estimated from digital orthophoto maps)
CF = Conversion factor = 102,802 (ft*l)/(in*acre-ft)

Multiplying the total stormwater volume by the average FC concentration monitored in the stormwater from stormdrains in this area (3,500 and 6,000 cts/100ml for July 23, 2002 and October 16, 2002, respectively, as shown on Table 12), the total load of bacteria from this area can be estimated to be 65 billion organisms on July 23, 2002 and 468 billion organisms on October 16, 2002. Table 17 shows this calculation.

Table 17: Modeled FC loads from Hampton Beach area

Parameter	Units	7/23/2002	10/16/2002
Monitored Load	billion org	35.5	235.4
Area	acres	156	156
Rainfall	in.	0.33	1.39
Rainfall	ft.	0.028	0.167
Runoff Coefficient	unitless	0.35	0.35
Stormwater Volume	acre-feet	1.50	6.32
Stormwater Volume	liters	1.85E+06	7.80E+06
Ave FC in stormwater	cts/100ml	3500	6000
Predicted Load	billion org	64.8	468.1
Ratio of Monitored Load to Predicted Load	Percent	55%	50%

The monitored loads from stormdrains in the Hampton Beach area were 36 and 235 billion organisms on July 23, 2002 and October 16, 2002, respectively. On July 23, 2002, the storm was short and intense and the stormdrains were monitored for the entire storm duration. Approximately 55 percent of the stormwater load was captured on this day. On October 16, 2002, the overnight portion of the storm was not monitored which resulted in a slightly lower portion of the load being captured (50 percent). Therefore, it appears that the stormdrain monitoring for the TMDL was capable of capturing approximately 50 percent of the stormwater loads from the Hampton Beach area. Small stormdrains and overland flow likely accounted for rest of the loading.

Tidal Flushing Model

The previous section was applicable to just the urban stormwater sources in the Hampton Beach area. It would be helpful to know the total stormwater load from all the sources both in the developed areas and in the less developed watersheds. The same model as was used to estimate the baseline dry weather non-point source loads (in Section 4(b)(ii)) can be used for this purpose as well. During wet weather, one new term is added to the model, k_{storm}, which signifies stormwater loads to the harbor. The equation for the model would then be:

Change in Storage = Sources - Sinks

$$\frac{\Delta(C \cdot V)}{\Delta t} = k_{storm} + k_b + k_w + k_d - C \cdot \frac{V_{TP}}{\Delta t} \cdot CF$$

Variable Definitions:
C = concentration of fecal coliform bacteria in the waterbody (MPN/100ml)
V = Estuary volume (gallons)
Δt = time step in increments of whole tidal cycles = 0.52 days
k_b = baseline load of NPS bacteria during dry weather conditions = 1,650 billion organisms per day (calculated in Section 4(b)(ii))
k_w = WWTF load = 0.3 billion organisms per day
k_d = Load from boat discharges = 238 billion organisms per day

k_{storm} = Stormwater load (billion organisms per day)
V_{TP} = Tidal exchange volume, equal to the difference between high tide and low tide volumes = 3.7 billion gallons (NAI, 1977)
CF = Conversion factor = 3.79E-08 (100ml*bill org)/(gallon*MPN)

Assuming steady-state conditions ($\Delta CV/\Delta t$=0), this equation reduces to a balance of sources and sinks.

$$Total\_Sources = k_{storm} + k_b + k_w + k_d = C \cdot \frac{V_{TP}}{\Delta t} \cdot CF = Total\_Sinks$$

which can be solved for k_{storm}:

$$k_{storm} = -k_b - k_w - k_d + C \cdot \frac{V_{TP}}{\Delta t} \cdot CF$$

The geomean FC concentrations in the harbor for different size storms can then be input for *C* to estimate the total stormwater load as shown in the following table:

Table 18: Modeled FC loads to Hampton/Seabrook Harbor during wet weather

Storm Size	Number of samples	Geomean (MPN/100ml)	Kstorm (bill org/day)
Dry (<0.01 in.)	662	7.023	0
0.02 to 0.50 in.	554	12.820	1,561
0.51 to 1.00 in.	289	19.129	3,260
>1.00 in.	166	29.167	5,964

Data Source: DES Shellfish Program, 1993-2002, all low tide data

The stormwater load predicted from this model is a combination of all sources (MS4 stormdrains, tributaries, overland flow). However, DES (2003a) only measured bacteria loads at 16 MS4 stormdrains and one tributary. On July 23, 2002, a load of 120 billion organisms per day was monitored from the 16 MS4 stormdrains combined, which is only 8 percent of the predicted load for a storm of this size (0.33 inches). Likewise on October 16, 2002, the total monitored load from the stormdrains was 630 billion organisms per day which was only 11 percent of the predicted total load for a 1.39 inch rainfall event. Therefore, the 16 MS4 stormdrains monitored by DES accounted for only approximately 10 percent of the total stormwater load predicted by the tidal flushing model.

Summary of Modeled Stormwater Loads

The two simple models used for this TMDL illustrate that the stormwater sources monitored for the TMDL were only a fraction (10 percent) of the total stormwater sources. In the developed Hampton Beach area, it appears that 50 percent of the bacteria loading sources were identified and monitored. Given that most of the TMDL monitoring effort was concentrated in this area, additional sampling is unlikely to produce a better capture rate. The uncaptured sources are probably diffuse overland flow or small pipes. For the watershed as a whole, the tidal flushing model predicts that only 10 percent of the MS4 sources were identified and monitored.

Therefore, contributions from other sources including tributaries and overland flow in the salt marshes are significant.

Both of the models used in this analysis are simplifications of a complex system and, therefore, have flaws. However, the purpose of this modeling exercise was to illustrate the relative strengths of the different bacteria sources based on the best available information. It is impossible to monitor diffuse bacteria loads from salt marshes and tributaries so models are a necessity.

For this TMDL, DES sought to document bacteria loads from stormwater sources to Hampton/Seabrook Harbor. Field sampling of loads from key MS4 stormdrains (Section 4(a)(ii)) and tributaries (Section 4(b)(iii)) provided information on the relative contributions of these sources. In addition, simple mass balance models were used to estimate the total load to the harbor. Since all sources were not monitored by the field sampling effort, it is not surprising that the modeled loads are significantly higher than the measured loads. The modeled loads are a better estimate of the total stormwater load to the harbor and will be used in the total load inventory in Section 4(c).

Stormwater will contain bacteria from both human and wildlife sources. The microbial source tracking data presented in Section 3(e) show that the ratio of human-related sources to wild animal sources during wet weather conditions is approximately 60:40. Therefore, the estimated stormwater loads from the model were split into human-related (human, pets, livestock) and wild animal (wildlife, avian) components using the same ratio.

Table 19 summarizes all the information on stormwater loads to the harbor.

Table 19: Summary of information on stormwater loads from human-related and wild animal sources

Source	Rainfall 0.02 to 0.50 in.		Rainfall 0.51 to 1.00 in.		Rainfall >1.00 in.		Comments
	Load*	Percent	Load*	Percent	Load*	Percent	
16 MS4 stormdrains	120	8%	NA	NA	630	11%	Monitored by DES on 7/23/02 (0.33 in. storm) and 10/16/02 (1.39 in. storm) (DES, 2003a)
Tributaries	68	4%	NA	NA	179	3%	The load from Mill Creek was monitored by DES on 7/23/02 (0.33 in. storm) and 10/16/02 (1.39 in. storm) (DES, 2003a). Loads from the other six tributaries were assumed to be equal to Mill Creek.
Other NPS stormwater	1,373	88%	3,260	100%	5,154	86%	Difference between model output and measured loads of MS4 stormdrains and tributaries.
Total	**1,561**		**3,260**		**5,964**		Estimated from tidal flushing model
Human-related bacteria load	937		1,956		3,578		Assumes 60% of bacteria in stormwater is human-related, based on results from Jones and Landry (2003).
Wild animal sourced load	624		1,304		2,385		Assumes 40% of bacteria in stormwater is from wild animals, based on results from Jones and Landry (2003).

** Bacteria load units are billion organisms per day*

c. Total Loading to Waterbody

Bacteria loads from the sources discussed in the previous sections are summarized in Table 20. The loading values in this table are estimates with considerable uncertainty, but they are useful to illustrate the relative magnitudes of the different sources of bacteria to the harbor.

Section A of Table 20 summarizes the daily bacteria loads from different sources during different rainfall amounts. The total load estimate ranges from 1,891 billion organisms per day for dry weather to 7,855 billion organisms per day for rainfall events greater than 1 inch of precipitation. The dominant source of bacteria to the harbor varies with rainfall condition. Under dry-weather conditions, dry-weather non-point source loads contribute 87 percent of the bacteria, followed by boat discharges (13 percent) (Figure 11). In contrast, during large rainstorms, stormwater sources dominate the bacteria loads (Figure 9). Overall, human sources are estimated to account for 61 to 65 percent of the bacteria under both wet and dry weather conditions.

Section B of Table 20 illustrates the average fecal coliform concentrations in the harbor during different rainfall conditions. Only during dry weather conditions do FC concentrations meet both components of the NSSP shellfishing standard (geomean <14 MPN/100ml, 90^{th} percentile <43 MPN/100ml). Therefore, it can conservatively be assumed that only the bacteria load during dry weather (1,891 bill org/day) is acceptable for meeting water quality standards in the harbor.

Section C of Table 20 shows the total load of bacteria to the harbor over a full year. The daily loading rates for each rainfall condition were multiplied by the number of days that this condition is expected to occur (see Table 6 and Section B of Table 20) and then the products were summed. Over the course of a year, the largest source of bacteria to the harbor are dry weather non point sources (52 percent), followed by stormwater loads (41 percent), boat discharges (7 percent), and the Hampton WWTF (0.01 percent) (Figure 13). Although dry weather sources contribute the most bacteria to the harbor over a year, the clam flats in Hampton/Seabrook harbor are typically open during dry weather and closed during rainfall events, during which stormwater bacteria sources are dominant.

Estimates of bacteria loads from the Hampton WWTF in Table 20 are based on data on treated effluent from discharge monitoring reports. The loading estimate does not take into account loadings from the plant due to emergency bypasses of untreated or partially treated wastewater during storm events or other temporary and infrequent system failures.

