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Field Evaluation of Wet Weather Bacteria Loading in Hampton/ Seabrook Harbor

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NH Department of Environmental Services

FIELD EVALUATION OF WET WEATHER BACTERIA LOADING IN HAMPTON/SEABROOK HARBOR

Work to Support the Development of a Bacteria TMDL

Workplan Number 01-A-10.1

A Final Report to

The New Hampshire Estuaries Project

Submitted by

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New Hampshire Estuaries Project

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Executive Summary

During 2002, in and around Hampton Harbor, the New Hampshire Department of Environmental Services (DES) conducted two rounds of wet weather sampling of stormdrains, tributaries, and harbor stations for bacteria and flow in order to calculate bacteria loads. This information was needed to prioritize pollution sources as part of a Total Maximum Daily Load (TMDL) study of bacteria in Hampton/Seabrook Harbor.

Introduction

Over the past several years, DES and other agencies have focused a significant effort on identifying pollution sources that contribute to wet weather contamination of Hampton/Seabrook Harbor (hereafter "Hampton Harbor"). The goal of these efforts has been to accurately identify and ultimately eliminate these sources, which contribute to the restrictions on shellfish harvesting that have been in place since 1994. The DES Shellfish Program has identified and sampled approximately 100 sources of stormwater to the estuary. The DES Watershed Assistance Section will soon have funding to address these types of sources. However, these funds can only be used for corrective actions in waterbodies for which a Total Maximum Daily Load (TMDL) has been developed.

DES has proposed the development of a bacterial TMDL for Hampton Harbor, targeted on wet weather sources of contamination. Full TMDL development generally consists of the following steps:

- Problem identification
- Identification of water quality indicators and targets
- Source assessment
- Linkage between water quality targets and sources
- Allocations
- Follow-up monitoring and evaluation
- Assembling the TMDL

The development of the above steps will be largely be completed by existing DES staff without NHEP funding. However, it was determined that the quality of the TMDL would be greatly enhanced with a better assessment of pollution source loadings. Thus, funding from the NHEP was solicited to enhance the "Source Assessment" step; specifically, enhancing the existing data on stormwater sources through targeted monitoring and discharge estimation. Before this study, data on these sources consisted of one sample per pipe from three different storm events, with no data on pipe discharge. To properly quantify bacterial loading from these sources, it was necessary to collect several samples from each source during the same storm, along with concurrent estimations of discharge. This more detailed evaluation of loading enabled a more accurate linkage between water quality targets and sources, enhanced the source allocations developed, and will ultimately lead to a rigorous process for targeting restoration funds on the most significant sources of bacteria.

Project Goals and Objectives

The goal of this project is to monitor the bacteria loads from the highest priority stormwater pipes or conveyances near the shellfish growing areas in Hampton Harbor. Specific objectives are to:

- Select sites for loading measurements
- Monitor bacteria concentrations and flow at selected sites during 2-3 storms of >0.25 inch total precipitation
- Analyze water samples for bacteria concentrations
- Manage and analyze the data from the study

Methods

Storm Selection

For this study, two or three storms were needed with the following characteristics: (1) Onset at or around low tide; (2) >0.25 inches total precipitation; (3) occurrence during daylight hours on Monday-Thursday; and (4) very little rainfall for the prior three days. These criteria were met for the two storms that DES used for this study.

The first storm on July 23, 2002 was a short, but intense rainstorm that dropped 0.33 inches of precipitation over 4 hours (precipitation measured at Seabrook Station). 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. Since these two storms were so different, the monitoring results from each day probably bracket the range of possible loadings. Both rainstorms coincided with a low tide as shown in the following table. Figures 1, 2, and 3 are radar images of precipitation from the storms.

Table 1: Total precipitation, tides, and sampling times for monitored storms

Date	Precip (in)	Low Tide Portland ME	Low Tide Hampton NH	Low Tide Height* (ft)	First Samples Collected	Last Samples Collected
7/23/02	0.33	17:10	17:55	0.7	14:29	19:20
10/16/02	1.39	14:40	15:25	1.3	09:40	16:50

* At Portland ME

Figure 1: The approaching storm on 10/16/02 at 07:25 local time

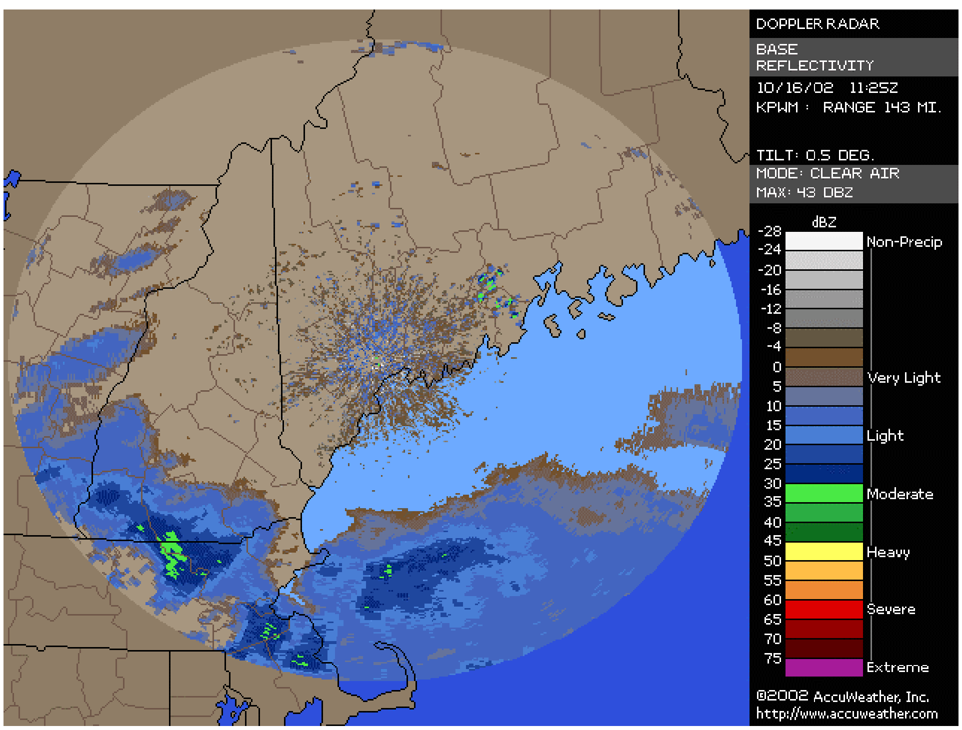


Figure 2: 24 hour precipitation totals for the storm on 7/23/02

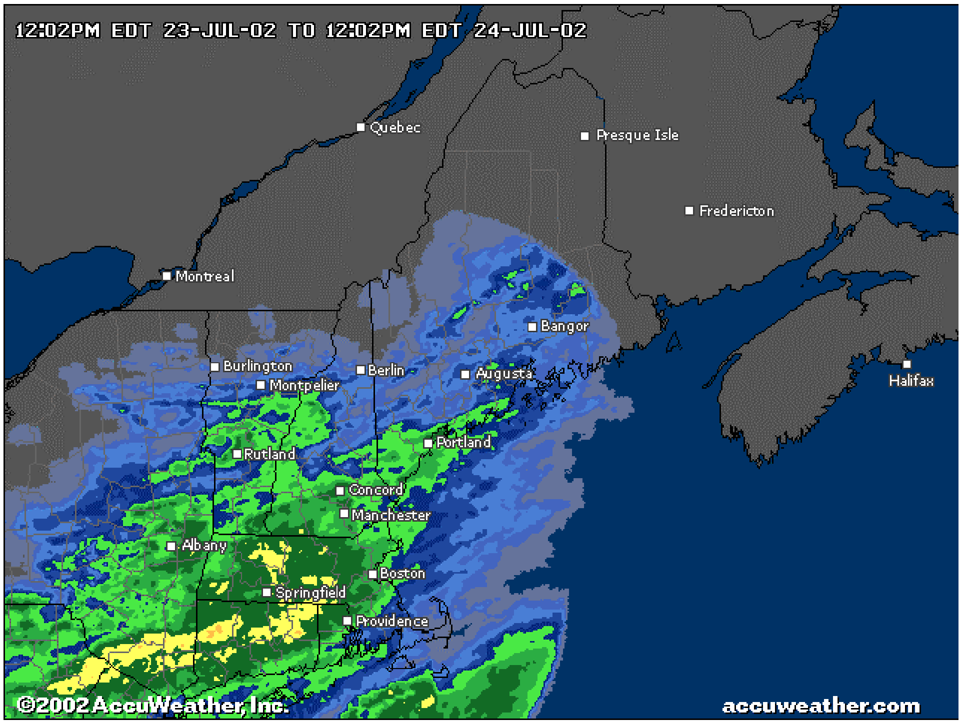
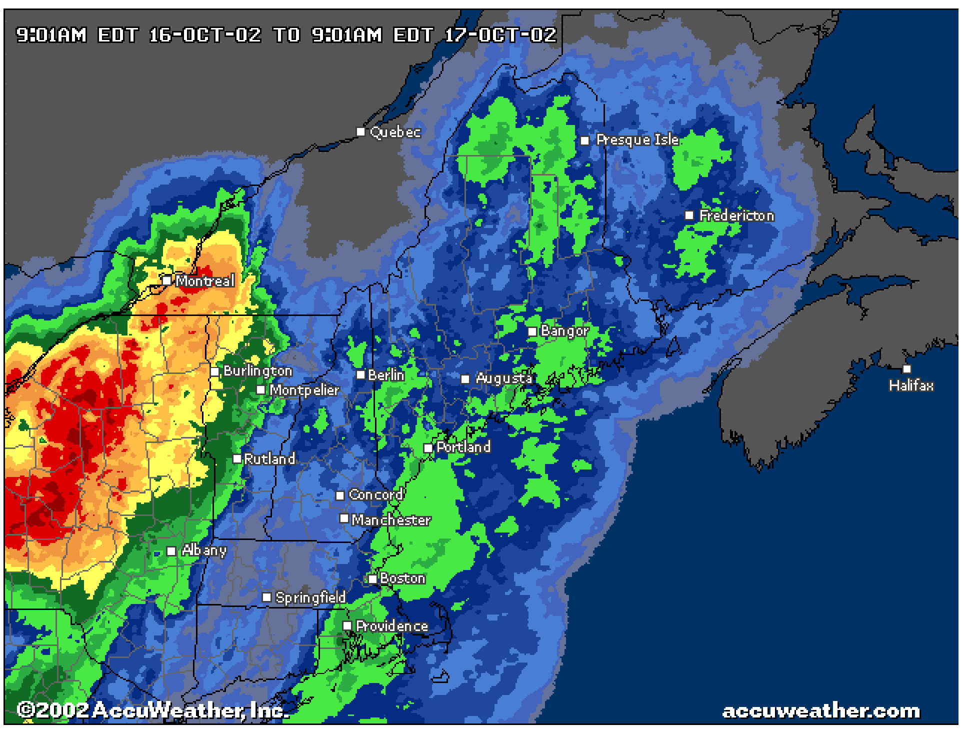
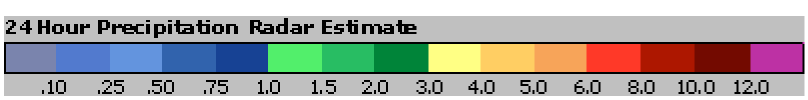


Figure 3: 24 hour precipitation totals for the storm on 10/16/02



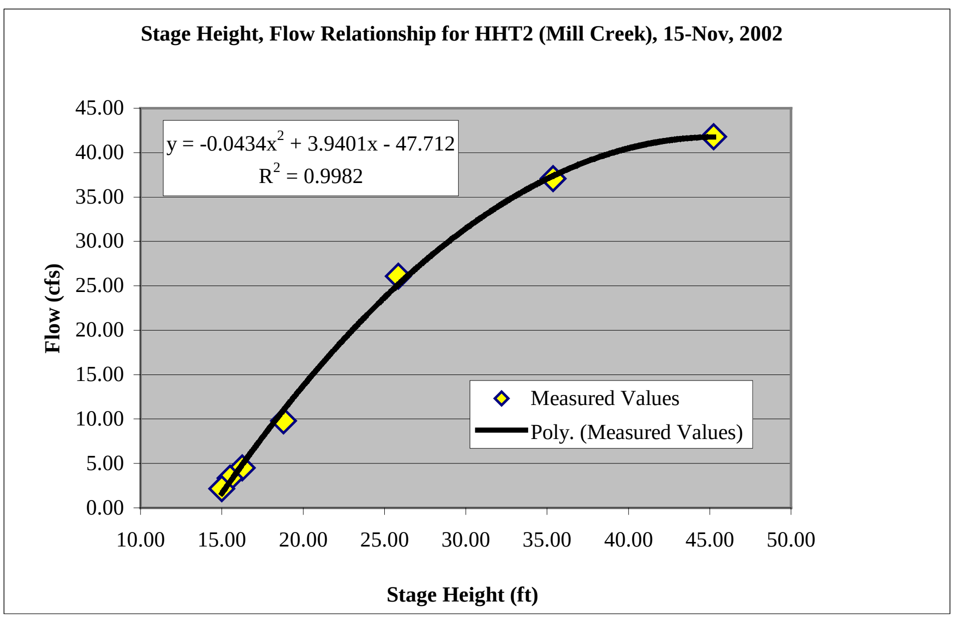


Station Selection and Field Methods

The sampling locations, methods, and data analysis procedures for this study are described in detail in the approved QA Project Plan, which is included as Appendix B to this report. The only portions of the study that are not covered by the QA Project Plan are: (1) Establishment of a stage-height/flow relationship for Mill Creek; and (2) flow estimates for HHPS182 . The methods used for these tasks are described below.

The flow through Mill Creek was needed in order to estimate the bacteria load from the tributary. During storms, the field teams did not have time to measure the flow directly because this would involve a 30 minute river traverse. Instead, a graduated pole was installed in the river near HHT2 on 5/30/02. Field teams recorded the height of water on the pole when they collected samples during the storms on 7/23/02 and 10/16/02. On 11/15/02, DES staff returned to HHT2 and measured the flow in the creek at seven different times during the falling tide. The tidal range on 11/15/02 (low tide height 1.2 ft.) was similar to the range that occurred on 7/23/02 and 10/16/02 (low tide height 0.7-1.3 ft.). DES Standard Operation Procedures for stream flow measurements were used (Appendix C). A quadratic relationship was developed between the flow and the water height on the graduated pole. This relationship was then used to estimate the flow at HHT2 at the time samples were collected during the two storms from the records of water height. The graduated pole was removed on 11/15/02 after the study was complete. The following figure illustrates the relationship between stage height and flow that was developed.

Figure 4: Stage height/flow relationship for HHT2



HHPS182 has two large culverts that are sealed with “duckbill” tide gates. The duckbills prevent measurements of flow in the culverts. However, the northern pipe receives most of its flow from two pump stations (River Street and Ocean Blvd stations). Therefore, total flow from this pipe was estimated from the hours that each pump ran during the storm multiplied by the pump rate. The running time for each pump during the storms was provided by the Seabrook Department of Public Works. The southern pipe at HHPS182 drains a smaller area than the northern pipe and is not associated with any pump stations. Assuming the runoff characteristics of the land are uniform, the flow from the southern pipe was estimated using flow from the northern pipe and the ratio of the area drained by the southern pipe to the area drained by the northern pipe (approx. 0.4). Table D4 in Appendix D contains the flow summaries for HHPS182.