Table 20: Summary of bacteria loads to Hampton/Seabrook Harbor

A. Summary of daily bacteria loads to Hampton/Seabrook Harbor under different rainfall conditions

Source	Bacteria Type	Rainfall Dry (<0.01 in.)	Rainfall 0.02 to 0.50 in.	Rainfall 0.51 to 1.00 in.	Rainfall >1.00 in.	Comments
Hampton WWTF	Human	0.30	0.30	0.30	0.30	From DMRs
	Wildlife	0	0	0	0	
Boat Discharges	Human	238	238	238	238	Estimated
	Wildlife	0	0	0	0	
Dry Weather Non-Point Sources	Human	992	992	992	992	Modeled
	Wildlife	661	661	661	661	Modeled
Stormwater Load	Human	0	937	1,956	3,578	Modeled
	Wildlife	0	624	1,304	2,385	Modeled
Total	Human	1,230	2,167	3,186	4,808	
	Wildlife	661	1,286	1,965	3,047	
	Total	**1,891**	**3,453**	**5,152**	**7,855**	

Bacteria load units are billion organisms per day

B. Summary of fecal coliform concentrations in Hampton/Seabrook Harbor under different rainfall conditions

Statistic	Rainfall Dry (<0.01 in.)	Rainfall 0.02 to 0.50 in.	Rainfall 0.51 to 1.00 in.	Rainfall >1.00 in.
Geometric mean concentration	7.02	12.82	19.13	29.17
90th percentile concentration	35.30	86.30	142.00	198.00
Percent of the year with this rainfall amount	55.3%	24.2%	10.9%	9.7%
Days per year with this rainfall amount	202	88	40	35

Fecal coliform concentrations in units of MPN/100ml.

C. Annual bacteria load to Hampton/Seabrook Harbor from different sources

Source	Rainfall Dry (<0.01 in.)	Rainfall 0.02 to 0.50 in.	Rainfall 0.51 to 1.00 in.	Rainfall >1.00 in.	**Total for the year**
Hampton WWTF	61	26	12	11	**110**
Boat Discharges	48,039	21,023	9,469	8,426	**86,957**
Dry Weather Non-Point Sources	333,682	146,024	65,771	58,530	**604,006**
Stormwater Load	0	137,905	129,715	211,141	**478,761**
Total	381,781	304,977	204,967	278,108	**1,169,834**

Bacteria load units are billion organisms per year
Annual load estimated by multiplying the daily load for different rainfalls by the number of days/yr when this condition occurs.

Figure 11: Percent of daily bacteria load from different sources during dry weather

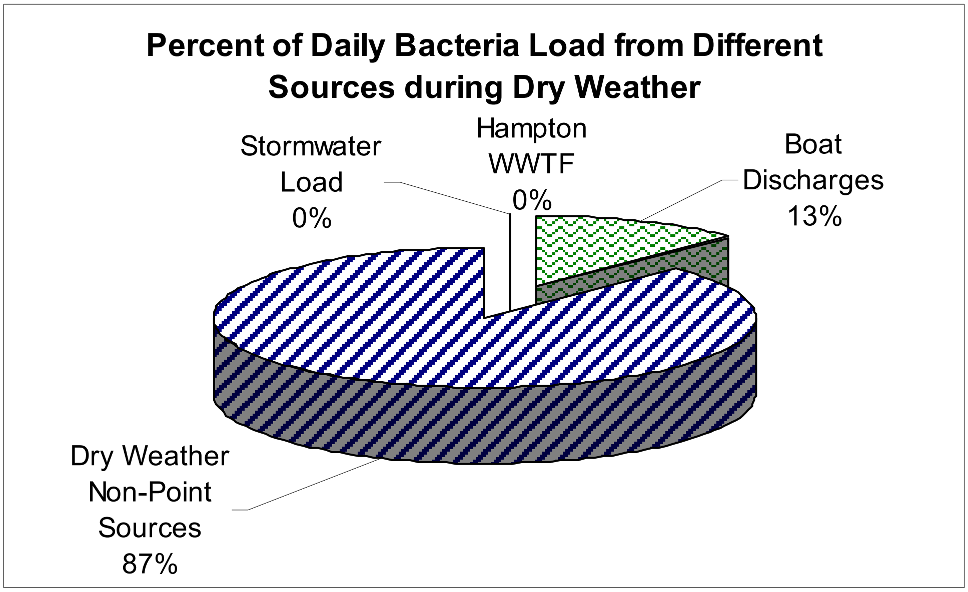


Figure 12: Percent of daily bacteria load from different sources during rainstorms (>1 in precipitation)

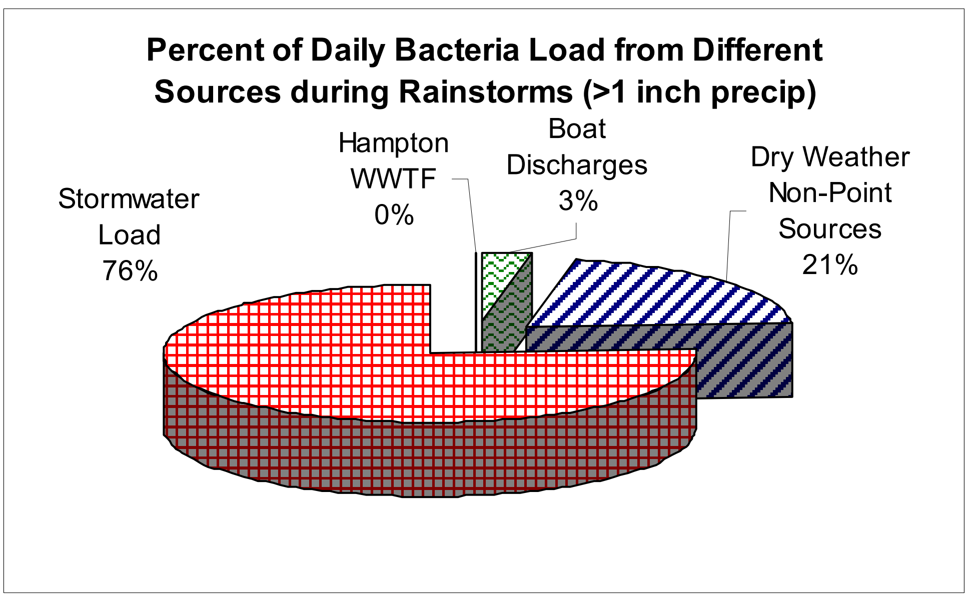
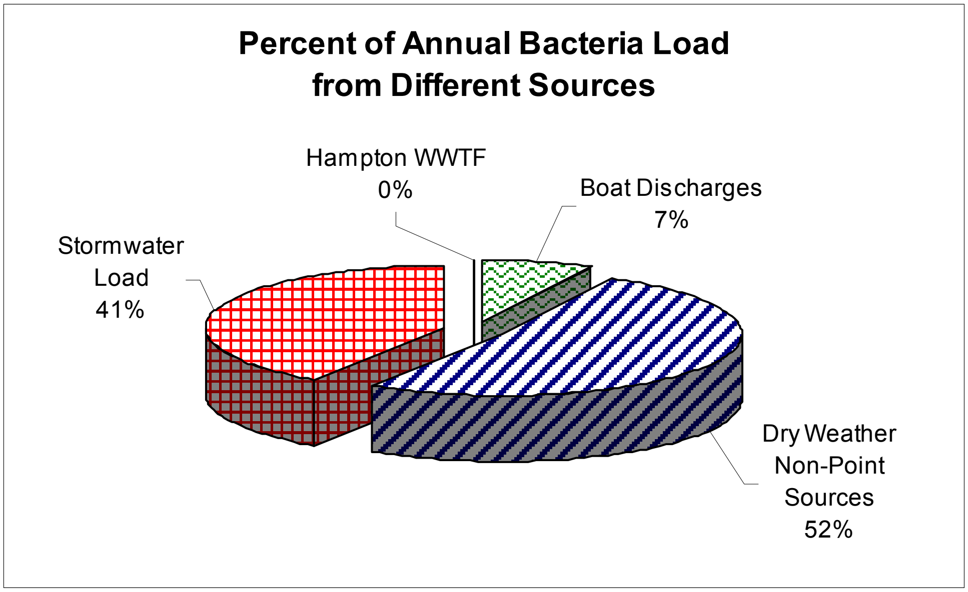


Figure 13: Percent of annual bacteria load from different sources



5. TMDL and Allocations

a. Definition of a TMDL

According to the 40 CFR Part 130.2, the total maximum daily load (TMDL) for a waterbody is equal to the sum of the individual loads from point sources (i.e., wasteload allocations or WLAs), and load allocations (LAs) from nonpoint sources (including natural background conditions). Section 303(d) of the CWA also states that the TMDL must be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety (MOS) which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

In equation form, a TMDL may be expressed as follows:

$$TMDL = WLA + LA + MOS$$

where:

WLA = Waste Load Allocation (i.e. loadings from point sources)

LA = Load Allocation (i.e., loadings from nonpoint sources including natural background)

MOS = Margin of Safety

TMDLs can be expressed in terms of either mass per time, toxicity or other appropriate measure [40 CFR, Part 130.2 (i)]. The MOS can be either explicit or implicit. If an explicit MOS is used, a portion of the total allowable loading is actually allocated to the MOS. If the MOS is implicit, a specific value is not assigned to the MOS. Use of an implicit MOS is appropriate when assumptions used to develop the TMDL are believed to be so conservative that they are sufficient to account for the MOS.

b. Determination of TMDL (Loading Capacity)

i. Seasonal Considerations/Critical Conditions

NHF&G closes the flats each year for June, July, and August to preserve the resource. Harvesting would be allowed in all other months if the water quality standards were met. The standards are met during dry weather except in September and October, but not during wet weather. Therefore, the critical period for this TMDL should be wet weather periods between September through May and dry weather periods in September and October. Data from these critical periods were used to estimate the bacteria loads to the harbor. Therefore, the TMDL and percent reduction goals set by this study should result in attainment of the water quality standards during the critical periods.

ii. TMDL Calculation and Load Allocation

The TMDL calculation in Table 21 was conducted using the annual bacteria loads to the harbor from Table 20, Section C.