Results and Discussion

The following tables summarize the monitoring data from stormdrains, tributaries, and harbor stations. Stormdrain results are presented as the total load of fecal coliform bacteria discharged from the source over the course of the storm. The results for tributaries are presented as mean concentrations during the two storms with the exception of HHT2 for which loads were also calculated. The table summarizing the harbor stations contains the raw measurements. Raw data for flow and fecal coliform concentrations are presented in Appendix D. For maps of station locations, refer to Figures 4 and 5 of the QA Project Plan (Appendix B). All measurements have passed the QA review specified in the QA Project Plan.

Stormwater from Stormdrains

Loads from the stormdrains monitored for this project are summarized in the following table. The data and any assumptions used for these calculations are shown in Table D5 in Appendix D.

Table 2: Summary of bacteria loads from stormdrain sources

Source	Bacteria Load (7/23/02) 0.33" precip	Bacteria Load (10/16/02) 1.39" precip	Percent of Total Load (7/23/02)	Percent of Total Load (10/16/02)	Comments
	(bill org)	(bill org)	(%)	(%)	
Loading from Stormdrains					
HHPS061	no info	0.0		0%	No Flow
HHPS062	no info	4.1		1%	
HHPS073	no info	0.0		0%	No Flow
HHPS072	5.2	7.7	4%	1%	
HHPS071	0.6	4.7	0%	1%	
HHPS070	0.2	14.7	0%	2%	
HHPS054	0.0	0.0	0%	0%	No Flow
HHPS055/056	0.0	5.0	0%	1%	No Flow 7/23
HHPS057	0.0	0.0	0%	0%	No Flow
HHPS015	1.7	10.8	1%	2%	
HHPS016	11.1	138.4	9%	22%	
HHPS066	13.9	67.0	12%	11%	
HHPS067	1.1	10.0	1%	2%	
HHPS068	0.1	24.0	0%	4%	
HHPS069	14.2	98.2	12%	16%	
HHPS182	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 7/23/02 and 630 billion organisms on 10/16/02. The source with the greatest individual loading (39-60% of the total) was HHPS182 which drains most of the Seabrook Beach area. The four stormdrains behind the Hampton Police Department (HHPS066, HHPS067, HHPS068, and HHPS069) collectively accounted for 25-33% of the monitored loads.

Stormwater from Tributaries

In addition to monitoring loading from stormdrains, the seven major tributaries to the harbor were sampled during the 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 fecal coliforms. The results of the monitoring is shown in the table below.

Table 3: Summary of fecal coliform concentrations in wet weather tributary samples

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 fecal coliform concentrations among the harbor stations is at HH19 at the mouth of Mill Creek (see next section).

The loading from Mill Creek during the two storms ranged from 10 to 26 billion organisms. 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.

Stormwater Effects on Harbor Water Quality

During the two TMDL sampling events, ten stations in the middle of the harbor were monitored before and after the storm. The goal was to document the immediate effect of stormwater loads on the ambient harbor water quality. Results from the harbor station sampling are shown in the following table.

Table 4: Fecal coliform concentrations in Hampton Harbor during TMDL sampling storms

	HH10	HH11	HH12	HH17	HH18	HH19	HH1A	HH2B	HH5B	HH5C	Geomean of All Stations
7/23/02 Pre-storm	10	10	10	10	10	10	10	10	10	5	9.33
7/23/02 Storm 1*	10	10	10	10	5	10	40	10	10	10	10.72
7/23/02 Storm 2*	10	10	30	10	10	20	10	10	10	10	11.96
10/16/02 Pre-storm	10	10	10	40	10	10	10	30	10	10	12.82
10/17/02 Post-storm	10	10	10	30	30	80	10	10	10	30	17.12

* “Storm 1” and “Storm 2” samples on 7/23/02 were collected during the storm.

During both storms, the geomean fecal coliform concentration across all the stations increased 28 - 34% from pre-storm conditions to post-storm conditions. However, these apparent increases were not statistically significant as tested using the Wilcoxon Signed Ranks Test for dependent samples. The only large jump in fecal coliform concentrations was at the mouth of Mill Creek (HH19) between 10/16/02 and 10/17/02. The fecal coliform concentration started at 10 cfu/100ml before the storm and ended at 80 cfu/100ml after the storm. The second reading was the only measurement in the harbor greater than 43 cfu/100ml during the TMDL sampling events. This observation is consistent with the data presented above showing higher fecal coliform concentrations in Mill Creek than in other tributaries.

Conclusions

The results of this study provide insight into the relative magnitude of known sources of bacteria to Hampton Harbor.

Recommendations

The data collected for this study should be used to develop the bacteria TMDL for Hampton Harbor.

Appendices

Appendix A

Budget and Expenditures

Class	Expenditure	NHEP funds Received	NHEP funds Spent	Balance of NHEP funds	NHEP funds to be applied to Little Harbor TMDL	NHEP funds to be repro-grammed
020	Supplies	$1,000	$1,000	$0	$0	$0
030	Equipment	$2,000	$1,418	$582	$582	$0
049	Lab analyses	$11,220	$4,080	$7,140	$2,500	$4,640
050	Overtime/Intern	$1,100	$0	$1,100	$1,100	$0
070	In-State Travel	$200	$0	$200	$0	$200
Total		$15,520	$6,498	$9,022	$4,182	$4,840

Note: $1,230 was amended to the NHEP contract with Great Bay Coast Watch for assistance with the HH TMDL. Since these funds were not included in the DES contract, they do not appear on this table.

Appendix B

Quality Assurance Project Plan

Wet-Weather Bacterial Loading for Hampton Harbor TMDL
Quality Assurance Project Plan

Revision 3 - FINAL

June 20, 2002

Prepared by
Phil Trowbridge
NH Department of Environmental Services
Watershed Management Bureau

Project Manager: ______________________
Signature / Date
Phil Trowbridge, NHDES

Project QA Officer: ______________________
Signature / Date
Peg Foss, NHDES

Program Manager: ______________________
Signature / Date
Gregg Comstock, NHDES

Laboratory Quality Assurance Officer: ______________________
Signature / Date
Rachel Rainey, NHDES

NHDES Quality Assurance Manager: ______________________
Signature / Date
Vincent Perelli, NHDES

USEPA NEP Project Manager: ______________________
Signature / Date
Jean Brochi, US EPA Region I

USEPA TMDL Project Manager: ______________________
Signature / Date
Alison Simcox, US EPA Region I

USEPA Quality Assurance Manager: ______________________
Signature / Date
Arthur Clark, US EPA Region I

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A3 – Distribution List

Table 1 presents a list of people who will receive the approved QAPP, the QAPP revisions, and any amendments.

Table 1. QAPP Distribution List

QAPP Recipient Name	Project Role	Organization	Telephone number and Email address
Phil Trowbridge	Project Manager	NHDES Watershed Management Bureau	603-271-8872 603-661-7561 (mobile) ptrowbridge@des.state.nh.us
Peg Foss	Project QA Officer	NHDES Watershed Management Bureau	603-271-5448 mfoss@des.state.nh.us
Gregg Comstock	Program Manager	NHDES Watershed Management Bureau	603-271-2983 gcomstock@des.state.nh.us
Rachel Rainey	Laboratory QA Officer	NHDES Laboratory	603-271-2993 rrainey@des.state.nh.us
Andrea Donlon	Program QA Coordinator	NHDES Watershed Management Bureau	603-271-8862 adonlon@des.state.nh.us
Vincent Perelli	NHDES Quality Assurance Manager	NH DES Planning Unit	603-271-8989 vperelli@des.state.nh.us
Chris Nash	Field Sampling Coordinator	NHDES Watershed Management Bureau	603-430-7900 cnash@des.state.nh.us
Andy Chapman	Field Sampling Team Leader	NHDES Watershed Management Bureau	603-430-4078 achapman@des.state.nh.us
Natalie Landry	Field Sampling Team Leader	NHDES Watershed Management Bureau	603-433-0877 nlandry@des.state.nh.us
Matthew A. Wood	Field Sampling Team Leader	NHDES Watershed Management Bureau	603-271-8475 mwood@des.state.nh.us
Rob Livingston	Field Sampling Team Leader	NHDES Watershed Management Bureau	603-271-3398 rlivingston@des.state.nh.us
Ann Reid	Volunteer Coordinator	Great Bay Coast Watch	603-749-1565 ann.reid@unh.edu
Jean Brochi	EPA Project Officer (National Estuary Program)	EPA New England	617-918-1536 brochi.jean@epa.gov
Alison Simcox	EPA Project Officer (TMDL Program)	EPA New England	617-918-1684 simcox.alison@epa.gov
Arthur Clark	USEPA Quality Assurance Officer	USEPA New England	617-918-8374 Clark.Arthur@epamail.epa.gov

Based on EPA-NE Worksheet #3

A4 – Project/Task Organization

This study will be completed by staff from NHDES Watershed Management Bureau with sampling assistance from Great Bay Coast Watch volunteers and laboratory analysis by the NHDES Laboratory.

NHDES Watershed Management Bureau

Phil Trowbridge, the N.H. Estuaries Project Coastal Scientist, will be the Project Manager, under the supervision of Gregg Comstock, supervisor of NHDES' Water Quality Planning Section. The Project Manager will be responsible for the overall completion of the project, preparation of the final report, preparation and maintenance of the approved QA Project Plan, and will be the primary contact between NHDES and EPA.

Peg Foss the TMDL Coordinator for the NHDES Water Quality Planning Section will act as the Project QA Officer.

Chris Nash, Supervisor of the NHDES Shellfish Program, will be responsible for deciding when to mobilize the field sampling effort, coordinating field sampling activities, and coordinating sample delivery to the laboratory. Chris Nash will notify Phil Trowbridge when a favorable storm is predicted. Phil Trowbridge will notify all members of the sampling teams by email to hold the date. As the storm nears, Chris Nash will update Phil Trowbridge regarding the suitability of the storm and Phil Trowbridge will keep the rest of the sampling crews informed. The final decision on whether to mobilize the crews will be made by Chris Nash. This decision will be communicated to Phil Trowbridge who will mobilize the crew members through telephone calls.

Natalie Landry, Matthew A. Wood, Rob Livingston, Andy Chapman, and possibly Gregg Comstock and Peg Foss, all of the NHDES Watershed Management Bureau, will be Field Sampling Team Leaders. During each sampling date, each of the Field Sampling Team Leaders will be in communication with the Project Manager via cellular phones in order to resolve any problems.

Great Bay Coast Watch

Ann Reid of Great Bay Coast Watch will organize volunteers to assist with the sampling effort.

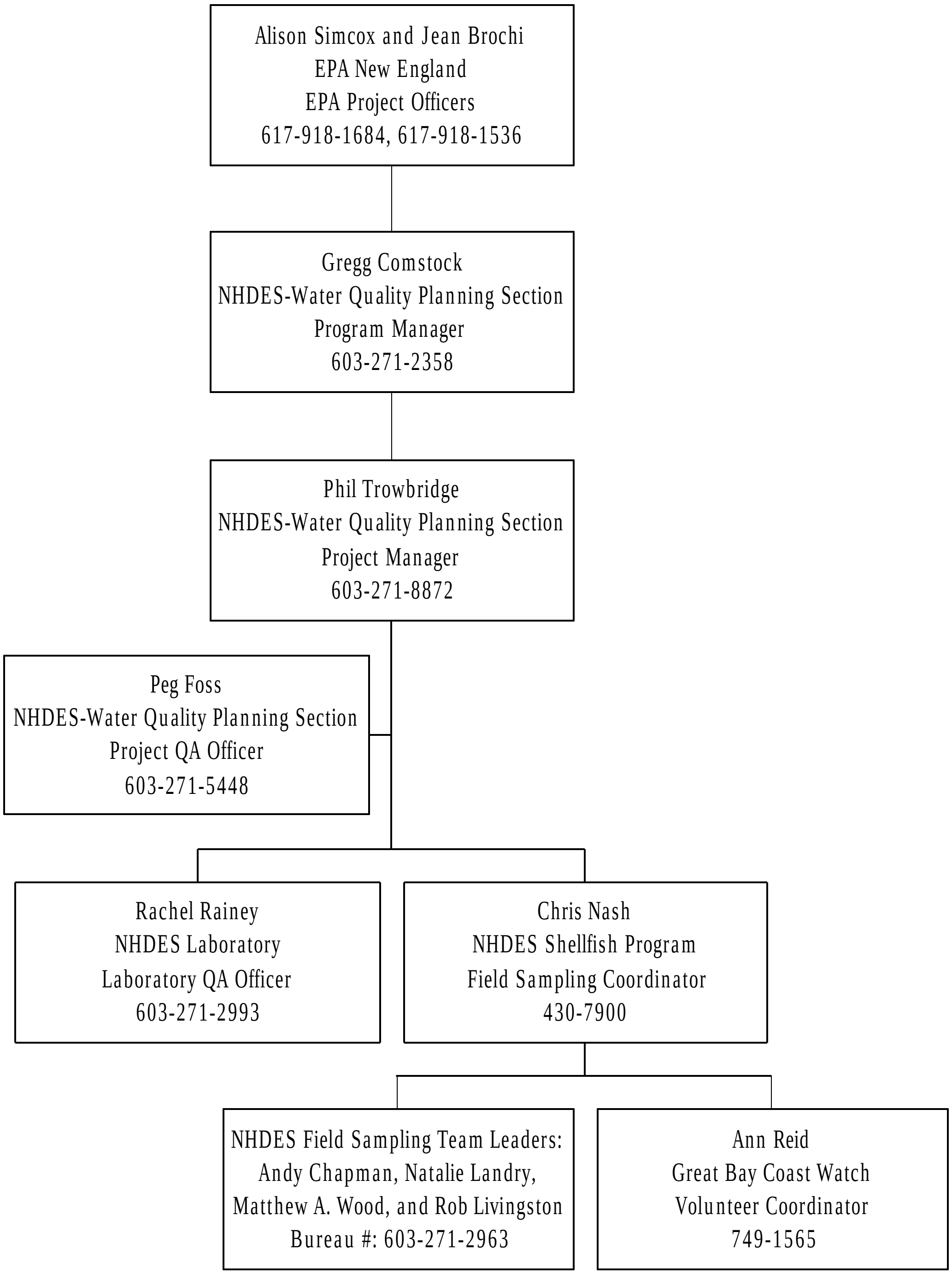
NHDES Laboratory

Rachel Rainey is the Project Manager and QA officer for the NH Department of Environmental Services Laboratory Services Unit (LSU). She will be responsible for conducting the analyses and communicating any analytical problems to the Project Manager.

The data generated by this study will be used by NHDES Water Quality Planning Section to complete a TMDL report to EPA Region I. These data will be made available to the public upon request.

Figure 1 shows an organizational chart for this project.

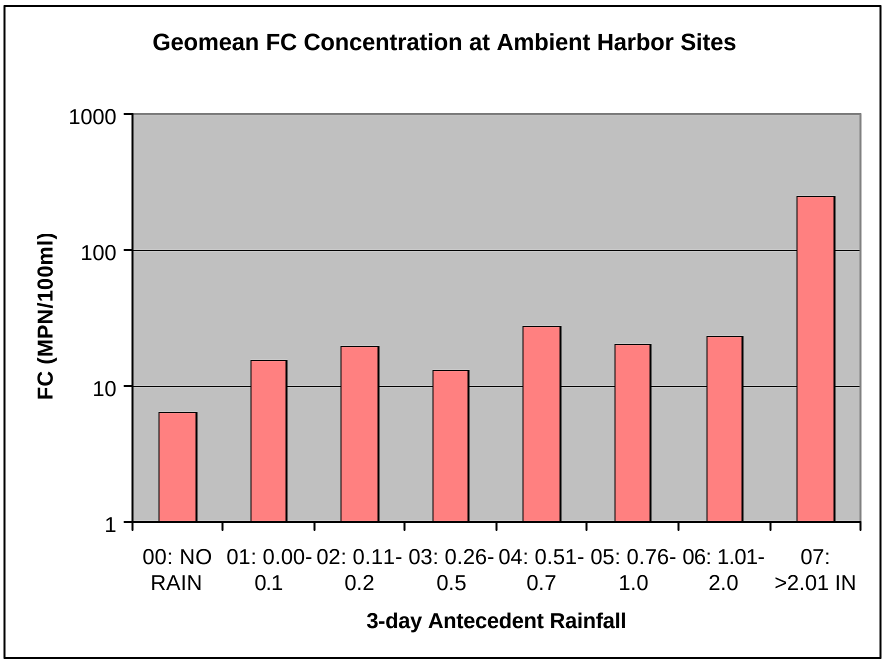
Figure 1. Project organizational chart



A5 – Problem Definition/Background

Hampton Harbor and its tributaries were included on NH's 1998 303(d) list of impaired waterbodies due to bacterial pollution (primarily during wet weather) that impairs its use for shellfishing (see Figure 2 below) (DES 1998). Over the past several years, NHDES and other agencies have focused on identifying pollution sources that contribute to wet weather contamination of Hampton Harbor. The goal of these efforts is to accurately identify and ultimately eliminate these sources (if possible), which contribute to the restrictions on shellfish harvesting that have been in place since 1994. The NHDES Shellfish Program has identified and sampled approximately 100 sources of stormwater to the estuary. The NHDES Watershed Assistance Section will soon have funding to address these types of sources. However, these funds can only be used for corrective actions in waterbodies for which a Total Maximum Daily Load (TMDL) has been developed.

Figure 2: Geometric mean concentrations of fecal coliforms at Hampton Harbor sites (1988-2001)



Note: The NSSP standard for geomean FC is 14 MPN/100ml.

NHDES has proposed the development of a bacterial TMDL for Hampton Harbor, targeted on wet weather sources of contamination. This study will provide information needed for the "Source Assessment" step of the TMDL; specifically, enhancing the existing data on stormwater sources through targeted monitoring and discharge estimation. Existing data on these sources consists of one sample per pipe from three different storm events, with no data on pipe discharge. To properly quantify bacterial loading from these sources, it is necessary to collect several samples from each source during the same storm, along with concurrent estimations of discharge. Simultaneous measurements of bacteria concentrations in the Harbor will provide information on the effects of bacterial loadings on the receiving waters. This detailed evaluation of loading and its effects will be used by NHDES in the TMDL study to: (1) provide for more accurate comparisons of the relative contributions of different bacteria sources (e.g., stormwater, WWTF discharges, natural background, boat discharges, etc.); (2) provide a more accurate linkage between water quality targets and sources; (3) enhance the source allocations developed, and (4) ultimately lead to a rigorous process for targeting restoration funds on the most significant sources of bacteria.

A6 – Project/Task Description

Training Tasks

- Field sampling staff will be trained by the Project Manager and the Field Sampling Coordinator on the sampling and analysis methods and safety measures that will be used for this program.

Sampling Tasks

- Stormwater samples will be collected from approximately 25 storm drain pipes or harbor tributaries. The samples will be analyzed for fecal coliform bacteria ("FC"). Three different storms of greater than 0.25 inches/day will be monitored. For each storm, samples of the stormwater will be collected approximately hourly in order to characterize changes in bacteria concentrations over the storm hydrograph.
- When stormwater samples are collected, the flow of stormwater from the pipe will also be measured in the field.
- Surface water samples from 10 ambient stations in the harbor will be collected simultaneously along with the stormwater samples. These data will be used to illustrate the effect of stormwater loadings on ambient water quality.

Analysis Tasks

- For each pipe, measurements of flow will be combined with bacteria concentrations to estimate the bacteria loading over the duration to the storm.
- FC concentrations at the harbor sites during the storm will be plotted against time to qualitatively evaluate the timing and magnitude of the response relative to the loading.

TMDL Preparation

- The results of the analyses as well as the raw data will be compiled in a TMDL report which is scheduled to be submitted to EPA Region I as a draft by the end of 2002. The public participation component of the TMDL and final revisions will be completed in 2003.

Table 2. Project Schedule Timeline

Activity	Dates (MM/DD/YYYY) Anticipated Date(s) of Initiation	Dates (MM/DD/YYYY) Anticipated Date(s) of Completion	Product	Due Date
QAPP Preparation	04/08/02	06/10/02	QAPP Document	06/10/02
Training	06/11/02	06/12/02	Training records	06/12/02
Wet-weather monitoring and analysis for 2 to 3 storms	06/13/02	10/31/02	Field and Lab Data Packages	10/31/02
TMDL Preparation	11/01/02	12/31/02	Draft TMDL Document	12/31/02
Public Participation	01/01/03	03/01/03	Public participation records	03/01/03
Final TMDL Report	03/01/03	05/01/03	Final TMDL Document	05/01/03

Based on EPA-NE Worksheet #10.

A7 – Quality Objectives and Criteria

Two environmental measurements will be made for this study: (1) FC concentrations in stormwater and ambient harbor water, and (2) flow of stormwater. Water temperature will also be measured but no regulatory decisions will be made based on this parameter. The data quality objectives for each of these measurements are described below.

Table 3: Accuracy and Precision Data Quality Objectives

Parameter	Measurement Range	Precision	Accuracy	Maximum Total Error (1)	Reporting Limit
Fecal Coliforms – Overall for stormwater samples (1ml dilution)	100-20,000 (#/100ml)	60% RPD	NA (see "accuracy" text)	±60%	100 (#/100ml)
Fecal Coliforms – Overall for ambient samples (10ml dilution)	10-2,000 (#/100ml)	40% RPD	NA (see "accuracy" text)	±40%	10 (#/100ml)
Stormwater flux	0-15 (cfs)	20% RPD	±32% (low flow, <0.5 cfs) ±14% (med flow, 0.5-3.0 cfs) ±8% (high flow, >3 cfs)	±38% ±24% ±22%	0.02 (cfs)
Water Temperature	-10 to 40 degC	NA	±0.5 degC	±0.5 degC	-10 degC

Notes:

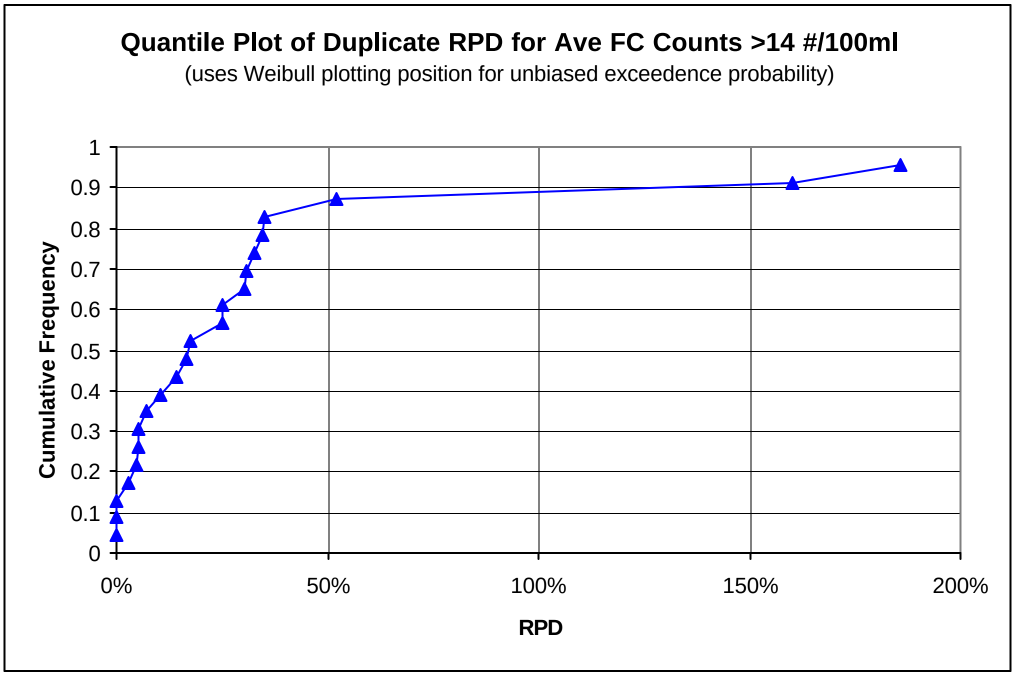
(1) Accuracy error and precision error can be assumed to be independent, random variables. Therefore, the total error in the measurement can be calculated to be root mean square of the two errors:

$$TotalError = \sqrt{AccuracyError^2 + PrecisionError^2}$$

<u>Precision</u>: The concentrations of FC in stormwater are expected to be highly heterogeneous due to fluctuating inputs from rainfall. The 1997 DES Stormwater Characterization Study (DES 1997) found RPDs for *E. coli* duplicate samples between 1.5 and 60% (25% on average) for two storm drains in Concord NH over seven storms. Differences between field duplicate samples collected from storm drains in Hampton Harbor will mostly represent heterogeneity in the stormwater medium, not lack of uniformity in the field sampling methods. As a result, the precision data quality objective for stormwater FC samples has been set at the highest RPD observed in the 1997 study (60%) to match the natural heterogeneity in stormwater that has already been observed.

For the FC samples from ambient harbor samples, the data quality objective for field duplicates will be 40% RPD. This value was determined after analyzing field duplicates of FC measurements (by plate counts) collected in Hampton Harbor by the DES Shellfish Program during 2000. For this study, FC concentrations in ambient samples are expected to be >14 #/100ml. Consequently, only the RPDs for samples with average FC concentrations > 14 #/100ml were used (n=21). A quantile plot of these data, show that greater than 80 percent of the samples were clustered together with RPDs less than 40% (see Figure 3). The few samples with RPDs greater than 40% plotted far away from the rest of the samples and appeared anomalous. Based on these data, an RPD of 40% appears to separate duplicate samples reflective of natural variability in the medium and duplicate samples reflective of potential sampling error. Therefore, 40% was adopted for the data quality objective for ambient harbor samples in this study.

Figure 3: Quantile Plot of RPD from Duplicate Ambient Samples for FC



The field duplicates of stormwater and ambient harbor samples will capture error from all stages of the data collection and analysis. Therefore, RPDs between field duplicates will be considered representative of the total error in the FC measurements.

Duplicate measurements of flow will be conducted to characterize heterogeneity in flow or field methods. The data quality objective for the field duplicates will be 20% RPD.

Accuracy: No accuracy objectives have been set for the FC analyses because there is no practical way to perform spiked samples or analyze standard reference materials for coliforms.

For flow measurements, the accuracy of the methods that will be used have been assessed by the DES Shellfish Program in Appendix A. The methods involve calculating the stormwater flux by measuring the velocity and cross sectional area of the flow. Flux estimates from these methods were checked against accurate measurements of flow (collecting the stormwater in container of known volume and recording the time). During the Hampton Harbor field work, it will not be possible to confirm the accuracy of this method because the bottom of the outfall pipes are set flush with the ground, and, therefore, cannot be evaluated using volumetric measurements. However, if the SOPs for flow measurements are followed (Appendix B), the resulting flow estimates should be accurate to within the limits established in Appendix A. These limits have also been adopted as the data quality objectives for stormwater flux.

Representativeness: The objective of this study is to make measurements that will be representative of the loading of bacteria from storm drains around Hampton Harbor. To that end:

- The storm drains that have been selected for the study were chosen because of their size, previous sampling data indicating elevated bacteria concentrations, and proximity to ambient harbor stations. As a result, these storm drains are expected to be representative of the major stormwater sources of bacteria to the harbor.

- To be representative of the stormwater loading, this study needs to capture the elevated FC concentrations during the "first flush" and to collect subsequent samples at a high enough frequency to characterize how quickly the first flush concentrations decline. By stationing the teams at key outfalls before the storm, this project will be sure to capture the important information of the first flush concentration. Subsequent measurements of bacteria and flow from the storm drains will be taken as frequently as possible, at approximately 30-60 minute intervals. Therefore, the proposed sampling design will capture in both the elevated FC concentrations of the first flush and the changing concentrations during the storm, so that the resulting loading estimate is representative of the overall loading from these pipes.
- The stations that will be sampled in the harbor are used by the Shellfish Program to assess growing areas and, therefore, are considered representative of the harbor. They are the stations that will be used to make future decisions about shellfish growing areas, which makes them uniquely representative of harbor conditions.

Comparability: The field and laboratory methods for this study are identical to those used by the DES Shellfish Program for shoreline surveys and other wet-weather monitoring projects. Therefore, the results will be comparable to other similar studies. The laboratory analyses by the Membrane Filtration Method are based on procedures from Standard Methods for the Examination of Water and Wastewater (18^{th} edition, 9222D).

Sensitivity. Background information on wet-weather FC concentrations in stormwater in Hampton Harbor exists, and the data show that the sensitivity of the proposed laboratory methods are adequate (expected FC concentrations >500 #/100ml in many pipes, see Tables 5 and 6 for data on individual stations). The quantification limit for stormwater flux in the table in Section A7 is based on field studies reported in Appendix A in which the method to be used for this study produced accurate measurements of flow down to 0.02 cfs at the Hubbard Road culvert on 4/1/02.

Completeness: This study proposes to monitor a total of three storms between June and October. However, the study will be sufficiently complete if two storms are monitored. Therefore, a data completeness percentage of 67% is needed.

Total Error For Project: The objective of this sampling program is to monitor loads of bacteria from individual storm drains over the course of three storms. The instantaneous loading from a storm drain at time i (L_i) (in bacteria/minute) will be calculated by (Peters et al., 1974):

$$L_i = CF \cdot F_i \cdot C_i$$

Where F_i is the stormwater flux from an individual drain at time i (in cfs) and C_i is the concentration of bacteria in the stormwater sample (in counts per 100ml) collected at the same time as the flux measurement. CF is a conversion factor of 16,992 (1000 ml/l*28.32 l/ft^3*60s/minute). The error associated with each instantaneous loading calculation will be the combination of the error in the measurements of F and C. The following equation defines the variance in L_i (Var(L)) given known variance in Fi and Ci (Var(F) and Var(C), respectively):

$$Var(L) = \left(\frac{\partial L}{\partial F}\right)^2 \cdot Var(F) + \left(\frac{\partial L}{\partial C}\right)^2 \cdot Var(C)$$

Assuming that the variance is approximately equal to the square of the absolute error (δL), the equation reduces to:

$$\frac{dL}{L} = \sqrt{\left(\frac{dF}{F}\right)^2 + \left(\frac{dC}{C}\right)^2}$$

Where

100% • $\delta L/L$ = the total percent error in instantaneous loading estimate;

100% • $\delta F/F$ = the total percent error in the stormwater flux estimate;

100% • $\delta C/C$ = the total percent error in the FC concentration.