On the left side of Table 21, the existing bacteria loads to the harbor are listed as either point sources or non-point sources and then summed to a total annual load of 1,169,834 billion organisms per year. On the right side of the table, the TMDL, MOS, WLA, and LA are shown.

The TMDL was set at the annual load for dry weather conditions (1891.459 bill org/day * 365 day = 690,382 bill org/yr). As shown in Table 20, both the geomean and 90th percentile FC concentration standards are met during dry weather but not during wet weather when the loads are higher. Therefore, 1891 billion organisms per day can be conservatively assumed to be the acceptable daily FC load for the harbor, which is why this loading value was chosen for the TMDL.

The MOS was set at 10 percent of the TMDL (69,038 bill org/yr).

The WLA was set equal to TMDL-MOS multiplied by the ratio of total loads from point sources to total loads from non-point sources ((47,986/1,121,848)*(690,382-69,038)=26,577 bill org/yr). Within the WLA, 2,810 bill org/yr is allocated to the Hampton WWTF which has a maximum permitted load of 2,810 bill org/yr (7.7 bill org/day*365 day = 2,810 bill org/yr). This method of apportioning allocations is from EPA (2001b).

The LA was set equal to TMDL-MOS-WLA (690,382-69,038-26,577=594,767 bill org/yr).

iii. Margin of Safety

An explicit margin of safety equal to 10 percent of the TMDL was assumed to conservatively account for possible datagaps when setting the TMDL.

c. Load Reductions Needed to Achieve the TMDL

Table 21 shows the percent reduction calculation for this TMDL. The sum of the WLA and LA were compared to the total loading value to determine the percent reduction needed. Based on this calculation, a 47 percent reduction in total loading is needed to reach the TMDL. This value matches the percent reduction in 90th percentile FC concentrations in the harbor that is needed to comply with shellfishing water quality standards. On Table 22, the 90th percentile concentrations for all the NSSP stations in the harbor are compared to the NSSP standard minus a 10 percent margin of safety (43 MPN/100ml – 4.3 MPN/100ml=38.7 MPN/100ml). On average, 90th percentile FC concentrations need to be reduced by 35 percent in order to comply with NSSP standards. The reductions needed are not uniform in the harbor. The greatest percent reduction (65 percent) is needed in the area around HH19. The lowest percent reduction (4 percent) was calculated for station HH18.

The goal for this TMDL is for the bacteria concentrations throughout Hampton/Seabrook Harbor to meet all the water quality standards for shellfishing, primary contact recreation, and secondary contact recreation. Of these three designated uses, the water quality standards for shellfishing are the most stringent. Therefore, the targeted goal for this TMDL is for the water quality in Hampton/Seabrook Harbor to meet both aspects of the NSSP shellfishing standard (geomean and 90^{th} percentile concentrations) as measured in accordance with NSSP protocols. The 90^{th} percentile concentration is the NSSP shellfishing standard that is most out of compliance and requires the greatest percent reductions. It is expected that bacteria loading reductions needed to meet the NSSP standards will also cause primary and secondary contact recreation standards to be met. Follow-up monitoring, discussed in Section 6(b)(ii), will include measurements of both fecal coliforms and enterococci so that the water quality standards for all the designated uses can be assessed.

Table 21: TMDL Calculation

Bacteria TMDL Calculation for Hampton/Seabrook Harbor

		Existing Loads			TMDL Calculation				Percent Reduction Needed[8]
Location	**Source**	Point Sources[2]	Non-Point Sources[3]	Total Load	TMDL[4]	MOS[5]	WLA[6]	LA[7]	
Hampton Harbor	Hampton WWTF	110		1,169,834	690,382	69,038	26,577	594,767	47%
	Boat Discharges		86,957						
	Dry Weather Non-Point Sources		604,006						
	Stormwater Load	47,876	430,885						
	Total	47,986	1,121,848						

Notes
1. Bacteria loads expressed as billion organisms per year.
2. Ten percent of the total annual stormwater load from Table 20 (Section C) was considered "point sources" (478,761*0.1=47,876) because the 16 Phase II MS4 pipes accounted for 10% of estimated stormwater load on 7/23/02 and 10/16/02. The Annual WWTF load (110) was taken from Table 20 (Section C).
3. Annual loads from boat discharges and dry-weather non-point sources taken from Table 20 (Section C). Non-point source stormwater load calculated as the difference between the total annual stormwater load from Table 20, Section C (478,761) and the point-source stormwater load (47,876).
4. TMDL set at annual load for dry weather conditions in Table 20, Section A (1891.459 bill org/day * 365 day = 690,382 bill org/yr).
5. MOS set at 10% of the TMDL.

6. WLA set equal to TMDL-MOS multiplied by the ratio of total loads from point sources to total loads from non-point sources ((47,986/1,121,848)*(690,382-69,038)=26,577). Within the WLA, 2,810 bill org/yr is allocated to the Hampton WWTF which has a maximum permitted load of 2,810 bill org/yr (7.7 bill org/day*365 day = 2,810 bill org/yr). This method of apportioning allocations is from EPA (2001b).
7. LA set equal to TMDL-MOS-WLA.
8. Percent reduction calculated by 1-(WLA+LA)/Total Load.

Table 22: Percent reduction in concentrations needed to achieve the TMDL

Station	90th %ile FC Concentration	Target: TMDL minus MOS	Percent Reduction Needed
	(MPN/100ml)	(MPN/100ml)	(%)
HH10	48.4	38.7	20
HH11	52.6	38.7	26
HH12	78.8	38.7	51
HH17	77.6	38.7	50
HH18	40.3	38.7	4
HH19	109.4	38.7	65
HH1A	74.8	38.7	48
HH2B	68.8	38.7	44
HH5B	58.2	38.7	34
HH5C	44.3	38.7	13
Average	65	---	35
Min	40.3	---	4
Max	109.4	---	65

Data source: DES Shellfish Program data, 1993-2002, for all months except June-July-August, low tide samples (collected 3 hours before to 0.5 hours after dead low tide). Only routine samples collected with a systematic random design were used for the 90^{th} %ile calculation.

d. Supplemental Information on Load Reductions

The percent reduction goal calculated in the previous section will be the official goal of the TMDL and progress toward this goal will be evaluated using ongoing monitoring in accordance with NSSP protocols by the DES Shellfish Program. However, for implementation planning, some additional information would be helpful. For instance, managers should know how much of a load reduction is needed to achieve the water quality standards for different size storms. Likewise, it would be useful to know the largest size storm for which the total load from natural sources would still be acceptable (e.g., would not cause exceedences of the standards). The estimated loading values from Table 20 can be used to derive answers to these important questions.

In Section 4(c), the total FC load to the harbor during dry weather conditions was estimated to be 1891 billion organisms per day. As shown in Table 20, both the geomean and 90th percentile FC concentration standards are met during dry weather but not during wet weather when the loads are higher. Therefore, 1891 billion organisms per day can be conservatively assumed to be the acceptable total FC load for the harbor. In order to reduce the loading during wet weather periods to the dry weather level, the wet weather loads would have to be reduced by 45 percent for 0.02-0.50 inch storms ((3453-1891)/3453), 63 percent for 0.51-1.0 inch storms ((5152-1891)/5152), and 76 percent for >1.0 inch storms ((7855-1891)/7855) (see Table 20 Section A). Reductions of this magnitude may not be feasible for larger storms. If only human sources can be controlled, the human sources would have to be cut by 72 percent for 0.02-0.50 inch storms ((3453-1891)/2167) and approximately 100 percent 0.51-1.0 inch storms ((5,152-1,891)/3,186) (see Table 20 Section A). For storms of greater than 1 inch of precipitation, the wildlife load (3,047 bill org/day) is greater than the total load for dry weather conditions (1,891 bill org/day). Therefore, reducing wet weather loads to dry weather levels does not appear to be feasible for storms with more than approximately one inch of precipitation without somehow reducing the wildlife load.

6.

Implementation Plan

a. Statutory/Regulatory Requirements

Section 303(d)(1)(C) of the CWA provides that TMDLs must be established at a level necessary to implement the applicable water quality standard. The following is a description of activities that are planned to abate water quality concerns in Hampton/Seabrook Harbor.

b. Description of Activities to Achieve the TMDL

i. Implementation Plan

Approach

The objective of the implementation plan is to remove all human sources of bacteria to the estuary to the extent practicable. A phased and iterative approach will be used. Follow-up monitoring both in the harbor and at specific sources will be conducted to evaluate the effectiveness of remedial actions, to identify any new sources, and to characterize public health risks from primary contact recreation exposure to undiluted stormwater.

DES will work with the towns of Hampton and Seabrook to develop specific projects to reduce human-related bacteria loads to the estuary. Preliminary ideas for implementation actions are listed below. DES staff met with public works and conservation officials from Hampton and Seabrook in April 2003 to initiate a discussion of these ideas and other means of effectively reducing bacteria loads. Specific action items for this implementation plan will be developed collaboratively with the towns following the public comment period for this TMDL. Implementation of action items will depend upon the availability of funds.

Preliminary List of Implementation Projects

- Use wet-weather loading data from the TMDL study to prioritize stormdrains for remedial measures.
- Eliminate any illicit connections to stormdrains that are discovered.
- Promote nonstructural best management practices (such as street sweeping, pet waste ordinances, and catch basin stenciling) in areas with stormwater drainage infrastructure.
- Assist EPA in implementing Federal Storm Water Program Phase II MS4 General Permit regulations.
- Promote and expand boat sewage pumpout facilities.
- Pursue a “No Discharge Area” designation for the New Hampshire coast.
- Promote public education about septic system maintenance.
- Conduct a shoreline survey of Mill Creek to identify bacteria sources.
- Implement recommendations of NHEP/UNH study of untreated or partially treated wastewater discharges due to runoff-induced hydraulic overloading or exfiltration from aging sewer infrastructure. (Report with recommendations due December 2003.)
- Develop more accurate measurements of bacteria loads from tidal tributaries.

ii. Monitoring

Data from routine monitoring conducted in accordance with NSSP protocols by the DES Shellfish Program will be used to assess progress toward the goals of this TMDL and compliance with water quality standards for shellfishing.