Applying the maximum total error associated with the data quality objectives for FC in stormwater samples (60%) and stormwater flux measurements (22-38%) from Table 3, the maximum total error in each instantaneous loading estimate will be ±64-71%.

The cumulative loading of bacteria from each outfall over the course of the storm (for n stormwater samples) will be calculated by:

$$Ltot = \int_{t=0}^{t=t} L(t)dt \approx \sum_{i=1}^{i=n-1} \frac{(L_i + L_{i+1})}{2} \cdot (t_{i+1} - t_i) = \sum_{i=1}^{i=n-1} Lave_i \cdot \Delta t_i$$

Where Ltot has units of bacteria loaded over the course of the storm. The relative error for each $(L_i + L_{i+1})/2$ term ("Lave") in the summation will be approximately $(\delta L/L)\bullet\sqrt{2}$. There will not be any significant error in the $(t_{i+1} - t_i)$ term ("Δt") because this is simply the time between the collection of sample_i and sample_{i+1} (in minutes). Therefore, the total error for each product of $Lave_i$ and Δt_i will be $(\delta L/L)\bullet\sqrt{2}$. Assuming that each $Lave_i \bullet \Delta t_i$ term in the summation is approximately equal to their average values (Lave and Δt, respectively), Ltot for n stormwater samples can be approximated by:

$$Ltot = \sum_{i=1}^{i=n-1} Lave_i \cdot \Delta t_i \approx (n-1) \cdot Lave \cdot \Delta t$$

and the cumulative error for Ltot can be expressed as:

$$Var(Ltot) \approx (n-1)^2 \cdot Var(Lave \cdot \Delta t)$$

Assuming that the variance of Ltot is approximately equal to the square of the absolute error, $\delta Ltot$, this expression can be rewritten as:

$$\frac{dLtot}{Ltot} = \frac{d\,(Lave \cdot \Delta t)}{Ltot} \cdot (n-1)$$

Substituting (n-1) • $Lave \bullet \Delta t$ for Ltot on the right hand side and then $(\delta L/L)\bullet\sqrt{2}$ for $\delta(Lave\bullet\Delta t)/Lave\bullet\Delta t$ shows that the relative error in the cumulative loading estimate will be equal to the average relative error in the individual loading estimates:

$$\frac{dLtot}{Ltot} = \frac{d\,(Lave \cdot \Delta t)}{Lave \cdot \Delta t} = \left(\frac{dL}{L}\right) \cdot \sqrt{2}$$

Therefore, for the data quality objectives listed in Table 3, the maximum error in the cumulative loading estimate will be ±64-71%. The majority of this error is associated with the high data quality objective for precision for FC in stormwater samples (60% RPD). This high precision value is due to real heterogeneity in FC concentrations in the stormwater samples, and therefore cannot be eliminated.

A8 – Special Training/Certification

Prior to the first storm sampling event, all the Field Sampling Team Leaders for this project will be trained in the methods for collecting stormwater samples and measuring flows (as well as field data sheets for recording measurements and sample numbers). The Field Sampling Team Leaders will be taken to the field sampling locations to orient them to the area. Chris Nash and Andy Chapman of the DES Shellfish Program will conduct the training because Shellfish Program methods will be used for this study. Phil Trowbridge, the Project Manager, will brief the Team Leaders on logistics for each sampling effort including: where/when samples should be delivered, emergency communication networks, and personal protective equipment. Attendance will be mandatory for all Field Sampling Team Leaders. Attendance sheets will be kept on file in the DES Water Quality Planning Section office.

Table 4: Special Personnel Training Requirements

Project function	Description of Training	Training Provided by	Training Provided to	Location of Training Records
Storm drain monitoring	Field methods for collecting FC samples and measuring flows and field sampling logistics. This training will be conducted once at the beginning of the field season.	Chris Nash Phil Trowbridge	All Field Sampling Team Leaders	DES Water Quality Planning Section TMDL records

Based on EPA-NE Worksheet #7.

A9 – Documents and Records

QA Project Plan: The Project Manager will be responsible for maintaining the approved QA Project Plan and for distributing the latest version of the plan to all parties on the distribution list in section A3. A copy of the approved plan will be on file at the DES Water Quality Planning Section offices in Concord.

Field Data Reports: The field data sheets will be used for this project. The Project Manager will collect all field data sheets by the end of each sampling day. All the field data sheets will be photocopied and then distributed in the following manner:

- NHDES Shellfish Program Routine Monitoring QA/Field Data Sheet (Appendix C): Field observations for ambient harbor samples will be recorded on this sheet during the ambient harbor runs. Pertinent information will be transferred to the DES Laboratory's Login and Custody Sheet (see below). The original field data sheets for the ambient sites will be given to the DES Shellfish Program for data entry. The photocopies will remain with the Project Manager.
- DES Laboratory's Login and Custody Sheets (Appendix D): Field data on sample collection at pipes and tributaries will be recorded directly on this form. Field data for the ambient harbor samples will be transferred to this form from the DES Shellfish form after each round of interval sampling. The water temperature will be recorded in the "other" column. The original login and custody sheet will be delivered to the DES Laboratory along with the samples. The photocopies will remain with the Project Manager.
- NHDES Stormwater Flux Field Data Sheet (Appendix E): Field data on measured stormwater fluxes will be recorded in the field on the standardized form. The Project Manager will retain the

original field data sheets for stormwater fluxes and will give the copies to the DES Shellfish Program for redundancy.

Laboratory Data Reports: Data packages from the laboratory will be hardcopy laboratory data sheets containing the FC concentration for each sample.

Final Report to EPA: Field and laboratory data will be reported to EPA Region I in a TMDL report for Hampton Harbor. Phil Trowbridge will prepare the report. A draft of the report is expected to be complete by 12/31/02 (depending on the number of suitable storms that occur in 2002).

Archiving: The original field and laboratory data sheets, QA Project Plan, and the final report to EPA will be kept on file by the DES Water Quality Planning Section for a minimum of 10 years after the publication date of the final report.

B1 – Sampling Process Design

There are two components to the sampling design for this project: (1) stormwater sampling at approximately 25 storm drains and tributaries around Hampton Harbor; and (2) wet-weather monitoring at 10 stations inside the harbor.

Sampling Locations

Approximately 100 stormwater sources have been identified around the harbor. A set of approximately 25 stormwater pipes and tributaries have been selected for intensive wet-weather field sampling. These pipes were selected by the DES Shellfish Program, DES Water Quality Planning Section, and DES Watershed Assistance Program based on the following criteria:

- **Geographic proximity to the actual growing waters of the harbor.** All the pipes with diameters of 12 inches or greater within 5,000 feet of shellfish area monitoring stations were selected to define the universe of pipes close to the growing areas (see Figures 4 or 5 for the boundary of the 5,000 ft buffer). Of these 20 pipes, four (HHPS040, HHPS041, HHPS043, HHPS044) were eliminated because they only received road runoff from a bridge (an approximately 200 ft x 30 ft area). One other pipe (HHPS065) was eliminated because low bacteria concentrations have been consistently recorded in past stormwater samples. One pipe with a 10 inch diameter (HHPS062) was added to the list because it is co-located with another pipe on the list (HHPS061). Therefore, a total of 16 pipes will be monitored for this study. Influences of sources farther upstream from the growing areas will be assessed by monitoring key tributaries at the point where they discharge to the Harbor. A total of 9 tributary stations will be monitored. The combined number of storm drain and tributary stations will be 25.
- **Demonstrated high FC concentrations from past sampling.** The pipes chosen to be monitored comprise the pipes with 8 of the 10 highest FC concentrations measured during wet weather on 9/13/00.
- **Likely to have high flows, based on pipe diameter or nearby land use.** The pipes chosen for the study are located within the developed areas of Hampton and Seabrook. This area has the greatest concentration of impervious surfaces and development within the watershed of Hampton Harbor.
- **Located in areas that may have sources of bacteria related to development.** The pipes that will be monitored are in the most developed areas of Hampton and Seabrook where human sources of bacteria are possible. Monitoring at tributary stations will be used to assess bacteria sources upstream in the watershed.

Based on these criteria, the selected monitoring stations for storm drain pipes and tributaries are as follows (see Figure 4 for locations):

Table 5: Stormwater pipes and tributaries for this study

Field Team	Pipe Station No.	Pipe Diameter (in)	Wet-weather FC range (1,2) (#/100ml)	Dry-weather FC range (1,2) (#/100ml)	Comments
Pipe Team 1	HHPS061	20	660-7,200	20-30	Next to 062
Pipe Team 1	HHPS062	10	60-2,900	20-21	Next to 061
Pipe Team 1	HHPS073	12	8000	No data	
Pipe Team 1	HHPS072	18	500-5480	No data	Next to 071
Pipe Team 1	HHPS071	28	120-10,560	20	Next to 072
Pipe Team 1	HHPS070	28	7,060-12,840	20-660	
Pipe Team 2	HHPS063	15	500-3,420	10-20	No flow meas.
Pipe Team 2	HHPS054	12	10,220	No data	(3) No flow meas.
Pipe Team 2	HHPS055	18	5,960	20	(3)
Pipe Team 2	HHPS056	36	220-10,320	1-3	(3) No flow meas.
Pipe Team 2	HHPS057	18	20-1,760	1-2	(3) No flow meas.
Pipe Team 2	Conveyances from wetland areas NE of Rte 101 (HHPS015)	42	1,845-3,280	120-258	Next to 016 (a.k.a. HHT7)
Pipe Team 2	Same as above (HHPS016)	60	4,300-7,740	475-880	Next to 015 (a.k.a HHT6)
Pipe Team 2	Tide Mill Creek (HHT8)	NA-Tributary	0.5-138	1-40	Downstream of WWTF
Pipe Team 3	HHPS066	36	200-13,400	40-980	(4) 30 minute data
Pipe Team 3	HHPS067	12	100-8,000	14-20	(4) 30 minute data
Pipe Team 3	HHPS068	36	700-15,600	20-31	(4) 30 minute data
Pipe Team 3	HHPS069	36	740-20,800	17-20	(4) 30 minute data
Trib Team	HHPS182	30	70-7,300	90-2,200	(5) No flow meas.
Trib Team	Blackwater River (HHT1)	NA-Tributary	0.7-64	0.5-10	
Trib Team	Mill Creek (HHT2)	NA-Tributary	7-760	18-190	
Trib Team	Hampton Falls River (HHT4)	NA-Tributary	8-450	1-15	
Trib Team	Taylor River (HHT5)	NA-Tributary	1-370	17-51	
Boat Team	Browns River (HH35)	NA-Tributary	No data	No data	
Boat Team	Hampton River (HH15)	NA-Tributary	No recent data	No recent data	Head of the Hampton River

Notes:

(1) Wet-weather data defined as either stormwater data collected during a rainstorm or data from tributary stations where more than 0.5 inches of rain had fallen in the previous 3 days (DPHS, 1994). Dry weather samples were samples collected when the three day antecedent rainfall was zero.

(2) All FC data on this table are concentrations measured as counts in #/100ml.

(3) HHPS054, HHPS055, HHPS056, and HHPS057 are in the same general area. Of these four, the greatest area is drained by HHPS055. The flow from HHPS055 passes under a roadway to become HHPS056. The only additional contribution of stormwater between HHPS055 and HHPS056 is HHPS054 and some road run-off. HHPS054 only receives flow from a small catchbasin nearby and bacteria from HHPS054 will be captured by the sample taken at HHPS056. HHPS057 is a broken culvert on which flows cannot be measured. Therefore, for this set of drains, bacteria samples will be collected from all four pipes; however, stormwater flow will only be measured at HHPS055. If roadwork on Highland Avenue is complete, the flow measurement at HHPS055 can be taken in a grated culvert a short distance upstream. It will be assumed that the flow from HHPS054 is approximately equal to the flow from HHPS056. The flow from HHPS054 and HHPS057 cannot be estimated reliably but bacteria measurements throughout the hydrograph will provide useful information about bacteria loads from this culvert.

(4) HHPS066, 067, 068, and 069 drain approximately one half of the developed portion of Hampton Beach. These four pipes have outfalls at the same location. Due to the size of their collective drainage area and their proximity to each other, one team will remain at these pipes during the storm and will collect samples and conduct flow measurements at approximately 30 minute intervals.

(5) HHPS182 has two large culverts that are sealed with “duckbill” tide gates. The duckbills prevent measurements of flow in the culverts. However, the northern pipe receives most of its flow from two pump stations so total flow during a storm can be estimated from pump station records kept by the Seabrook Department of Public Works. The flow from the southern pipe will be estimated using flow from the northern pipe and the ratio of the area drained by the southern pipe to the area drained by the northern pipe. Stormwater samples will be collected from the pool of water where these two pipes discharge to characterize the fluctuations in bacteria concentrations throughout the hydrograph.

Simultaneous with the storm drain sampling, the 10 ambient stations in the harbor will be sampled for FC. These stations cover the full extent of the harbor and its major tributaries and are considered representative of the major shellfish growing areas in Hampton Harbor (Figure 5). Data from the ambient harbor stations during the storm will be used to evaluate the effects of stormwater bacteria loads on ambient water quality in the growing areas.

Table 6: Ambient harbor stations for this study

Field Team	Station No.	Wet-weather FC geomean and range (1,2) (MPN/100ml)	Dry-weather FC geomean and range (1,2) (MPN/100ml)	Comments
Boat Team	HH1A	**24.3** (1.8-790)	**7.8** (1.8-130)	
Boat Team	HH10	**20.8** (1.8-1,300)	**5.6** (1.8-149)	
Boat Team	HH11	**16.8** (1.8-1,300)	**6.8** (1.8-149)	
Boat Team	HH5B	**25.4** (2-1,300)	**6.5** (1-79)	
Boat Team	HH5C	**29.0** (1.8-1,600)	**6.5** (1.8-79)	
Boat Team	HH12	**18.6** (1.8-1,300)	**6.3** (1.8-140)	
Boat Team	HH17	**23.3** (1.8-490)	**7.9** (1.8-240)	
Boat Team	HH18	**15.6** (1.8-330)	**4.4** (1.8-95)	
Boat Team	HH19	**25.9** (1.8-1,300)	**7.4** (1.8-130)	
Boat Team	HH2B	**26.8** (1.8-1,300)	**6.8** (1.8-230)	

Notes:

(1) Wet weather sample are defined as samples collected when there had been more than 0.5 inches of rain over the previous 3 days (DPHS, 1994). Dry weather samples are defined as samples for which the three day antecedent rainfall was zero.

(2) All FC measurements on this table are MPN in MPN/100ml. Data summarized are all results from 1988 through 2000 for low-tide samples (excluding split samples and emergency closure sampling). The geometric mean concentration for all the samples is shown in **bold**. The range is shown in parentheses.

Selection of Storms for Wet-Weather Monitoring

Sampling will be initiated for storms that are predicted to have total rainfall >0.25 inches per 24 hours. Sampling will begin in the spring of 2002 and will conclude by late fall 2002. Up to 3 storms will be monitored. Based on an assessment of precipitation data from the nearby station in Durham NH (see table below), 15 to 29 storms of at least 0.25 inches daily precipitation are expected between June and October. For this study, storms that begin a few hours prior to the time of low tide will be preferred because many of the storm drains are submerged at high tide. Storms will also have to occur during daylight hours, and the normal workweek (excluding Fridays). Short-term storms, such as thunderstorms, will not be targeted because it would be difficult to mobilize field teams on such short notice. Given these restrictions, only a fraction of the storms of >0.25 inches will be suitable for this study. The expected number of storms meeting all the criteria is 2 or 3 based on the following assumptions and equation:

- Assume that storms occur randomly relative to tide, daylight hours, and days of the week;
- Assume that tide, daylight hours, and days of the week are independent;
- Assume that that the probability of a storm occurring at low tide is 0.5;
- Assume that the probability of the storm occurring during daylight hours is 0.5;
- Assume that the probability of the storm occurring between Monday and Thursday is 0.6,
- Then the expected number of storms will be the total storms greater than 0.25 inches (15 to 29) multiplied by 0.5*0.5*0.6, which equals 2 or 3 integral storms.

Table 7: Number of storms of different size classes recorded in June-October in Durham

PRECIP (inches)	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
0-0.1	122	112	121	118	119	124	125	122	120	132
0.11-0.25	10	12	8	10	14	11	8	10	14	6
0.26-0.50	8	12	12	13	5	11	13	10	7	8
0.51-0.75	2	7	3	4	6	2	2	3	3	3
0.76-1.00	2	6	3	4	5	3	2	3	1	1
1.01-2.00	8	4	5	2	3	2	2	5	4	3
2.01+	1		1	2	1		1		3	
>0.25	21	29	24	25	20	18	20	21	18	15

If no suitable storms have occurred by September 1, 2002, it may be necessary to target smaller storms. The decision to target smaller storms will be made by the Project Manager after consulting with the rest of the project team and the EPA TMDL Project Officer. Sampling will be done for up to three storms.

Sampling Schedule

When an appropriate storm is predicted, five sampling teams will be dispatched to Hampton Harbor: 3 "pipe teams" for stormwater sampling in pipes, 1 "trib team" for collecting samples from tributary sites, and 1 "boat team" to collect ambient harbor samples. Each team will collect "pre-storm" samples, "first flush" samples, and then samples at 30-60 minute intervals for the first 2-3 hours of the storm. Each team will be lead by a Field Team Leader from NHDES and a volunteer from Great Bay Coast Watch.

Table 8: Field sampling team members

Team	Leader	Members
Pipe Team 1	Matthew A. Wood or Rob Livingston	1 Great Bay Coast Watch volunteer
Pipe Team 2	Andy Chapman	1 Great Bay Coast Watch volunteer
Pipe Team 3	Phil Trowbridge	2 Great Bay Coast Watch volunteers
Trib Team	Natalie Landry	1 Great Bay Coast Watch volunteer
Boat Team	Chris Nash	1 Great Bay Coast Watch volunteer

* Alternates: Peg Foss (QA Project Officer), Gregg Comstock (Program Manager)

Pre-Storm Samples

Each team will be sent to its starting location to collect "pre-storm" water samples before precipitation begins. The pipe teams will also measure "pre-storm" flows. It will not be possible to collect pre-storm samples at all of the pipes because the teams must remain in place in order to capture the first flush samples. However, the following starting locations have been chosen to represent the major stormwater outfalls.

Table 9: Field team locations for "pre-storm" samples

Team	Location for "Pre-Storm" Samples
Pipe Team 1	HHPS071, HHPS072. These two outfalls are collocated so it will be possible for the team to collect samples from multiple pipes at the same time.
Pipe Team 2	HHPS054, HHPS055, HHPS056, HHPS057. These four outfalls are collocated.
Pipe Team 3	HHPS066, HHPS067, HHPS068, HHPS069. These four outfalls are collocated.
Trib Team	This team will attempt to collect a full suite of samples from all their sites before the rainfall begins (approximately 1 hour required).
Boat Team	This team will attempt to collect a full suite of samples from all their sites before the rainfall begins (approximately 1 hour required).

First Flush Samples

The pipe teams will remain at their starting locations until they notice a significant increase in stormwater flow from the pipe at which point they will collect a "first flush sample". The Trib and Boat teams will collect another round of samples from all of their stations over the first hour of the storm. As explained in the previous section, it will not be possible to collect first flush samples at all of the pipes due to the limited number of field teams. The locations chosen for first flush samples are the major outfalls that drain the majority of stormwater from Hampton. Because each pipe will have a different response time to the rainfall, the first flush samples at all of the pipes will not be taken at the same time – but rather at the time each individual pipe demonstrates a response to the rainfall.

Table 10: Field team locations for "first-flush" samples

Team	Location for "First Flush" Samples
Pipe Team 1	HHPS071, HHPS072. These two outfalls are collocated so it will be possible for the team to collect samples from multiple pipes at the same time.
Pipe Team 2	HHPS054, HHPS055, HHPS056, HHPS057. These four outfalls are collocated.
Pipe Team 3	HHPS066, HHPS067, HHPS068, HHPS069. These four outfalls are collocated.
Trib Team	This team will attempt to collect a full suite of samples from all their sites during the first hour of the storm (approximately 1 hour required).
Boat Team	This team will attempt to collect a full suite of samples from all their sites during the first hour of the storm (approximately 1 hour required).

Interval Samples

After collecting the first flush samples, the pipe teams will move to their next location as specified on the following table. For the last sample of each interval, they will return to the site where the collected the first flush sample. The Trib and Boat teams will continue to rotate through all of their stations. Each team will rotate through all of their sites every 30 to 60 minutes during the first 2-3 hours of the storm. The stations where flow will not be measured (as discussed in Section B1) are marked. The field teams will continue to collect samples until either (1) the Project Manager terminates the effort; or (2) the stormwater outfalls assigned to the team are inundated by the rising tide.

Table 11: Field team locations for "interval" samples

Team	Locations for Interval Samples	Frequency	Duration
Pipe Team 1	1. HHPS061 & HHPS062 2. HHPS070 3. HHPS073 4. HHPS071 & HHPS072	Approximately hourly	2-3 hours (2-3 complete sets of samples)
Pipe Team 2	1. HHPS063 [no flow] 2. HHPS016 & HHPS015 3. HHT8 [no flow] 4. HHPS054/055/056/057 [flow only at HHPS055]	Approximately hourly	2-3 hours (2-3 complete sets of samples)
Pipe Team 3	1. HHPS066, HHPS067, HHPS068, HHPS069.	Approximately every 30 minutes	2-3 hours (4-6 complete sets of samples)
Trib Team	1. HHT1 [no flow] 2. HHT2 [no flow] 3. HHT4 [no flow] 4. HHT5 [no flow] 5. HHPS182 [no flow]	Approximately hourly	2-3 hours (2-3 complete sets of samples)
Boat Team	10 harbor sites plus HH35 and HH15	Approximately hourly	2-3 hours (2-3 complete sets of samples)

[no flow] = a flow measurement will not be made at this location.

Field Documentation

When the field samplers collect bacterial samples at a stormwater pipes and tributary stations, they will also note time, and water temperature (in the “other” column) on the Laboratory Login and Custody Sheet (Appendix D). Flow measurements will be recorded on the Stormwater Flux Field Data Sheet (Appendix E)

At harbor stations, the field samplers note time and water temperature on the NHDES Shellfish Program Routine Monitoring QA/Field Data Sheet (Appendix C). Pertinent information will be transferred from this sheet to the Laboratory Login and Custody Sheet (Appendix D) after each sampling interval.

Summary

The total number of stormwater samples that will be collected for this project range from 132 to 171 samples per storm. The number of QC samples will be discussed in section B5.

B2 – Sampling Methods

Fecal Coliforms

Samples are collected in 250 mL-clear, polyethylene, pre-sterilized Nalgene bottles, supplied by the DES laboratories. On sample bottle labels, the sample date, sample time, and sample site identification code will be recorded using water proof/ indelible ink.

The bacterial sample will be collected by positioning the mouth of the bottle opposite the direction of flow. If the water is deep enough, the sample should be collected using a sampling pole by thrusting the bottle 8-12 inches under the surface of the water using a continuous "U" shaped motion until almost full, leaving a one-inch air space. Samples are collected with the container completely submerged, so as to minimize the collection of water on the immediate surface. The bottle may need to be shaken to remove water, allowing for a one-inch air space. Samples are collected without disturbing the substrate. If the substrate is disturbed while collecting a sample, the sampler will discard the sample and bottle and will collect another sample away from the disturbed area to minimize contamination possibilities.

Samples will be immediately stored on ice or ice pack in a light-tight cooler until delivery to the laboratory.

The temperature of all samples are measured using an infrared sensor and recorded when they are delivered to the laboratory to confirm that the proper temperature was maintained, preferably between 0-10°C, during sample collection and transport.

Stormwater Flux

Stormwater flux will be measured at each stormwater pipe by measuring the cross sectional area of flow in the pipe and its average velocity. For flows greater than 2 inches in depth and greater than 0.1 ft/s (the detection limit of the meter), current meters from Global Water will be used to measure the velocity. For shallower flows or flows less than 0.1 ft/s, the velocity will be inferred from the time required for a miniature float to move a known distance. The protocols for making the flow measurements are attached in Appendix B. An evaluation of the accuracy of the methods is attached in Appendix A.

Temperature

Water temperature at each sample site is measured using a Reotemp, stainless steel, bi-metal thermometer or equivalent. Water temperature is measured by placing the thermometer in the water until the thermometer reading has stabilized. If this method is not appropriate for the field conditions, a sample will be collected in a sample bottle, the thermometer will be inserted into the bottle to measure the temperature, and the water will be discarded after the temperature has been recorded. The temperature is measured by looking squarely at the face of the thermometer. The water temperature for each stormwater and tributary sample will be recorded in the "comments" field of the DES Laboratory Login and Custody Sheet (Appendix D). The water temperature for each ambient water sample will be recorded on the second page of the DES Shellfish Program Routine Monitoring QA/Field Data Sheet (Appendix C)

Table 12: Sample Requirements

Analytical parameter	Collection method	Sampling SOP	Sample volume	Container size and type	Preservation requirements	Max. holding time (preparation and analysis)
Fecal coliforms	Grab	See text	150 mL	250 mL sterile clear polyethylene	Chilled to = 10ºC	8 hours (except under extenuating circumstances - see B3)
Water Temperature	measured in-situ	See text	NA	NA	NA	NA
Stormwater flux	measured in-situ	See text	NA	NA	NA	NA

Based on EPA-NE Worksheet #12b.

Field Corrective Measures

The Project Manager will be responsible for making decisions in the field to correct for any field sampling problems. All of the Field Sampling Team Leaders and the Project Manager will have mobile phones for communication in the field. If a Field Sampling Team Leader is not able to follow the SOPs for sampling listed in the QA Project Plan, they will call the Project Manager and explain the problem. The Project Manager will decide on the course of action and will relay consistent information to all the other Field Sampling Team Leaders.

B3 – Sample Handling and Custody

Water samples for bacteria analysis will be stored and transported on ice in coolers. The water temperature of the samples is measured by DES Laboratory staff using an infrared sensor and is recorded on the data sheet at the time of sample delivery. The samples will be delivered to and analyzed by the laboratory within 8 hours of collection. Although DES will make every effort to meet the 8 hour holding time requirement, if the stormwater sampling must occur after 5 pm due to timing of the storm and low tide, the samples will not be analyzed until the following morning. The samples would be stored on ice in the secure DES Laboratory cold room overnight and would be analyzed no later than 30 hours after collection. While this duration exceeds the holding time for the Membrane Filtration Method (SOP 10.34a), 30 hours is considered an acceptable holding time by APHA (1970). If samples are stored in the laboratory cold room, they will be signed in and signed out of storage on the laboratory login and custudy sheet with the date, time, and staff noted.

Each sampling team will be responsible for delivering their samples and field data sheets to the Project Manager at two times during the sampling day.

1. Between the first and second set of interval samples, the field teams will drop off all their samples collected up to that point and their associated Laboratory Login and Custody Sheets (Appendix D) with the Project Manager at the parking lot behind the Hampton Police Department (corner of Brown and Ashworth Streets). The Project Manager will transfer the samples iced coolers and confirm that all samples are properly documented with field sheets. Then, these samples will be delivered by a Great Bay Coast Watch volunteer in one batch to the DES Laboratory. The volunteer will make copies of the Login and Custody Sheets and will leave them with the Laboratory staff to deliver to the Project Manager.
2. The sampling teams will reconvene again at the end of the sampling day at this same location. All other samples and all field data sheets will be transferred to the Project Manager. The Project

Manager will confirm that all samples are properly documented with field sheets before releasing the field teams. The Project Manager will deliver the second batch of samples to the laboratory and will make copies of all field data sheets. The copies of the field data sheets will be distributed according to the plan in Section A9.

B4–Analytical Methods

Fecal coliforms in stormwater and ambient samples will be analyzed by the DES Laboratory using the Membrane Filtration Method (SOP 10.43a on file with EPA). This will be conducted by the DES Laboratory. Samples of stormwater will be analyzed at the 1 ml dilution. Pre-storm samples and samples from the ambient harbor sites will be analyzed at the 10 ml dilution.

The Laboratory QA Officer will be responsible to resolving any problems with the laboratory method and informing the Project Manager of the quality of the data.

B5 – Quality Control

Precision Calculations

Precision of FC and flow measurements will be assessed from field and laboratory duplicates using relative percent difference (RPD):

$$RPD = \frac{|x_1 - x_2|}{\frac{x_1 + x_2}{2}} \times 100\%$$

where x_1 is the original sample concentration (or flow)
x_2 is the duplicate sample concentration (or flow)

Fecal Coliforms

Overall Precision: Each team will collect a field duplicate for every 10th fecal coliform sample. The RPD between the duplicate pair will be calculated using the formula at the beginning of section B5. If one of the two samples is qualified as “less than” or “greater than” a value, the reported value will be used in the RPD calculation. The RPD will be compared to the data quality objective. If the RPD is less than or equal to the data quality objective, the duplicate samples will be considered “in control”. If the RPD is greater than the data quality objective, the two duplicate samples will be flagged for investigation by the Project QA Officer.

Stormwater Flux

Each team will repeat every 10th field measurement of stormwater flux. The RPD between the duplicate pair will be calculated using the formula at the beginning of section B5. If the RPD is less than or equal to the data quality objective, the duplicate samples will be considered “in control”. If the RPD is greater than the data quality objectives, the two duplicate samples will be flagged for investigation by the Project QA Officer.