As part of the EPA-funded National Coastal Assessment, enterococci concentrations are monitored at four stations in the middle of the harbor between April and December on a monthly frequency. Data from this monitoring program will be used to assess progress toward the goals of this TMDL and compliance with water quality standards for primary and secondary contact recreation.

The Water Quality Section of the DES Watershed Management Bureau will collect samples of stormwater and near-shore waters near stormdrains to be analyzed for enterococci to characterize public health risks from exposure. This study will target stormdrains that are easily accessible and are located near areas frequented by people.

Individual restoration actions to remove bacteria sources may involve before and after monitoring to document the loading reduction achieved.

7.

Public Participation

a. Description of the Public Participation Process

DES staff have worked closely with officials from the towns of Hampton and Seabrook during the TMDL development. The following is a list of the interactions between the towns and the State during the TMDL development.

Table 23: State-Town interactions during the TMDL development

Date	Participants	Purpose
5/12/02	DES and Seabrook DPW officials	To explain the TMDL process and solicit information on stormwater infrastructure
5/12/02	DES and Hampton DPW officials	
7/23/02	DES and Seabrook DPW officials	Notification of DES stormwater sampling event
7/23/02	DES and Hampton DPW officials	
10/16/02	DES and Seabrook DPW officials	Notification of DES stormwater sampling event
10/16/02	DES and Hampton DPW officials	
4/21/03	DES and Seabrook Sewer Department	To present the results of the microbial source tracking (Jones and Landry, 2003) and Hampton/Seabrook Harbor TMDL studies and to solicit ideas for reducing bacteria loads to the harbor
4/21/03	DES and Seabrook Conservation Commission	
4/22/03	DES and Hampton DPW officials	
4/22/03	DES and Hampton Conservation Commission	
4/28/03	DES and Seabrook DPW and Seabrook WWTF	

EPA regulations [40 CFR 130.7(c)(ii)] requires that calculations to establish TMDLs be subject to public review. In accordance with this requirement, a public comment draft was distributed on May 28, 2003 to the three towns abutting the harbor: Hampton, Seabrook, and Hampton Falls. At the same time, the report was posted on the DES website: www.des.state.nh.us/wmb/TMDL/. Notices about the report were run in the Portsmouth Herald, the Hampton Union, and the Fosters Daily Democrat newspapers on Sunday, June 1, 2003. Finally, the New Hampshire Estuaries Project and New Hampshire Coastal Program broadcast notices about the report to their email lists (68 addresses total). The public comment period lasted for 60 days (June 1 to August 1, 2003).

b. Public Comment and DES Response

DES did not receive any comments from the public on the draft report.

8.

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APPENDIX A

Figures 4 and 5 from QA Project Plan (DES, 2002b)

Figure 4: Stormwater pipes and tributary stations for wet-weather monitoring.

The labeled pipes and tributary stations will be part of the wet-weather monitoring program for the TMDL.

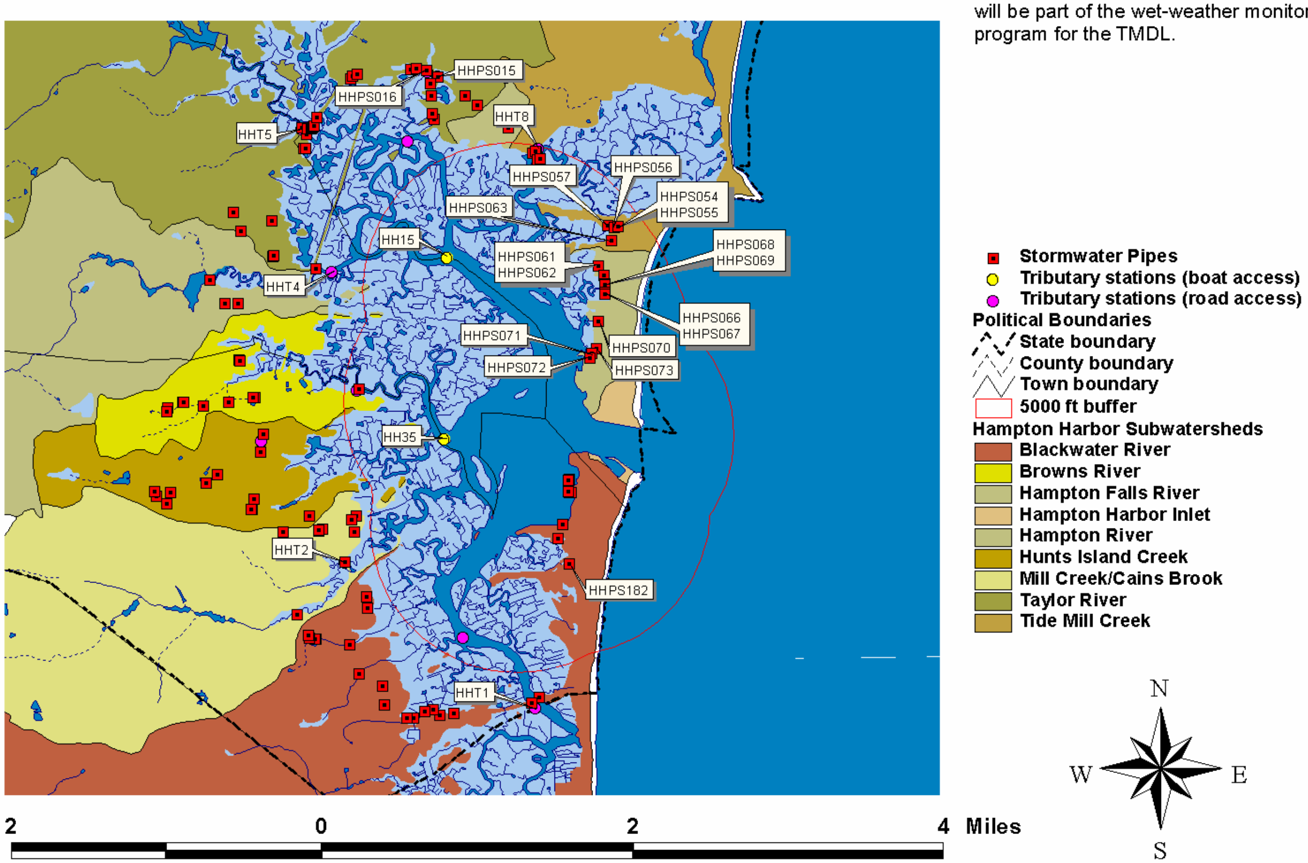
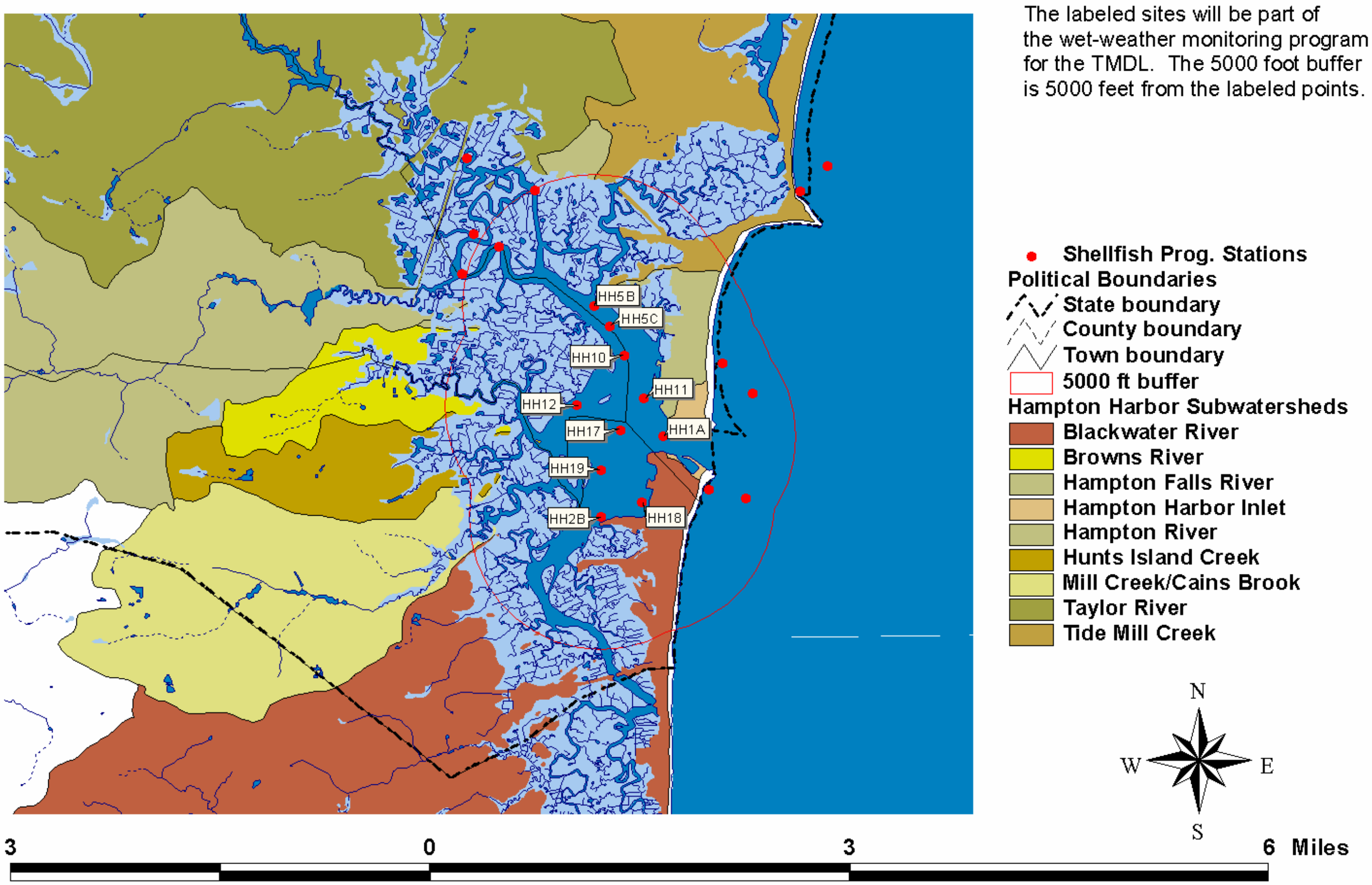


Figure 5: DES Shellfish Program Stations in Hampton Harbor.



APPENDIX B

Data from DES Stormwater Sampling Program 2002 (DES, 2003a)

APPENDIX C

QA/QC Review – Tidal Bacteria TMDL Program

STATE OF NEW HAMPSHIRE
Inter-Department Communication

DATE December 17, 2002

FROM Phil Trowbridge
Watershed Management Bureau

AT (OFFICE) Water Division,

SUBJECT QA/QC Review: Tidal Bacteria TMDL Program

TO Vince Perelli

This memorandum summarizes the QA activities conducted under the Tidal Bacteria TMDL Program during 2002. Only one project was completed during this time: the Hampton Harbor Bacteria TMDL.

Summary of QA/QC Objectives
The objectives described in the approved QAPP, dated June 28, 2002, were met. These include the proper training of the field technicians, proper handling of water samples, proper collection of field data, the review of data relative to the acceptance criteria documented in the QAPP, and input of the data to appropriate databases. All water sampling was conducted in accordance with the approved QAPP and the associated SOPs. Each field measurement and laboratory result was reviewed by the Project Manager to determine data quality.

Description of Training Activities
The training session consisted of two parts:

- The Program Manager instructed the Field Team Leaders on proper use of the water quality sampling and flow measurement equipment according to the approved SOPs on 6/12/02. This instruction was given in the field at the project site.

Conformance to QAPP Requirements/Descriptions of Deviations
All inconsistencies with the approved QAPP during the 2002 monitoring season are shown in Table 1.

Limitations of the Data
The data were collected from stormdrains during two rainstorm events. Therefore, these data do not represent ambient or typical conditions.

Table 1. QAPP inconsistencies during the 2002 monitoring season.

QAPP Section	Description	QAPP/SOP Inconsistency
A4	Project Task/Organization	The QA officer is not supposed to also participate in the field sampling. However, due to a lack of staff to help with the sampling, the QA Officer participated in both rounds of sampling. ***This non-conformity is not expected to affect the quality of the data.***
A7	Quality Objectives and Criteria - Precision	One set of duplicate stormwater samples from 7/23/02 had an RPD value for fecal coliforms outside the criteria of <60%. These were duplicate samples of HHPS070 taken at 1825. One measurement was 1700 cfu/100ml the duplicate sample was 6600 cfu/100ml. The field teams did not report any nonconformities with SOPs for these samples. ***These two samples were rejected and not used in any calculations. The data was retained in the database but was flagged with comments describing the high RPD between the two duplicates.*** 3 of the 5 field duplicates of fecal coliforms in harbor samples had RPD values of 67%, which is higher than the criteria of <40%. The FC concentrations in the harbor were low (average: 14.5 cfu/100ml) so the absolute difference in concentrations between these samples was small. ***Therefore, this nonconformity is not expected to affect the quality of the data.*** Stormwater flow measurements One set of duplicate measurements of stormwater flow from 7/23/02 had an RPD of 22% and another set of duplicates from 10/16/02 had an RPD of 24%. The criteria RPD for duplicate flow measurements is <20%. ***These nonconformities were considered acceptable and are not expected to affect the quality of the data***.
A7	Quality Objectives and Criteria – Completeness	Overall- QAPP called for 145 samples per storm for 3 storms. Data on two storms for a completeness of 67% was considered acceptable. Two storms were monitored and a total of 265 samples were collected for a completeness of 61%. ***This non-conformity is not expected to affect the quality of the data. It was most important to get data on two different storms which was done. Many of the planned samples could not be collected during the first storm because some target pipes did not flow during the storm. Based on the number of storms monitored, the completeness would be 2 of 3 (67%).***
B1	Sampling Process Design	Three of the targeted pipes (HHPS061, 062, and 073) were not monitored at all during the 7/23/02 storm because one of the field teams was missing. Two of these pipes HHPS061 and 073 were found to not flow during the storm on 10/16/02 so it can be assumed that they did not flow on 7/23/02. HHPS062 was observed to flow during the second storm so measurements from 7/23/02 represent a datagap. In addition, pre-storm samples were not obtained at the following two pipes on 7/23/02 (excluding pipes that were dry during prestorm conditions): HHPS063 (collected by Pipe Team 2 but mislabeled so rejected) HHT8 (not collected by Pipe Team 2 due to lack of time) On 10/16/02, only one round of harbor samples was collected instead of the 3-4 rounds of samples called for in the QAPP. Very high winds made it unsafe for the boat to be deployed in the harbor during the storm after the first round of samples was collected. ***Taken as a whole, these datagaps do not invalidate the study. Excellent***

QAPP Section	Description	QAPP/SOP Inconsistency
		monitoring coverage of all stormwater pipes was achieved during the second storm. Data from this storm provide good information on the relative importance of each pipe. To make up for the missing boat runs during 10/16/02, the boat stations were monitoring on the day following the storm.
B2	Sampling Methods	Temperature measurements were dropped from the SOPs after the first storm event because the data served no useful purpose and slowed down the field teams. This decision was made by the Project Manager after the field sampling audit of the first sampling event and interviews with field teams. ***This non-conformity is not expected to affect the quality of the data.***
B5	Quality Control	For stormwater samples on 10/16/02, 8 duplicates were taken for 117 samples (6% rate). For harbor samples over both storms, 5 duplicate samples were taken for 60 samples (8% rate). The rate of duplicate samples is supposed to be 10%. ***This non-conformity is not expected to affect the quality of the data.***

Documentation of Usable Data Versus Actual Data Collected

The Program Manager reviewed all results from field sampling and laboratory analysis. Comments relative to the field data were written directly on the field data sheets. **Two laboratory data points were flagged as provisional and not used in TMDL calculations,** as field duplicate samples for several parameters indicated significant deviations from the approved RPDs during the sampling day (Table 2). All other data are acceptable. The provisional data will be input to the database, but will not be used for TMDL calculations.

Table 2. Parameters and site IDs for data and RPDs outside the acceptable range given in the QAPP dated June 7, 2002.

Analysis	Date	Parameter	Site ID
Laboratory	7/23/02 1825	Fecal coliforms	HHPS070, HHPS070DUP

APPENDIX D

QA Officer Report

Quality Assurance Officer Report for the Hampton Harbor Bacteria TMDL

Prepared by Peg Foss, TMDL Coordinator, NHDES
January 9, 2003

The purpose of this Quality Assurance Report is to provide detailed information pertaining to the Hampton Harbor Bacteria TMDL project's compliance with the guidelines set forth in the Quality Assurance Project Plan dated June 7, 2002 ("the QAPP"), approved by EPA on June 28, 2002. This study was conducted under the supervision of Greg Comstock, Supervisor, of the Water Quality Planning Section, Watershed Management Bureau, of the New Hampshire Department of Environmental Services ("NHDES"). The Project Manager for the study is Phil Trowbridge, NH Estuaries Project Coastal Scientist, NHDES. Section D of the QAPP outlines the responsibilities of the QA Officer in reference to the review, verification, validation and reconciliation of the data collected for this study.

In 2002, wet weather monitoring was conducted during two storm events in Hampton Harbor. A memorandum dated December 17, 2002 was prepared by the Project Manager ("the memo") contains a review of all of the known non conformities found during the course of the monitoring work. This Quality Assurance report will serve to provide a detailed assessment of the impact of the nonconformities found on the quality of the data collected to determine whether the data quality objectives set forth in the QAPP have been met. Ultimately it is up to the Project Manager to decide whether or not to include data, collected which falls outside the parameters set forth in the QAPP, in any calculations, assumptions, predictions, or conclusions in the final TMDL Report. If any such suspect data is included, the Project Manager is required to clearly identify the suspect data and the resultant uncertainty associated with it's use.

A detailed discussion of each known nonconformity and decision regarding the inclusion or exclusion of data itemized in Table 1 of the memo and the resultant impact to the project is discussed below;

1. Section A4, Project Task Organization: QA Officer participation in field sampling.

Section A8 of the QAPP requires that all "Field Sampling Team Leaders" participate in a mandatory field training session which was held in the field at the project site on June 12, 2002. The QA Officer participated in the training session and was designated a Field Sampling Team Leader. The attendance sheet for the training session with the signatures of all attendees, including the QA Officer's, is included in Appendix C of the TMDL report. Since the QA Officer met the training requirement as outlined in the QAPP this nonconformity is not expected to affect the quality of the data.

2. Section A7, Quality Objectives and Criteria-Precision: Duplicate samples outside the precision criteria.

Table 3 in Section A7 of the QAPP details the precision criteria requirement for each parameter tested or sampled in the study. The Project Manager is responsible for preparation of the final report and has the ultimate decision authority over whether to accept or reject any data that falls outside any of the criteria set forth in the QAPP.

The Project Manager rejected the fecal coliform duplicate samples taken at sample ID HHPS070 on 7/23/02 because the testing results revealed that samples fell outside the acceptable range of precision identified in section A7, Table 3 of the QAPP. Rejection of this data is in compliance with the criteria set forth in the QAPP.

The Project Manager included three of five fecal coliform duplicate samples taken in the Harbor that fell above the acceptable range in precision. This nonconformity is not expected to have a significant impact on the quality of the results/conclusions drawn from the data because the concentration of FC in the three samples was low, hence the absolute difference in concentrations between the samples was small.

The Project Manager included one set of duplicate flow measurements from each sample round that fell just slightly above the acceptable range of precision. Since the samples were just slightly outside the acceptable range, this nonconformity is not expected to have a significant impact on the quality of the results/conclusions drawn from the data.

3. Section A7, Quality Objectives and Criteria-Completeness: Two storm events monitored.

This TMDL study proposed to collected water quality samples during three storm events of greater than 0.25 inches/day of precipitation between June and October. According to Section A7 of the QAPP, "the study will be sufficiently complete if two storms are monitored" and "a data completeness percentage of 67% is needed". In 2002, sampling/monitoring was conducted during two storm events, both resulted in greater than 0.25 inches/day of total precipitation, therefore the project has met the project description and completeness criteria set forth in the QAPP. An added benefit to the data collected for this study is that the two storm events that were monitored were different. The first storm event was a typical summer thunderstorm with heavy wind and rain over a short period, which resulted in relatively small total precipitation. The second storm was a "Nor'easter" which was much longer in duration and resulted in a much higher amount of total precipitation. Gathering information on two different, but typical storm events over the course of this study affords the opportunity to develop a more comprehensive review of the impact of storms on the water quality and Hampton Harbor and the resultant impact to the shellfish resource found there.