Project QA Officer Investigations

For any measurement flagged for investigation, the Project QA Officer will review the field and laboratory data sheets and talk with the field sampling team that collected the sample to determine if the large variation can be explained by deviation from field sampling SOPs. If all SOPs were appropriately followed, the difference between the duplicate samples will be considered representative of natural heterogeneity in the sampled medium. The conclusions of the Project QA officer will be documented in a report to the Project Manager.

B6/B7 – Instrument/Equipment Testing, Inspection, Maintenance, Calibration and Frequency

Field instruments used during water sample collection include a Global Water "Global Flow Probe" flow meter and a Reotemp thermometer.

Global water flow meters are calibrated at least annually when their batteries are changed. See Appendix B for calibration procedures.

The Reotemp thermometer is calibrated annually at a minimum. The date of calibration is recorded on a piece of tape attached to the thermometer. Temperature measurements will not be used to make any management decisions. This information will be collected to provide background information.

Laboratory instruments and equipment are inspected, maintained and calibrated by the laboratory. Refer to the NHDES Standard Operating Procedures for the Fecal Coliform Test by Membrane Filtration (SOP 10.43a) and the Quality Systems Manual: State of New Hampshire Department of Environmental Services Laboratory Services Unit.

Table 13: Instrument/Equipment Calibration Table

Equipment name	Procedure	Frequency of calibration	Acceptance criteria	Corrective action	Person responsible
Global Water "Global Flow Probe"	Appendix B	Annually	Code = 33.31	Reset code to 33.31	Field operator

Based on EPA-NE Worksheet #14.

B8 – Inspection/Acceptance Requirements for Supplies and Consumables

Field Inspection: Sample bottles will be inspected by field personnel before sample collection. Bottles that may have been contaminated will be returned to the laboratory for sterilization.

Laboratory Inspection: The procedures used by the DES Laboratory to inspect supplies and consumables are described in SOP 10.43a.

B9 – Non-direct Measurements

Tidal data are used in making decisions on when to sample. Samples are collected during tidal conditions suitable for sample collection. Data on time of low tide are acquired from National Oceanic and Atmospheric Administration tide charts, using times for the Portland, ME base station (available at http://www.co-ops.nos.noaa.gov/cgi-bin/predictions.cgi?stn=8418150+Portland+,+ME). Using this information and the tidal lag for each sampling site, the appropriate tidal conditions for sampling can be determined.

Rainfall data are used to measure the amount of liquid precipitation from each storm. The weather station from which data will be acquired is Seabrook (North Atlantic Energy Service Corporation), NH.

Predictions of weather from internet sources and the National Weather Service will be used to identify potential storms meeting the criteria for this study. Some specific sources include: www.accuweather.com and the National Weather Service office in Grey ME (207-688-3216 or 800-482-0913 after 5 pm).

Pump station records from the Town of Seabrook DPW will be used to estimate total discharge through the northern outfall at HHPS182. The pumps are rated at 2,340 gallons/minute. DPW staff will read the log of pump run time before the target storm and again at the end of the DES sampling round. The total amount of time that the pumps ran during this time will be multiplied by the pumping rate to estimate the total amount of water discharged during the time that water samples were collected from the outfall.

B10 – Data Management

Data Recording Procedures: Field data will be recorded on standardized field data sheets (Appendices C, D, and E). When completing these forms, the field staff will follow the procedures from the DES *Quality Management Plan (QMP)* (June 2001) sections 6.3 and 8.7, especially the sections excerpted below:

- 6.3.a. The records shall clearly indicate the date of the field observation, sample collection, sample preparation, equipment calibration or testing, and other related activities.
- 6.3.b. The records shall include the identity of personnel involved in making observations, collecting field data, sampling, preparation, calibration, or testing.
- 6.3.c. The record-keeping system shall facilitate the retrieval of all working files and archived records for inspection and verification purposes.
- 6.3.d. All documentation entries shall be signed or initialed by responsible staff. The reason for the signature or initials shall be clearly indicated in the records such as “sampled by”, “prepared by”, or “reviewed by”.
- 6.3.e. All generated data except those that are generated by automated data collection systems, shall be recorded directly, promptly, and legibly in permanent ink.
- 6.3.f. Entries in records shall not be obliterated by methods such as erasure, overwritten files, or markings. All corrections to record-keeping errors shall be made by one line marked through the error and initialed. These criteria also shall apply to electronically maintained records, where applicable.

For the purposes of this study, the identities of all field staff should be recorded as their first initial and full last name. Also, because the sampling will occur during rainstorms, waterproof paper and pencils will be used to record the field data.

Manipulations of Raw Data: There will be no manipulations of raw data prior to data entry.

Data Entry Procedures: In accordance with Section 9.2 of the QMP, stormwater data from field and laboratory data sheets will be entered into a database by one DES staff person and then checked by another. The person who entered the data and the person who checked the data entry will both sign the data sheet. The Project Manager will also sign the data sheet after the data entry check has been performed. Any discrepancies between the data sheets and the database will be resolved by the Project Manager.

Ambient harbor data will be entered following the protocols of the DES Shellfish Program. Chris Nash is responsible for data entry. All ambient data are managed in Microsoft Access databases. As data are entered, the appropriate section of the QA/Field Data Sheet is initialed and dated. Chris Nash is assisted in data entry verification by Andy Chapman or a program volunteer. As data entry is verified, the entry in the database field entitled “ENTRYQA” is changed from a “No” (the default value) to a “Yes,” and the appropriate section of the QA/Field Data Sheet is initialed and dated.

Data Management: Electronic data from the stormwater samples will be maintained in an Excel spreadsheet by the DES Water Quality Planning Section. Data from this spreadsheet will ultimately be imported into the DES Shellfish Program Shoreline database. Electronic data from the ambient stations will reside in the DES Shellfish Program Water Quality database. Management of hardcopy data and documents is described in Section A9.

Data Security: All databases will be maintain on password protected computers. Hardcopy files will be stored in a secured office with a key-card system (6 Hazen Drive, Concord NH) to which only DES employees have access.

Data Analysis: The procedures for data analysis were described in Section A7.

C1 – Assessments and Response Actions

In order to determine that field sampling, field analysis and laboratory activities are occurring as planned, field staff and laboratory personnel shall meet, after the first sampling event, to discuss the methods being employed and to review the quality assurance samples. At this time all concerns regarding the sampling protocols and analysis techniques shall be addressed and any changes deemed necessary shall be made to ensure consistency and quality of subsequent sampling. Assessment frequencies and responsible personnel are shown in Table 6.

Table 14: Project Assessment Table

Assessment Type	Frequency	Person responsible for performing assessment	Person responsible for responding to assessment findings	Person responsible for monitoring effectiveness of corrective actions
Field sampling audit	Once after first sampling day	Phil Trowbridge Project Manager DES	Phil Trowbridge Project Manager DES	Phil Trowbridge Project Manager DES
Field analytical audit	Once after first sampling day	Phil Trowbridge Project Manager DES	Phil Trowbridge Project Manager DES	Phil Trowbridge Project Manager DES
NHDES Laboratory Services Fixed Lab	Weekly	Rachel Rainey Lab QA/QC Officer NHDES	Rachel Rainey Lab QA/QC Officer NHDES	Rachel Rainey Lab QA/QC Officer NHDES

Based on EPA-NE Worksheet #27b.

Field Sampling Audit: QAPP deviations and project deficiencies determined during the field sampling assessment will be evaluated for source of deviation and corrected with verbal communications in the field and documented in field log books. Any necessary written/structural changes will be made through a revision of the SOP for that activity (and this QAPP). Field sampling activities will be monitored to determine compliance.

Field Analytical Audit: QAPP deviations and project deficiencies determined during the field analytical assessment will be evaluated for source of deviation and corrected with verbal communications in the field and documented in field log books. Any necessary written/structural changes will be made through a revision of the SOP for that activity (and this QAPP). Field analytical activities will be monitored to determine compliance.

NHDES Laboratory Services Fixed Laboratory Audit: QAPP deviations and project deficiencies determined during the NHDES Laboratory Services fixed laboratory assessments will be addressed immediately. Replicates and critical range tables will be checked with data to determine if sources of error exist. Any deviations in results will be addressed in both written and verbal formats, and future sampling will be monitored to verify that compliance is reached.

C2 – Reports to Management

The reports to management are summarized in the following table.

Table 15: Reports to Management

Report	Frequency	Author	Recipient	Action expected of recipient
Quarterly reports to the NH Estuaries Project	Quarterly from 6/30/02 until 12/31/02	Chris Nash	Cynthia McLaren, Director, NHEP	Review work completed compared to expected schedule in contract.
DRAFT TMDL Report for Hampton Harbor	One DRAFT report, expected by 12/31/02	Phil Trowbridge	Alison Simcox, TMDL Coordinator, EPA Reg I	Review and comment on TMDL study and implementation plan
Final TMDL Report	One report, expected by 5/1/03	Phil Trowbridge	Alison Simcox, TMDL Coordinator, EPA Reg I	Approve TMDL study and implementation plan

D1 – Data Review, Verification and Validation

The Project QA Officer will be responsible for conducting the following data review tasks. The QA Project Officer will prepare a memorandum to the Project Manager documenting the completion of the review and any inconsistencies between the actual methods and the QA Project Plan that were identified.

Table 16: Data Review, Verification, and Validation Tasks

Project Activity	Review Activities
Sampling Design	1. Check that sampling strategy conforms to QAPP. 2. Check that selection of sampling locations by field teams matches QAPP.
Field Sampling	1. Check use of prescribed procedures and equipment. 2. Check that proper containers and preservatives were used.
Field Documentation	1. Check that proper data entry procedures were used for field data sheets. 2. COC forms: Check that forms are properly completed, signed, and dated during transfer. Check that all samples were assigned identification numbers and accounted for. 3. Check that all samples were properly packaged.
Field Screening and Analytical Testing Data	1. Check that field instruments were properly calibrated. 2. Check calculations, transcriptions, and reporting units for field measurements recorded on data sheets.
Laboratory	1. Check that all requested data is reported, and is in compliance with contract analytical specifications and methods. 2. Check that COC documentation from laboratory matches COC field data sheets. 3. Check that sample temperatures were $<10^{o}C$ upon receipt at laboratory. 4. Check that holding times were not exceeded. 5. Check that QC samples (e.g., duplicate samples) were analyzed. 6. Check that trip, method, and instrument blanks are not contaminated.
Project file	Check that the project file at the DES Water Quality Planning Section office contains all field and laboratory data for the project.

D2 – Verification and Validation Procedures

The Project QA Officer will be responsible for evaluating results from QC samples and determining whether data quality objectives have been met. Specifically, the Project QA Officer will

- Calculate the RPD between duplicate samples to determine if the data quality objectives for precision were met (for more details see Section A7 and B5).
- Review the sign-off blocks on the field data sheets to determine whether the data entry procedures from Section B10 were followed.
- Calculate the data completeness for the project and compare it to the data quality objective of 67%.

The Project QA Officer will prepare a memorandum for the Project Manager with findings regarding the quality of the data for the project.

D3 – Reconciliation with User Requirements

The Project Manager will be responsible for reconciling the results from this study with the requirements of the TMDL (the ultimate use of the data). Results that are qualified by the Project QA Officer may still be used in the TMDL report if the uncertainty in the results is clearly reported to decision-makers. Because the stormwater samples will be collected synoptically during specific storms, it will not be possible to collect additional samples to confirm any questionable results. To that end, the Project Manager will:

1. Review data with respect to sampling design.
2. Review the Data Verification and Validation reports from the Project QA Officer.
3. If any of the results have been qualified by the Project QA Officer, calculate the cumulative error in the loading estimates to determine whether data can be used to for the TMDL report.
4. Draw conclusions from the data.

References

APHA (1970) Recommended Procedures for the Enumeration of Seawater and Shellfish, 4th Edition, Part III – Procedures for the Bacteriologic Examination of Sea Water and Shellfish. American Public Health Association, 1970.

DES (2001) Quality Management Plan, Revision 2, NHDES-C0-01-4, NH Department of Environmental Services, Concord, NH. June 13, 2001.

DES (1998) Methodology for 1998 303(d) List. Water Division, NH Department of Environmental Services, Concord, NH. 1998.

DES (1997) Stormwater Characterization Study, State of New Hampshire, Department of Environmental Services, Water Division, Surface Water Quality Bureau, Concord NH. November 1997.

DPHS (1994) Hampton Harbor Sanitary Survey Report. N.H. Division of Public Health Services, Concord, NH. July 1994.

Peters DG, Hayes JM, and Hieftje GM (1974) Chemical Separations and Measurements: Theory and Practice of Analytical Chemistry. Saunders Golder Sunburst Series. 1974.

Appendix C

Appendix C: SOP for Flow Measurements

2002 TMDL Stream Flow Determinations SOP

Equipment: Marsh-McBirney Model 2000 Flo-Mate, Flow field sheet
Velocity Measurement: Electromagnetic
Zero Stability: +/- 0.05 ft/sec
Accuracy: +/- 2% of reading + zero stability
Range: -0.5 to +19.99 ft/sec (-0.15 m/sec to 6 m/sec)

Calibration:

1. Flow meter calibration shall occur before the first measurement of the day, after the last measurement of the day and after any battery change.

2. Turn meter on and look for 'low battery' display. If display does not come on, proceed as follows. If light comes on, change batteries, then proceed with the following procedures. If you get a message on the screen that says "**NOISE - - -"** there is excessive electrical noise (such as from high voltage power lines) that could interfere with the readings. In such case it may be necessary to take flow readings at another location.

3. Set meter reading to **'time constant filtering" (rC)** by pressing the up and down arrow keys at the same time until the screen shows "rC". Set the time to **5 seconds** by pressing either the up or down arrow key.

4. Fill a 5 gallon bucket with water from stream. Insert the velocity probe into bucket **keeping it at least 3 inches away from the sides and bottom of the bucket**. To make sure the water and probe are motionless, **wait 10 minutes** after you have positioned the sensor before taking any zero readings. **Clear the meter reading by pressing the On/C key** and check for zero reading (no flow should be going on in bucket, thus zero reading). Based on a rC filter value of 5 seconds, **zero stability is +/- 0.05 ft/sec**. If the reading is outside of this range, see the manual for "Zero Adjust" procedures.

Quality Control/Quality Assurance:

For quality assurance purposes, duplicate analyses are required on at least ten percent (10%) of all incremental velocity/depth measurements collected as part of each flow measurement event. For every set of 10 increments where velocity and depth are recorded, duplicate the velocity and depth measurements for one full increment *(D_b, D_m, D_e, and V)* and record them on the worksheet. Quality control shall be based on a comparison of flows calculated for each increment (Velocity x Area of increment where the area is equal to the average of the depths at the beginning and end of the increment times the width of the increment) and should be less than 10%. If greater than 10%, repeat the measurements and recalculate the flow. The flow for an increment may be calculated using the following equation:

$$\text{Flow for an increment (cfs)} = \text{Velocity (ft/sec)} \times \text{Increment Width (ft)} \times \frac{[D_b + D_m + D_e]\ \text{(ft)}}{3}$$

Where:

D_b= depth at the beginning of the increment
D_m= depth at the middle of the increment
D_e= depth at the end of the increment.