4. Section B1, Sampling Process Design: Data gaps.

The lack of pre storm sampling at two storm pipes (all other rounds collected) is not expected to affect the quality of the data collected at those locations for that storm event.

The lack of sample collection during the first storm at one storm water pipe location is not expected to affect the quality of the data. Water quality sampling was done on this pipe during the second storm event and provided sufficient information relative to the significance of the comparative contribution from this location to the water quality in Hampton Harbor.

According to the Department of Public Health Services 1994 report, the effects of a storm event on water quality in Hampton Harbor have been found to persist for three days. Therefore, the collection of water quality samples in the harbor the day after the second storm, to make up for the missing runs the day of the storm (for safety reasons) is not expected to affect the quality of the data or the results/conclusions drawn from the data.

5. Section B2, Sampling Methods: Temperature Measurements dropped from SOP's.

Section C-1, Assessments and Response Actions, and Section B2 of the QAPP, under "Field Corrective Measures" authorize the Project Manager to make decisions and necessary changes during the course of the study to ensure the quality of the sampling. Section A7 of the QAPP states that "Water temperature will also be measured but no regulatory decisions will be made based on this parameter". Since the collection of temperature data was considered secondary/non critical information, and the activity significantly slowed down the sampling teams during the storm events, the decision to drop temperature measurements from the SOP's should have no impact on the quality of the data or the results/conclusions drawn from the data.

6. Section B5, Quality Control: Duplicate criteria.

According to section B5 of the QAPP, the rate set for the collection of duplicate samples of fecal coliform is10%. The boat team, sampling in Hampton Harbor, fell short of the duplicate criteria by 2%. The Project Manager has decided to include the sampling results from the boat team in TMDL calculations. Since this is a minor deviation from the criteria set forth in the QAPP, the decision to include the data should have no impact on the quality of the data collected or the results/conclusions drawn from the data.

APPENDIX E

Responses to EPA Comments on the Hampton/Seabrook Harbor Bacteria TMDL

September 25, 2003

Introduction

The Hampton/Seabrook Harbor TMDL was made available for public comment between June 1 and August 1, 2003. DES did not receive any public comments on the report. DES added information about the public comment period and then sent a final draft of the report to EPA for approval on August 7, 2003. On September 11, 2003 EPA provided a list of comments on the final report. DES responses to these comments are provided below.

EPA Main Comment: "While NH DES did a good job in the TMDL report (dated August 2003) presenting data and the analysis used for estimating loading reductions needed in the central harbor, we have determined that the report does not provide sufficient information for approving TMDLs for the other AUs listed in the TMDL report. For the tributary areas (eight AUs), there is not enough information on sources, existing loads, and load allocations to ensure that the tributaries will attain water quality standards (WQS). We also do not have sufficient information for the shoreline areas (one AU) to ensure that those areas will meet WQS. However, we encourage NH DES to pursue completion of the bacteria TMDLs for the tributary areas, and would be happy to provide assistance."

Hampton/Seabrook Harbor consists of 14 assessment units (AUs) for 305(b) reporting. Ten of the 14 AUs are listed on New Hampshire's 2002 303(d) list for impairments of the shellfishing designated use. The other four AUs in the harbor are safety zones which are closed for shellfishing due to administrative reasons and therefore are not listed on the 303(d) list.

A revised Figure 1 (shown at the end of this addendum) shows how the ambient harbor stations used to calculate the TMDL relate to the ten AUs on the 303(d) list. The stations surround the two AUs that are conditionally approved for shellfishing in the central harbor area (NHEST600031004-09-01, NHEST600031004-04-03). Therefore, this TMDL should at least apply to both of these AUs.

DES accepts that the TMDL should not apply to the six AUs representing tributaries because there is not enough information in these areas to classify them for shellfishing designations. The tributary AUs are: NHEST600031003-01, NHEST600031004-05, NHEST600031004-06, NHEST600031004-07, NHEST600031004-08-01, and NHEST600031004-08-02.

The remaining two AUs are shoreland areas along the developed portions of Hampton and Seabrook (NHEST600031004-09-02, NHEST600031004-04-02). Both of these AUs are classified as restricted for shellfishing because of the presence of marinas and other potential pollution sources. DES accepts that there is not sufficient information to characterize all the microenvironments along the shoreland areas.

Finally, while DES accepts that the scope of this TMDL should be limited to the two central harbor AUs, we do not agree that separate TMDLs are needed for each of the other eight assessment units. The data collected for the TMDL provides sufficient information to move forward on the implementation plan without any further effort to estimate or allocate bacteria loads. Sources to the shoreline areas and tributaries will be targeted for removal in order to reduce the total loading to the central harbor. We expect that the shoreline areas and tributaries will experience dramatic improvements in water quality as a result of these efforts. The most cost effective next step for these AUs is follow-up monitoring in accordance with the NSSP protocols to determine whether these AUs are still impaired after the implementation plan has been completed.

EPA Comment 1: "Include June-August data in your calculations and, if necessary, revise any tables, including those that present the TMDL (in terms of loading or percent reduction) consistent with the calculation results. These tables, if different from those in the TMDL report, will become part the final TMDL for EPA approval."

The DES Shellfish Program database was queried for FC results collected in June, July, and August between 1993 and 2002. The query returned 257 records, 246 of which were routine (i.e., pre-scheduled) samples. The TMDL calculations were re-run using the updated database. The values in Tables 7, 8, 18, 20, 21, and 22 were updated. Revised versions of these tables are shown at the end of this addendum. As a result of these changes, the percent reduction needed to reach the TMDL from Table 21 changed from 47% to 48%. Therefore, the inclusion of the summer data had a negligible effect on the outcome of the TMDL.

EPA Comment 2: "Present the TMDL load and wasteload allocations as daily loads rather than annual loads."

On the revised Table 21, the annual loads have been divided by 365 days/year to express them as daily loads, rather than annual loads.

EPA Comment 3: "Clarify that although the TMDL is referred to as a 'dry-weather TMDL', the allocations actually apply at all times and weather conditions."

EPA commented that it was unclear whether the TMDL was applicable to all conditions or just the dry weather. The confusion arises because the total load to the harbor during dry weather was used as the TMDL, because the water quality standards are only met during dry weather. However, section 5(b)(i) of the report explicitly states that the TMDL set in the report should result in attainment of the water quality standards during critical conditions. Attainment of the standards during the critical conditions will ensure attainment of the standards for all conditions. Therefore, for the record, the TMDL set for Hampton/Seabrook Harbor is applicable to all times and weather conditions.

EPA Comment 4: "In addition to the 10 NSSP stations, please assign percent reductions at the mouths of the seven tributaries that enter Hampton/Seabrook Harbor. This is important because it gives an indication of loading reductions needed from these sources."

Since this TMDL will only be approved for the two central harbor assessment units, the ten NSSP stations around the central harbor already monitor the points where the tributaries discharge to this area (see revised Figure 1). The mouth of the Blackwater River is monitored at HH2B. Mill Creek and Hunts Island Creek/Browns River are monitored by HH19 and HH12, respectively. Finally, HH5B, HH5C, and HH10 are located in the mouth of the Hampton River. Given the scope of this TMDL, the percent reductions at the mouths of the tributaries have already been calculated and discussed in Table 22 of the report.

EPA Comment 5: "Please explicitly note that illicit connections and minor NPDES permittees are part of the wasteload allocation (WLA) portion of the TMDL, assign allocations to each of these source categories, and revise report tables as necessary. Illicit connections are point sources subject to NPDES permits and should have a WLA set at zero because these discharges are illegal and should be eliminated. For the minor NPDES permittees, please give the current and permitted discharge levels for bacteria. WLAs are needed for these facilities so that it is clear that they are allowed to continue to discharge."

Illicit connections are considered part of the WLA portion of the TMDL because these connections discharge to MS4 stormwater systems. It is not possible to estimate the loading from illicit connections to Hampton Harbor. DES recognizes that these sources are illegal and therefore should have an allocation of zero. Footnote 6 in Table 21 has been changed to reflect this fact.

There are two minor NPDES permittees that discharge to Hampton/Seabrook Harbor in addition to the major discharge of the Hampton WWTF. The combined discharge from these two facilities represents 0.0002% of the annual load of bacteria to the harbor. Allocations for the maximum permitted discharge limits for these two facilities have been added to footnote 6 on Table 21.

EPA Comment 6: "Boats and failing septic systems are properly included in the load allocation (LA) portion of the TMDL, but, if feasible, these should be given separate aggregate LA's. For example, the allocation assigned to boats could reflect the load reduction expected from NH DES's goal of designating the New Hampshire coast as a 'no discharge area'. For failing septic systems, the allocation could be set at zero (if the intent is to eliminate such systems) or at a level that reflects properly operating septic systems (if the expectation is that the systems would be repaired or relocated). If the data or techniques do not exist for estimating or predicting load allocations for these categories, then they may remain part of the gross aggregate load allocation. But because of potential localized impacts, we believe that a separate allocation for boats could be particularly beneficial."

DES is in the process of establishing a No Discharge Area (NDA) for the NH coast. We expect that this designation plus our ongoing work with the DES pumpout boat will reduce the bacteria load from boats; however, we do not feel it is prudent to speculate on the amount of the reduction at this time. There is little information nationally on the effectiveness of a NDA designation on reducing overboard discharges. Estimates of compliance with the law range from 20% to 50% of boaters.(Walz, 2003). Therefore, we do not believe it is feasible to set separate aggregate load allocations for boat discharges and failing septic systems as part of this TMDL.

References Cited

Walz L (2003) Boatings dirty secret, Boating Industry, September/October 2003, pp. 40-49.

REVISED Table 7: Characterization of FC Concentrations in Hampton/Seabrook Harbor

Station	Weighted Geomean	90th %ile (based on systematic random data)
	(mpn/100ml)	(mpn/100ml)
HH10	14	60
HH11	12	61
HH12	14	81
HH17	14	89
HH18	11	55
HH19	19	123
HH1A	16	87
HH2B	15	88
HH5B	16	77
HH5C	17	58
Average	**15**	**78**
NSSP Standard	**14**	**43**

Data Source: DES Shellfish Program, records from 1993-2002

REVISED Table 8: Yearly and autumn dry weather FC concentrations

Period	Sample Size	Geomean (MPN/100ml)	90^{th} %ile (MPN/100ml)
September through May	437	5.56	24.05
September and October	97	16.87	80.77
November through May	340	4.05	12.80
June, July, and August	83	12.73	66.73

Data Source: DES Shellfish Program, 1993-2002, low tide, routine samples

NEW Table: Seasonal FC concentrations for all weather conditions combined.

Period	Sample Size	Geomean (MPN/100ml)	90^{th} %ile (MPN/100ml)
September and October	289	29.26	147.26
November through May	688	6.08	31.62
June, July, and August	246	18.76	138.01

Data Source: DES Shellfish Program, 1993-2002, low tide, routine samples

REVISED Table 18: Modeled FC loads to Hampton/Seabrook Harbor during wet weather

Storm Size	Number of samples	Geomean (MPN/100ml)	Kstorm (bill org/day)
Dry (<0.01 in.)	745	7.50	0
0.02 to 0.50 in.	670	13.52	1,621
0.51 to 1.00 in.	327	18.92	3,074
>1.00 in.	186	36.31	7,758

Data Source: DES Shellfish Program, 1993-2002, all low tide data

REVISED Table 20: Summary of bacteria loads to Hampton/Seabrook Harbor

A. Summary of daily bacteria loads to Hampton/Seabrook Harbor under different rainfall conditions

Source	Bacteria Type	Rainfall Dry (<0.01 in.)	Rainfall 0.02 to 0.50 in.	Rainfall 0.51 to 1.00 in.	Rainfall >1.00 in.	Comments
Hampton WWTF	Human	0.30	0.30	0.30	0.30	From DMRs
	Wildlife	0	0	0	0	
Boat Discharges	Human	238	238	238	238	Estimated
	Wildlife	0	0	0	0	
Dry Weather Non-Point Sources	Human	1,070	1,070	1,070	1,070	Modeled
	Wildlife	713	713	713	713	Modeled
Stormwater Load	Human	0	972	1,844	4,655	Modeled
	Wildlife	0	648	1,229	3,103	Modeled
Total	Human	1,308	2,280	3,152	5,963	
	Wildlife	713	1,361	1,942	3,816	
	Total	**2,021**	**3,642**	**5,095**	**9,779**	

Bacteria load units are billion organisms per day

B. Summary of fecal coliform concentrations in Hampton/Seabrook Harbor under different rainfall conditions

Statistic	Rainfall Dry (<0.01 in.)	Rainfall 0.02 to 0.50 in.	Rainfall 0.51 to 1.00 in.	Rainfall >1.00 in.
Geometric mean concentration	7.50	13.52	18.92	36.31
90th percentile concentration	38.52	88.23	137.75	298.05
Percent of the year with this rainfall amount	55.3%	24.2%	10.9%	9.7%
Days per year with this rainfall amount	202	88	40	35

Fecal coliform concentrations in units of MPN/100ml.

C. Annual bacteria load to Hampton/Seabrook Harbor from different sources

Source	Rainfall Dry (<0.01 in.)	Rainfall 0.02 to 0.50 in.	Rainfall 0.51 to 1.00 in.	Rainfall >1.00 in.	**Total for the year**
Hampton WWTF	61	26	12	11	**110**
Boat Discharges	48,039	21,023	9,469	8,426	**86,957**
Dry Weather Non-Point Sources	359,825	157,464	70,924	63,116	**651,330**
Stormwater Load	0	143,162	122,280	274,677	**540,119**
Total	407,925	321,675	202,685	346,230	**1,278,515**

Bacteria load units are billion organisms per year

Annual load estimated by multiplying the daily load for different rainfalls by the number of days/yr when this condition occurs.

REVISED Table 21: TMDL Calculation

Bacteria TMDL Calculation for Hampton/Seabrook Harbor

		Existing Loads			TMDL Calculation				Percent Reduction Needed[8]
Location	**Source**	Point Sources[2]	Non-Point Sources[3]	Total Load	TMDL[4]	MOS[5]	WLA[6]	LA[7]	
Hampton Harbor	Hampton WWTF	0.3		3,503	2,021	202	80	1,738	48%
	Boat Discharges		238						
	Dry Weather Non-Point Sources		1,784						
	Stormwater Load	148	1,332						
	Total	148.3	3,355						

Notes

1. Bacteria loads expressed as billion organisms per day.

2. Ten percent of the annual stormwater load from Table 20 (Section C) was considered "point sources" (540,119 bill org/yr * 1 yr/365 d * 0.1=148 bill org/day) because the 16 Phase II MS4 pipes accounted for 10% of estimated stormwater load on 7/23/02 and 10/16/02. The average daily WWTF load (0.3) was taken from Table 20 (Section A).

3. Annual loads from boat discharges and dry-weather non-point sources taken from Table 20 (Section A). Average non-point source stormwater load calculated using the annual stormwater load from Table 20, Section C and the point source stormwater load (540,119 bill org/yr * 1 yr/365 d -148 bill org/day = 1332 bill org/day).

4. TMDL set at average daily load for dry weather conditions in Table 20, Section A (2021 bill org/day).

5. MOS set at 10% of the TMDL.

6. WLA set equal to TMDL-MOS multiplied by the ratio of total loads from point sources to total loads from non-point sources ((148.3/3355)*(2021-202)=80 bill org/day). Within the WLA of 80 bill org/day, 7.731 bill org/day is allocated to the three existing NPDES permits discharging to the harbor: The Hampton WWTF which has a maximum permitted load of 7.7 bill org/day, Aquatic Research Organisms, Inc. which has a maximum daily permitted load of 0.024 bill org/day, and EnviroSystems, Inc. which has a maximum daily permitted load of 0.007 bill org/day. The remaining 72.269 bill org/day is allocated to MS4 stormwater discharges. However, any illicit connections discharging to the harbor through MS4 systems will have an allocation of zero because these discharges are illegal. This method of apportioning allocations is from EPA (2001b).

7. LA set equal to TMDL-MOS-WLA.

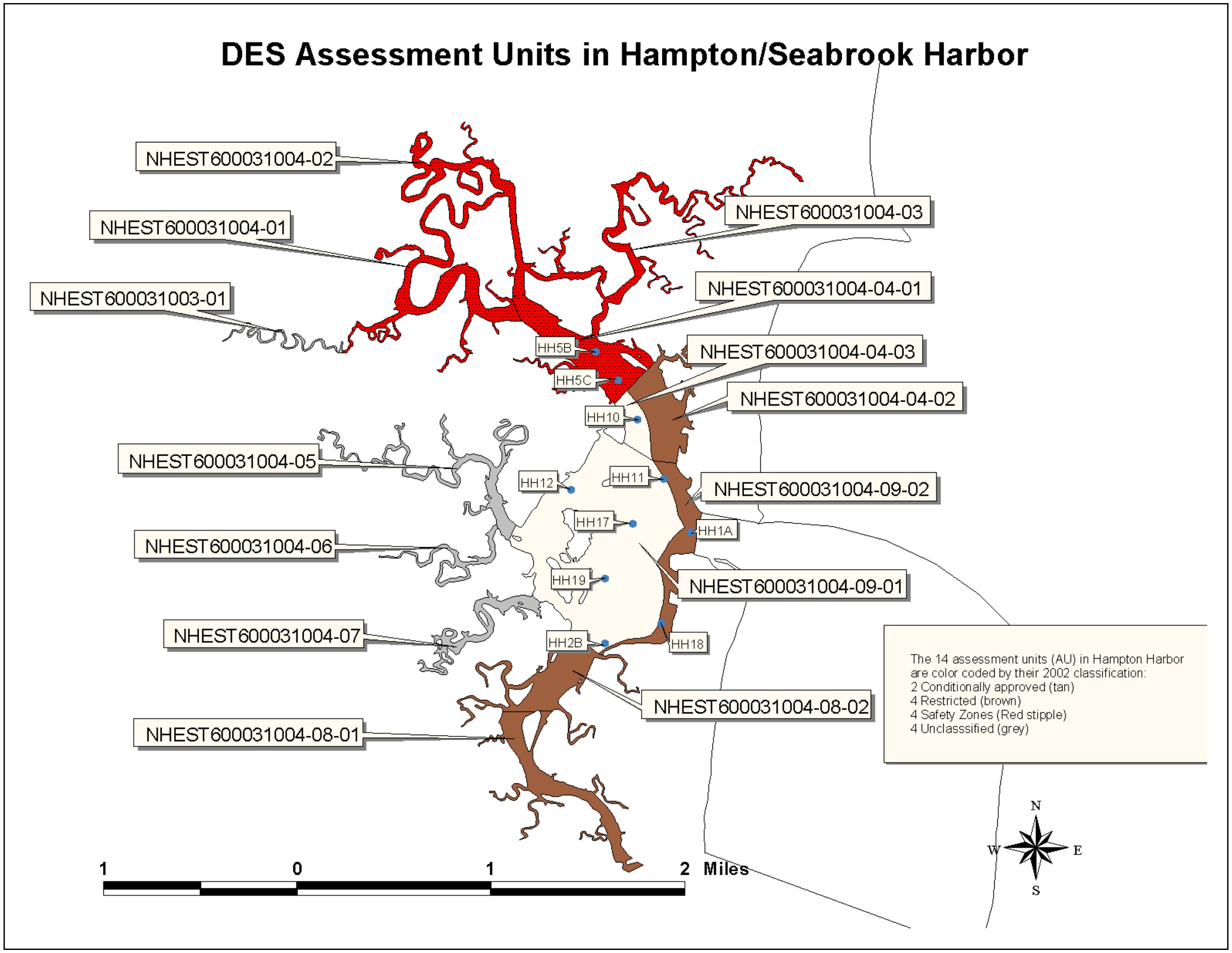
8. Percent reduction calculated by 1-(WLA+LA)/Total Load.