Measuring Stream Channel Flow:

1. Select an area of the stream in which to measure flow (area near staff gauge is usually selected). Guidelines for site selection include the following:

- The channel should have as much straight run as possible. Where the length is limited, the straight length upstream from the selected location should be twice the downstream straight length.
- The channel should be as free as possible from flow disturbances.
- The flow should be free from swirls, eddies, vortices, backward flow or dead zones.
- Avoid areas immediately downstream from sharp bends or obstructions.
- Avoid converging or diverging flow or vertical drops
- Avoid areas immediately downstream of a sluice gate or where the channel empties into a body of stationary water.
- The stream bottom should be relatively flat and free of obstructions (large rocks, plants). Clear them if necessary.

2. Measure the width of the stream from bank to bank using a measuring tape. Record the total width of the stream on the worksheet.

3. Divide the total stream width by 20 and round down to the nearest one half foot. For example, if the stream width is 60 feet, the largest size increment would be 3 feet (60/20). If the stream width is 46 feet, the largest size interval would be 2.0 feet (46/20 = 2.3 feet which rounds down to 2.0 feet). For intervals of less than 10 feet, use an interval of 0.5 feet. Using the measuring tape, break the stream width into segments at that are no larger than the maximum size interval calculated above.

4. Set the meter to record in **feet per second (ft/s)** by pressing down on the ON/C and OFF keys simultaneously until FT/S appears on the display.

5. Set meter reading to **'Fixed Point Average"** by pressing the up and down arrow keys at the same time until the screen shows "**FPA**". In the FPA mode, the meter will display the average of velocities over a fixed period of time. **Set the averaging time to 30 seconds** by pressing either the up or down arrow key.

6. Take a **depth reading at the <u>beginning, middle and end</u> of each increment** across the stream, starting at river right and ending at river left. Record these depths on the flow sheet. Measure the velocity at the midpoints of each increment at the same time its dept is being measured. To do this, attach the velocity probe to either a top-setting or bottom setting rod. **For increments with a depth less than 2 feet at the point where a velocity reading will be taken**, point the velocity probe upstream and position the center of the probe at a depth which is 60% of the way down from the surface of the stream, and 40% of the way above the sediments. When

taking velocity measurements, **stand an arm's length away facing perpendicular to the flow, to the side, and downstream of the flow meter.** This is very important to avoid interfering with the velocity measurements. **Clear the display by pressing the ON/C button**. **Allow one full averaging period to pass. Record the velocity on the flow sheet after the second, 30 seconds averaging periods has elapsed.**

7. Move to the middle of the next increment and Step 8. **For increments where the middle depth exceeds 2 feet, take velocity measurements at depths equal to 20 % and 80% from the surface** and record these on the worksheet. Continue until velocity readings are collected for entire stream width.

8. Take a reading off the staff gauge in the stream if available, recording this number in the appropriate column on the field data sheet and the time.

<u>Measuring Stream Flow from a Culvert:</u>

1. Find downstream end of culvert

2. Using a yardstick or other measuring device, take a depth reading in the center of the culvert invert. Record this on the field data sheet.

3. Next, take a measure of the width of the entire culvert. Record this on the data sheet.

4. Next, place the velocity probe into the flow of the water in the center of the culvert invert. Take a fixed point averaged velocity reading as described above. Record in appropriate column on field data sheet.

5. Take a reading off the staff gauge in the stream below the culvert, and record in appropriate column of the field data sheet.

<u>Volumetric Approach:</u>

1. Where flow is insufficient to make a measurement using the Flo-Mate 2000 and there is a spot where all (+/-) of the flow may be collected into a bucket or some other container, a volumetric approach will be used.

2. Collect the flow for a set period of time, recording the volume of water collected and the time period of collection. The period of collection should be greater than 10 seconds to minimize error.

3. If a small portion of flow is escaping collection, the two members of the flow team will independently estimate the percentage of seepage. The average of the two trials will be used to adjust the final flow.

4. Repeat this procedure a minimum of three times. The average flow from all trials will be used as the flow at the site.

Appendix D

Bacteria and Flow Sampling Data

Table D1: Fecal coliform sample concentrations from Hampton Harbor TMDL wet weather sampling program.

Station	Date	Time	Water Temp (degC)	Fecal Coliforms (cts/100ml)	FC Qualifier	Field Comments
HHPS015	7/23/2002	15:46	26	800		none
HHPS015	7/23/2002	16:27	25	1,000		none
HHPS015	7/23/2002	17:46	21	3,500		none
HHPS015	7/23/2002	18:31	21	700		none
HHPS015DUP	7/23/2002	16:28	25	1,600		Field duplicate for HHPS015 7/23/02 16:27
HHPS016	7/23/2002	15:48	22	200		none
HHPS016	7/23/2002	16:44	21	700		none
HHPS016	7/23/2002	17:55	22	1,400		Sample time missing from label. The time was taken from the field data sheet.
HHPS016	7/23/2002	18:38	22	4,400		none
HHPS055	7/23/2002	14:46	20	100	<	none
HHPS055	7/23/2002	16:00	24	100	<	none
HHPS055	7/23/2002	17:03	23	100		none
HHPS055	7/23/2002	18:06	23	100		none
HHPS056	7/23/2002	14:56	24	100	<	none
HHPS056	7/23/2002	16:03	24	100	<	none
HHPS056	7/23/2002	17:30	23	1,100		none
HHPS056	7/23/2002	18:10	23	1,100		none
HHPS056DUP	7/23/2002	18:14	NA	800		Field duplicate for HHPS056 7/23/02 18:10; sample bottle had the wrong station number, the station number was taken from the field data sheet.
HHPS063	7/23/2002	16:10	22	100	<	none
HHPS063	7/23/2002	18:16	21	200		none
HHPS066	7/23/2002	15:13	23	100	<	none
HHPS066	7/23/2002	16:20	25	17,000	>	none
HHPS066	7/23/2002	16:50	21	8,400		none
HHPS066	7/23/2002	17:40	24	7,500		none
HHPS066	7/23/2002	18:10	23	570		none
HHPS066	7/23/2002	18:50	23	8,800		none
HHPS067	7/23/2002	16:53	21	200		none
HHPS067	7/23/2002	17:45	25	8,600		none
HHPS067	7/23/2002	18:15	23	20,000	>	none
HHPS067	7/23/2002	18:55	24	9,000		none
HHPS067DUP	7/23/2002	18:15	23.5	20,000	>	Field duplicate of HHPS067 7/23/02 18:15
HHPS068	7/23/2002	15:02	25	100	<	none

Station	Date	Time	Water Temp (degC)	Fecal Coliforms (cts/100ml)	FC Qualifier	Field Comments
HHPS068	7/23/2002	16:10	NA	100		none
HHPS068	7/23/2002	16:37	24	20,000	>	none
HHPS068	7/23/2002	17:25	25	8,700		none
HHPS068	7/23/2002	18:00	24	200		none
HHPS068	7/23/2002	18:40	24	300		none
HHPS068DUP	7/23/2002	16:37	24	20,000	>	Field duplicate of HHPS068 7/23/02 16:37
HHPS069	7/23/2002	15:04	22	100	<	none
HHPS069	7/23/2002	16:09	NA	100	<	none
HHPS069	7/23/2002	16:36	24	20,000	>	Debris in water
HHPS069	7/23/2002	17:20	26	5,100		Oil sheen on water
HHPS069	7/23/2002	17:55	25	1,000		none
HHPS069	7/23/2002	18:35	24	700		none
HHPS070	7/23/2002	15:39	22	100		none
HHPS070	7/23/2002	16:10	21	100	<	none
HHPS070	7/23/2002	17:27	22	1,000		Sample is smelly and dirty
HHPS070	7/23/2002	18:25	22	1,700		RPD with field duplicate was 118%. Do not use for TMDL calculations.
HHPS070DUP	7/23/2002	18:25	NA	6,600		Field duplicate of HHPS070 7/23/02 18:25 RDP was 118%. Do not use for TMDL calculations.
HHPS071	7/23/2002	16:15	22	1,500		Sample is dirty
HHPS071	7/23/2002	17:30	22.5	1,500		none
HHPS071	7/23/2002	18:30	21.5	800		none
HHPS071DUP	7/23/2002	18:35	NA	800		Field duplicate of HHPS071 7/23/02 18:30
HHPS072	7/23/2002	16:20	18	14,800		none
HHPS072	7/23/2002	17:33	19	2,500		Sewer smell
HHPS072	7/23/2002	18:35	20	500		none
HHPS072DUP	7/23/2002	18:40	NA	500		Field duplicate of HHPS072 7/23/02 18:35
HHPS182	7/23/2002	15:15	29.5	300		none
HHPS182	7/23/2002	16:30	19.5	200		Northern duckbill was flowing. Sample collected from the northern duckbill.
HHPS182	7/23/2002	17:41	21	1,000		none
HHPS182	7/23/2002	18:52	22	20,000	>	none
HHT1	7/23/2002	15:07	20	100	<	none
HHT1	7/23/2002	16:34	21.4	100	<	none
HHT1	7/23/2002	17:44	21	100	<	none
HHT1	7/23/2002	18:56	21	100	<	Slack tide
HHT2	7/23/2002	14:55	22.5	500		Water depth at gage=21 inches

Station	Date	Time	Water Temp (degC)	Fecal Coliforms (cts/100ml)	FC Qualifier	Field Comments
HHT2	7/23/2002	16:44	23	300		Water depth at gage=15 inches
HHT2	7/23/2002	17:52	22	300		Water depth at gage=15 inches
HHT2	7/23/2002	19:03	22	900		Water depth at gage=15 inches; outgoing tide
HHT4	7/23/2002	14:42	22	100	<	none
HHT4	7/23/2002	16:56	21.5	100	<	none
HHT4	7/23/2002	18:04	21	100	<	none
HHT4	7/23/2002	19:15	21	200		Incoming tide
HHT5	7/23/2002	14:29	21	50		none
HHT5	7/23/2002	17:09	22	100		none
HHT5	7/23/2002	18:11	21	100	<	Incoming tide
HHT5	7/23/2002	19:20	21	300		none
HHT8	7/23/2002	16:17	23	100	<	none
HHT8	7/23/2002	17:40	23	100		none
HHT8	7/23/2002	18:23	22	100	<	none
HHPS015	10/16/2002	10:00	NA	100		
HHPS015	10/16/2002	11:35	NA	1,700		
HHPS015	10/16/2002	13:25	NA	2,200		
HHPS015	10/16/2002	15:05	NA	6,600		
HHPS015	10/16/2002	16:05	NA	3,500		
HHPS015	10/17/2002	12:25	NA	700		steady flow
HHPS016	10/16/2002	10:15	NA	100	<	
HHPS016	10/16/2002	11:43	NA	700		
HHPS016	10/16/2002	13:30	NA	5,300		
HHPS016	10/16/2002	15:20	NA	5,600		
HHPS016	10/16/2002	16:10	NA	8,300		
HHPS016	10/17/2002	12:30	NA	2,000		steady flow
HHPS016DUP	10/16/2002	13:34	NA	4,700		Field duplicate of sample collected at 10/16/02 1330.
HHPS016DUP	10/16/2002	16:15	NA	8,500		Field duplicate of sample collected at 10/16/02 1610.
HHPS055	10/16/2002	10:30	NA	100	<	
HHPS055	10/16/2002	12:30	NA	1,300		
HHPS055	10/16/2002	13:51	NA	2,800		
HHPS055	10/16/2002	15:28	NA	4,400		
HHPS055	10/16/2002	16:32	NA	6,000		
HHPS056	10/16/2002	10:28	NA	100	<	
HHPS056	10/16/2002	12:25	NA	800		

Station	Date	Time	Water Temp (degC)	Fecal Coliforms (cts/100ml)	FC Qualifier	Field Comments
HHPS056	10/16/2002	13:51	NA	1,800		
HHPS056	10/16/2002	15:28	NA	3,500		
HHPS056	10/16/2002	16:32	NA	4,400		
HHPS057	10/16/2002	10:30	NA	50	<	
HHPS061	10/16/2002	10:46	NA	20,000	>	
HHPS061	10/16/2002	12:42	NA	19,400		
HHPS061	10/16/2002	14:05	NA	17,000		
HHPS061	10/16/2002	15:40	NA	5,500		
HHPS061	10/16/2002	16:46	NA	5,900		
HHPS062	10/16/2002	10:47	NA	17,600		
HHPS062	10/16/2002	12:45	NA	4,900		
HHPS062	10/16/2002	14:10	NA	3,100		
HHPS062	10/16/2002	15:40	NA	2,900		
HHPS062	10/16/2002	16:47	NA	1,600		
HHPS063	10/16/2002	10:35	NA	100	<	
HHPS063	10/16/2002	12:39	NA	7,000		
HHPS063	10/16/2002	14:00	NA	8,200		
HHPS063	10/16/2002	15:37	NA	4,900		
HHPS063	10/16/2002	16:43	NA	2,500		
HHPS066	10/16/2002	10:20	NA	300		high tide, some flow out of pipe, sample taken in front
HHPS066	10/16/2002	11:10	NA	1,800		Full pipe width oil sheen flowing out of pipe.
HHPS066	10/16/2002	11:50	NA	11,600		
HHPS066	10/16/2002	13:35	NA	20,000	>	
HHPS066	10/16/2002	14:20	NA	20,000	>	
HHPS066	10/16/2002	15:10	NA	14,100		
HHPS066	10/16/2002	16:05	NA	17,600		
HHPS066	10/16/2002	16:45	NA	7,400		
HHPS067	10/16/2002	12:00	NA	20,000	>	
HHPS067	10/16/2002	13:40	NA	16,200		
HHPS067	10/16/2002	14:15	NA	17,200		
HHPS067	10/16/2002	15:15	NA	11,300		
HHPS067	10/16/2002	16:00	NA	13,700		
HHPS067	10/16/2002	16:50	NA	6,500		
HHPS068	10/16/2002	10:12	NA	600		high tide, standing water, sample taken in front of pipe
HHPS068	10/16/2002	11:00	NA	1,100		