REVISED Table 22: Percent reduction in concentrations needed to achieve the TMDL

Station	90th %ile (based on systematic random data)	Target: TMDL minus MOS	Percent Reduction Needed
	(mpn/100ml)	(mpn/100ml)	(%)
HH10	60	38.7	36%
HH11	61	38.7	37%
HH12	81	38.7	52%
HH17	89	38.7	56%
HH18	55	38.7	30%
HH19	123	38.7	69%
HH1A	87	38.7	55%
HH2B	88	38.7	56%
HH5B	77	38.7	50%
HH5C	58	38.7	33%
Average	**78**	**----**	**47%**
Min	55	----	30%
Max	123	----	69%

Data source: DES Shellfish Program data, 1993-2002, for all months ***including*** June-July-August, low tide samples (collected 3 hours before to 0.5 hours after dead low tide). Only routine samples collected with a systematic random design were used for the 90th %ile calculation.

REVISED Figure 1: DES assessment units in Hampton/Seabrook Harbor



APPENDIX F

TMDL Calculations for Hampton/Seabrook Harbor Tributaries

May 10, 2004

Introduction

The New Hampshire Department of Environmental Services (NHDES) completed a Total Maximum Daily Load study for Hampton/Seabrook Harbor in September 2003. The goal of the study (stated in Section 1(b)) was to:

> "Develop a TMDL for bacteria in Hampton/Seabrook Harbor located in the towns of Hampton, Seabrook, and Hampton Falls, New Hampshire. The goal is to reduce bacteria loads to the harbor so that water quality standards for all the designated uses affected by bacteria pollution are met in all areas of the harbor."

In September 2003, EPA approved TMDLs for two of the 10 requested assessment units in Hampton/Seabrook Harbor (the two units in the center of the harbor). However, after further discussions between the agencies in April 2004, NHDES and EPA agreed that the remaining eight assessment units in the harbor tributaries could also be included in the TMDL. Both agencies agreed that these assessment units were sufficiently evaluated as part of the TMDL study, and that data from the TMDL report itself can be used to make reasonable estimates of the TMDLs and loading reductions needed for the eight tributary assessment units to achieve water quality standards.

Objective

The objective of this addendum is to compile information on the tributary assessment units from the TMDL report and to calculate the TMDL and loading reduction needed to achieve water quality standards in each assessment unit.

Methods

The critical period for this TMDL is wet weather conditions. Therefore, wet weather data from the tributaries (from days with >0.25 inches of antecedent rainfall) was compiled in Table 1 of this addendum. These data were originally summarized in Tables 15 and 16 of the TMDL report. The geomean fecal coliform concentration during wet weather for each assessment unit was calculated and then compared to the geomean fecal coliform criterion used by the National Shellfish Sanitation Program. A 20% margin of safety was applied to the criterion to account for uncertainties and assumptions in the calculation as discussed in footnote 2 of Table 1. In contrast, a 10% margin of safety was used for the central harbor TMDL. A larger margin of safety was used for the tributary TMDLs because more assumptions were needed for the tributary calculations than for the central harbor calculations. Finally, the percent reduction in loadings that is needed for each tributary to meet water quality standards was calculated. In addition to calculating the percent reductions using the NSSP geomean criterion, the percent reductions needed to reach the 90th percentile criterion were also estimated.

Results and Discussion

Table 1 summarizes the data and calculations for each tributary assessment unit. The footnotes below the table provide additional details on data sources and methods.

For the purposes of this addendum, the TMDL for each AU was set at the NSSP geomean criterion for fecal coliforms (14 cfu/100ml, see footnote 2 for caveats). The percent reduction needed to achieve the TMDL was calculated using the wet-weather geomean fecal coliform concentration and the TMDL with a 20% margin of safety. The margin of safety for the tributary TMDLs was double that used for the central harbor TMDL.

Based on the geomean criterion, loading reductions between 11% and 94% are needed to achieve water quality standards in the tributaries. The geomean fecal coliform concentrations were highest in Mill Creek (179 cfu/100ml). Loads in Mill Creek need to be reduced by 94% to reach the water quality standard of 14 cfu/100ml with a 20% margin of safety. Mill Creek was identified as the most contaminated tributary in the TMDL report. The DES Shellfish Program has already begun a shoreline survey of Mill Creek to identify bacteria sources. We have confidence in our ability to identify and eliminate contributing sources in this AU. The tributary with the lowest percent reduction was Browns River. This tributary is small, in the middle of the salt marsh, and relatively undeveloped.

The NSSP guidelines for shellfishing water quality have a second component which is that the 90th percentile fecal coliform concentration should be less than 43 cfu/100ml. The last column on Table 1 shows that the percent reduction in loadings needed to reach the geomean criterion are roughly equivalent to the percent reductions that would be needed to reach the 90th percentile criterion. In some cases, the percent reduction for the 90th percentile criterion are higher (e.g., NHEST600031004-08-01, NHEST600031004-08-02). However, the 90th percentile concentration is supposed to be calculated using data from both wet and dry conditions. The 90th percentile concentration calculated from a collection of exclusively wet weather samples will be biased high with respect to the criterion. Therefore, NHDES considers the geomean criterion to be the more appropriate TMDL for the tributary AUs. The percent reduction in loadings based on the 90th percentile criterion have been calculated to demonstrate reasonable assurance that both water quality components of the NSSP guidelines will be met.

Conclusions

1. There is sufficient data in the Hampton/Seabrook Harbor TMDL Study to make reasonable estimates of the TMDLs and loading reductions needed for the eight tributary assessment units.
2. Based on the available data, bacteria loads need to be reduced by 11% to 94% in the tributary assessment units in order to achieve water quality standards.
3. The TMDLs for the eight tributary assessment units included herein should be approved as part of the Hampton/Seabrook Harbor TMDL Study.

Table 1: Allocation table for fecal coliforms in Hampton/Seabrook Harbor tributary and shoreline area assessment units

		Wet Weather Fecal Coliform Data (cfu/100ml)[1]				Percent Reduction Calculation (cfu/100ml)					
Tributary/ Water body Name	Assessment Unit ID	Station	Sample Size	Geomean	Estimated 90th %ile	TMDL = Geomean WQS[2]	MOS[3]	WLA[4]	LA[5]	Percent Reduction based on Geomean[6]	Percent Reduction based on 90th %ile[7]
Blackwater River	NHEST600031004-08-01, NHEST600031004-08-02	HHT1	27	13	108	14	2.8	11.2	0	15%	60%
Mill Creek	NHEST600031004-07	HHT2	27	179	1,630	14	2.8	11.2	0	94%	97%
Hunts Island Creek	NHEST600031004-06	HH35	5	17	NA	14	2.8	11.2	0	36%	NA
Browns River	NHEST600031004-05	HHT3	16	13	NA	14	2.8	11.2	0	11%	NA
Hampton Falls River	NHEST600031003-01	HHT4	27	34	171	14	2.8	11.2	0	67%	75%
Hampton River 2	NHEST600031004-04-02	NA[8]	189	44	465	14	2.8	11.2	0	74%	91%
Hampton/ Seabrook Harbor 2	NHEST600031004-09-02	NA[8]	189	44	465	14	2.8	11.2	0	74%	91%

Notes

1. Geometric mean and 90th percentile FC coliform concentrations calculated using data from the DES stormwater sampling effort in 2002 and the USGS study in 2000. Only samples collected with >0.25 inches of rainfall in the preceding 3 days were included in the calculation. The 90th percentile concentrations were calculated following NSSP guidance (see p.15 of the TMDL report). NSSP guidance calls for at least 30 samples to be included in the 90th percentile calculations (27 samples was considered adequate for this calculation). Therefore, 90th percentiles were not calculated for NHEST600031004-06 and NHEST600031004-05 because the sample sizes for these AUs were 5 and 16, respectively. The other AUs had 27 samples which was assumed to be sufficient for the purposes of this calculation. All the data used to generate these statistics were included in the TMDL report. Summary statistics for these data are shown on Tables 15 and 16 of the TMDL report.

2. TMDL = Total Maximum Daily Load. For the purposes of the percent reduction calculation, the NSSP criterion for geometric mean fecal coliform concentrations (14 MPN/100ml) will be used as the TMDL with the following caveats. The geomean criterion was chosen to the be the TMDL because it was possible to calculate the geomean for each of the tributary AUs. It was not possible to calculate the 90th percentile criterion for all of the AUs. The geomean criterion is only one of several criteria used for NSSP classifications (see section 2(b)(ii)). Moreover, the NSSP criterion is expressed in terms of MPN/100ml, not cfu/100ml. Despite these caveats, comparisons of geomean wet weather FC concentrations to the geomean criterion should provide a reasonable first order estimate of the percent reduction in loadings that is needed in the tributary and shoreline AUs. Wet weather data were used for this calculation because wet-weather is the critical condition of the TMDL (see Section 5(b)(i)). The TMDL equation is: TMDL = MOS + WLA + LA.

3. A 20% margin of safety (MOS) was subtracted from the TMDL/WQS to account for the caveats discussed in footnote 2.

4. WLA = Wasteload Allocation. Each assessment unit includes some WLA stormwater sources. For this TMDL, all stormwater was assigned to the WLA as there was insufficient data to determine individual WLA and LA stormwater contributions.

5. LA = Load Allocation (see note 6)

6. Percent reduction using the geomean criterion is calculated by: (Geomean-(WLA+LA))/Geomean

7. The NSSP criterion for the 90th percentile fecal coliform concentration is 43 cfu/100ml. Therefore, the TMDL based on the 90th percentile concentration would be 43 cfu/100ml. The WLA and LA would be 43 and 0, respectively. All stormwater loads have been assigned to the WLA because there is insufficient information to determine individual WLA and LA stormwater contributions. The MOS would be 0 because there is an implied margin of safety. The 90th percentile is supposed to be calculated using FC measurements during all weather conditions (wet and dry). By calculating the 90th percentile using only the wet weather samples, the estimate will be biased high. The estimated percent reduction needed if the 90th percentile were used as the TMDL is shown on the last column of the table. The reduction is calculated by (90th %ile-43)/90th %ile. The percent reduction using the 90th percentile has been included on this table to show that the percent reductions calculated using the geomean criteria and using the 90th percentile criteria, where applicable, are roughly the same for most of the AUs. The percent reductions using the geomean will be used to prioritize tributaries for TMDL implementation activities because this statistic is likely to be more representative of conditions in the AU.