Station	Date	Time	Water Temp (degC)	Fecal Coliforms (cts/100ml)	FC Qualifier	Field Comments
HHPS068	10/16/2002	11:43	NA	1,100		
HHPS068	10/16/2002	13:25	NA	1,300		
HHPS068	10/16/2002	14:05	NA	1,300		
HHPS068	10/16/2002	15:05	NA	5,200		
HHPS068	10/16/2002	15:50	NA	5,600		
HHPS068	10/16/2002	16:35	NA	7,000		
HHPS069	10/16/2002	10:15	NA	1,300		high tide, standing water
HHPS069	10/16/2002	10:50	NA	1,300		
HHPS069	10/16/2002	11:35	NA	1,000		
HHPS069	10/16/2002	13:20	NA	9,300		
HHPS069	10/16/2002	14:00	NA	9,800		
HHPS069	10/16/2002	15:00	NA	13,800		
HHPS069	10/16/2002	15:45	NA	14,800		
HHPS069	10/16/2002	16:30	NA	18,800		
HHPS069DUP	10/16/2002	13:20	NA	9,700		Field duplicate of sample collected at 10/16/02 1320.
HHPS069DUP	10/16/2002	15:00	NA	13,100		Field duplicate of sample collected at 10/16/02 1500.
HHPS069DUP	10/16/2002	16:30	NA	18,200		Field duplicate of sample collected at 10/16/02 1630.
HHPS070	10/16/2002	10:53	NA	100		
HHPS070	10/16/2002	12:52	NA	4,600		
HHPS070	10/16/2002	14:12	NA	7,200		
HHPS070	10/16/2002	15:25	NA	17,000		flow, sample
HHPS070	10/16/2002	16:46	NA	7,000		
HHPS070DUP	10/16/2002	15:26	NA	16,700		flow, sample. Field duplicate of sample collected at 10/16/02 1525.
HHPS071	10/16/2002	10:15	NA	40		sample, variable pulse flow
HHPS071	10/16/2002	11:30	NA	3,100		Flow / sample
HHPS071	10/16/2002	13:00	NA	2,800		flow, sample
HHPS071	10/16/2002	14:30	NA	1,700		sample, flow meas
HHPS071	10/16/2002	16:00	NA	2,200		
HHPS072	10/16/2002	11:35	NA	400		sample ponded, no flow meas
HHPS072	10/16/2002	13:10	NA	1,300		flow,sample
HHPS072	10/16/2002	14:35	NA	5,200		sample, flow meas
HHPS072	10/16/2002	16:05	NA	4,900		
HHPS182	10/16/2002	10:30	NA	2,000	>	sample, no flow out
HHPS182	10/16/2002	11:45	NA	4,400		sample coll. closer to South pipe
HHPS182	10/16/2002	13:15	NA	8,500		both pipe flowing, coll. Btw

Station	Date	Time	Water Temp (degC)	Fecal Coliforms (cts/100ml)	FC Qualifier	Field Comments
HHPS182	10/16/2002	14:41	NA	20,000	>	most flow from N pipe, sample from N pipe
HHPS182	10/16/2002	16:08	NA	8,100		sample from N pipe, both flow
HHPS182DUP	10/16/2002	11:46	NA	3,600		sample coll. closer to South pipe. Field duplicate of sample collected 10/16/02 1145.
HHPS182DUP	10/16/2002	14:42	NA	20,000	>	most flow from N pipe, sample from N pipe. Field duplicate of sample collected at 10/16/02 1441.
HHT1	10/16/2002	9:40	NA	80		Incoming, almost slack high
HHT1	10/16/2002	11:49	NA	60		outgoing tide
HHT1	10/16/2002	13:18	NA	5	<	
HHT1	10/16/2002	14:45	NA	50		
HHT1	10/16/2002	16:10	NA	10		incoming tide
HHT1	10/17/2002	13:00	NA	40		strong outgoing tide
HHT2	10/16/2002	9:48	NA	110		outgoing, barely - 65"
HHT2	10/16/2002	11:57	NA	130		outgoing 35"
HHT2	10/16/2002	13:24	NA	310		19"
HHT2	10/16/2002	14:52	NA	440		16"
HHT2	10/16/2002	16:19	NA	1,070		16", outgoing
HHT2	10/17/2002	13:10	NA	1,960		strong outgoing tide, 26"
HHT4	10/16/2002	10:00	NA	10	<	slack tide
HHT4	10/16/2002	12:09	NA	30		outgoing
HHT4	10/16/2002	13:30	NA	160		
HHT4	10/16/2002	14:59	NA	240		
HHT4	10/16/2002	16:29	NA	100		incoming?
HHT4	10/17/2002	13:25	NA	30		weak outgoing tide
HHT5	10/16/2002	10:05	NA	10	<	outgoing tide
HHT5	10/16/2002	12:13	NA	10	<	outgoing
HHT5	10/16/2002	13:38	NA	20		
HHT5	10/16/2002	15:12	NA	50		outgoing, barely
HHT5	10/16/2002	16:34	NA	30		incoming
HHT5	10/17/2002	13:35	NA	980		strong outgoing tide
HHT8	10/16/2002	10:25	NA	20		
HHT8	10/16/2002	11:48	NA	20		
HHT8	10/16/2002	13:45	NA	20	>	
HHT8	10/16/2002	15:23	NA	300		
HHT8	10/16/2002	16:26	NA	100	<	
HHT8	10/17/2002	12:40	NA	30		outgoing tide

Table D2: Stormwater flow measurements from Hampton Harbor TMDL wet weather sampling program.

Station	Date	Time	Flow Method	Discharge Qualifier	Discharge (cfs)	Depth (in)	Diameter (in)	Velocity (ft/s)	Comments
HHPS070	7/23/2002	15:39	none	no data					No flow measurement recorded. Time taken from lab login sheet.
HHPS071	7/23/2002	15:45	none	=	0				No flow. Time estimated from lab login sheet.
HHPS072	7/23/2002	15:50	none	=	0				No flow. Time estimated from lab login sheet.
HHPS070	7/23/2002	16:10	pipemethod-float	=	0.06	3.25	28	4.73	1 ft rod used
HHPS071	7/23/2002	16:15	pipemethod-meter	=	0.24	4	28	0.65	
HHPS072	7/23/2002	16:20	modUSGS-meter	=	0.26				Field team recorded the flow of both HHPS071 and HHPS072 as being 30 in wide by 2 in deep with velocity 1.21 ft/s. Calculated combined flow using w*d*v (=0.5 cfs). Subtracted flow at HHPS071 (0.24 cfs) to estimate flow from HHPS072.
HHPS070	7/23/2002	17:27	pipemethod-meter	=	0.37	4	28	0.99	depth not recorded; remembered on 7/24/02 by field team to be approximately 4"
HHPS071	7/23/2002	17:30	pipemethod-meter	=	0.14	4.5	28	0.32	time taken from lab login sheet
HHPS072	7/23/2002	17:33	modUSGS-meter	=	0.61	8		0.61	time taken from lab login sheet, box culvert with dimensions 18" x 8". Flow calculated by w*d*v.
HHPS070	7/23/2002	18:25	pipemethod-meter	=	0.11	3.75	28	0.32	time taken from lab login sheet
HHPS070DUP	7/23/2002	18:25	pipemethod-meter	=	0.09	3.75	28	0.27	Field duplicate of HHPS070 7/23/02 18:25; time taken from lab login sheet
HHPS071	7/23/2002	18:30	pipemethod-float	=	0.03	3	28	0.14	time taken from lab login sheet
HHPS071DUP	7/23/2002	18:30	pipemethod-float	=	0.03	3	28	0.135	Field duplicate of HHPS071 7/23/02 18:30;velocity measured with 2 ft rod, time taken from lab login sheet
HHPS072	7/23/2002	18:35	modUSGS-meter	=	0.2	3.5		0.45	box culvert with dimensions of 18" x 3.5"; flow calculated by w*d*v. time taken from lab login sheet
HHPS072DUP	7/23/2002	18:35	modUSGS-meter	=	0.18	3.5		0.42	Field duplicate of HHPS072 7/23/02 18:35. box culvert with dimensions of 18" x 3.5"; flow calculated by w*d*v. time taken from lab login sheet
HHPS055	7/23/2002	14:46	none	no data					small flow, but unreadable due to equipment failure and high winds
HHPS054	7/23/2002	14:51	none		0				no flow. This pipe never flowed during the course of the storm per P. Foss.
HHPS056	7/23/2002	14:56	none	no data					small flow, but unreadable due to equipment failure and high winds. This pipe receives most of its flow from HHPS055.
HHPS057	7/23/2002	14:57	none	=	0				no flow, just a trickle. This pipe never flowed during the course of the storm per P. Foss.
HHPS055	7/23/2002	16:00	none	no data					small flow, but unreadable due to equipment failure and high winds

Station	Date	Time	Flow Method	Discharge Qualifier	Discharge (cfs)	Depth (in)	Diameter (in)	Velocity (ft/s)	Comments
HHPS015	7/23/2002	16:25	none	no data					small flow, but unreadable due to equipment failure and high winds
HHPS016	7/23/2002	16:44	none	no data					flowing but unreadable due to equipment failure/high winds
HHPS055	7/23/2002	17:03	none	no data					small flow, but unreadable due to equipment failure and high winds
HHPS015	7/23/2002	17:46	pipemethod-meter	=	0.32	3.25	42	0.93	
HHPS016	7/23/2002	17:55	pipemethod-meter	=	2.07	6.5	60	1.8	
HHPS055	7/23/2002	18:06	none	no data					low flow, unable to measure
HHPS015	7/23/2002	18:31	pipemethod-meter	=	0.38	3.437	42	1.03	
HHPS016	7/23/2002	18:38	pipemethod-meter	=	4.06	9	60	2.2	
HHPS016DUP	7/23/2002	18:50	pipemethod-meter	=	3.88	9	60	2.1	Field duplicate of HHPS016 7/23/02 18:38
HHPS069	7/23/2002	14:57	none	<	0.02				There was a small current but the wind prevented a flow measurement using the float. Small flow but unmeasureable. Flow value assumed to be less than the lowest recorded flow value (0.02 cfs).
HHPS068	7/23/2002	15:02	none	=	0				Standing water but no flow.
HHPS066	7/23/2002	15:08	none	<	0.02				There was a small current but the wind prevented a flow measurement. Small flow but unmeasureable. Flow assumed to be less than the lowest recorded flow value (0.02 cfs).
HHPS067	7/23/2002	15:18	none	=	0				No flow. Just a trickle.
HHPS069	7/23/2002	16:09	pipemethod-meter	=	0.63	3.375	36	1.88	First flush
HHPS068	7/23/2002	16:19	none	=	0				Standing water but no flow.
HHPS066	7/23/2002	16:20	pipemethod-meter	=	0.52	3.625	36	1.59	First flush
HHPS067	7/23/2002	16:30	none	=	0		12		No flow
HHPS069	7/23/2002	16:35	pipemethod-meter	=	0.55	4.25	36	1.17	Heavy flow with debris
HHPS068	7/23/2002	16:45	none	=	0				Standing water but no flow.
HHPS068DUP	7/23/2002	16:45	none	=	0				Standing water but no flow. Duplicate measurement.
HHPS066	7/23/2002	16:50	pipemethod-meter	=	0.26	2.25	36	1.4	
HHPS067	7/23/2002	17:00	pipemethod-float	=	0.03	0.875	12	1.06	
HHPS069	7/23/2002	17:20	pipemethod-meter	=	1.91	5.5	36	2.8	
HHPS068	7/23/2002	17:33	none	=	0				Standing water but no flow
HHPS066	7/23/2002	17:36	pipemethod-meter	=	0.92	4.25	36	1.96	
HHPS067	7/23/2002	17:45	pipemethod-float	=	0.09	1.75	12	1.22	Much stronger flow than before
HHPS069	7/23/2002	17:50	pipemethod-meter	=	1.34	5.375	36	2.03	
HHPS068	7/23/2002	18:01	modUSGS-float	=	0.82	8		0.32	Box culvert of dimensions 46 in wide, 8 inches deep. Flow calculated by w*d*v
HHPS066	7/23/2002	18:10	pipemethod-meter	=	0.28	2.5	36	1.31	
HHPS067	7/23/2002	18:24	pipemethod-float	=	0.04	1.25	12	0.82	

Station	Date	Time	Flow Method	Discharge Qualifier	Discharge (cfs)	Depth (in)	Diameter (in)	Velocity (ft/s)	Comments
HHPS067DUP	7/23/2002	18:24	pipemethod-float	=	0.05	1.25	12	1.14	Field duplicate of HHPS067 7/23/02 18:24
HHPS069	7/23/2002	18:35	pipemethod-meter	=	0.45	4.5	36	0.89	
HHPS068	7/23/2002	18:42	modUSGS-float	=	0.24	8		0.096	Box culvert of dimensions 45 in wide, 8 inches deep. Flow calculated by w*d*v. Wind affecting float movement. Flow value is approximate.
HHPS066	7/23/2002	18:50	pipemethod-float	=	0.11	1.75	36	0.84	
HHPS067	7/23/2002	18:55	pipemethod-float	=	0.02	0.75	12	0.8	
HHPS071	10/16/2002	10:15	none			15			pressure induced, flow in then out. Standing water, no measurement
HHPS072	10/16/2002	10:23	none		0				no flow, dry
HHPS073	10/16/2002	10:27	none		0				no flow, dry
HHPS071	10/16/2002	11:30	pipemethod-float		0.27	4	28	0.71	
HHPS072	10/16/2002	11:35	none	no data		10.5			ponded water
HHPS073	10/16/2002	11:37	none		0				dry
HHPS071	10/16/2002	13:00	pipemethod-float		0.2	4.5	28	0.4467	
HHPS072	10/16/2002	13:05	modUSGS-meter		0.21	2		1.25	Box culvert with dimensions 12" x 2". Cons. width estimated; bulk of flow 12" wide
HHPS073	10/16/2002	13:10	none		0				dry
HHPS071	10/16/2002	14:30	pipemethod-float		0.88	9	28	0.742	
HHPS072	10/16/2002	14:35	modUSGS-meter		0.65	3.5		1.12	Box culvert of dimensions 24 in wide, 3.5 inches deep. Flow calculated by w*d*v
HHPS073	10/16/2002	14:37	none		0				dry
HHPS070	10/16/2002	15:25	pipemethod-meter		0.16	3.75	28	0.476	
HHPS070DUP	10/16/2002	15:26	pipemethod-meter		0.16	3.75	28	0.483	Field duplicate of measurement at 10/16/02 1525.
HHPS071	10/16/2002	16:00	pipemethod-float		0.21	4.75	28	0.437	
HHPS072	10/16/2002	16:05	modUSGS-meter		0.46	2.5		1.46	Box culvert of dimensions 18 in wide, 2.5 inches deep. Flow calculated by w*d*v
HHPS073	10/16/2002	16:07	none		0				dry
HHPS070	10/16/2002	16:46	pipemethod-meter		0.5	4.25	28	1.22	
HHPS015	10/16/2002	10:00	none			17.5			flow, but too low to measure
HHPS016	10/16/2002	10:15	none			25			flow, but too low to measure
HHPS054	10/16/2002	10:28	none		0				dry
HHPS055	10/16/2002	10:30	none						pipe completely submerged, flow, but culvert completely submerged
HHPS057	10/16/2002	10:30	none						completely submerged, flowing, but not measurable
HHPS061	10/16/2002	10:46	none						flowing but completely submerged, not measurable
HHPS062	10/16/2002	10:47	none						completely submerged, flowing but not measurable
HHPS070	10/16/2002	10:53	none		0	20.1	28		standing water but no flow

Station	Date	Time	Flow Method	Discharge Qualifier	Discharge (cfs)	Depth (in)	Diameter (in)	Velocity (ft/s)	Comments
HHPS015	10/16/2002	12:15	pipemethod-meter		0.24	2.9	42	0.82	Flow taken 40 minutes after sample collected for FC (11:35) because equipment failed and needed to be replaced.
HHPS016	10/16/2002	12:20	pipemethod-meter		0.88	5.8	60	0.903	Flow taken 40 minutes after sample collected for FC (11:43) because equipment failed and needed to be replaced.
HHPS054	10/16/2002	12:30	none		0				dry, time of observation estimated from time of sample collection at HHPS055
HHPS055	10/16/2002	12:30	modUSGS-meter		0.11	2.9		0.18	Box culvert of dimensions 31 in wide, 2.9 inches deep. Flow calculated by w*d*v
HHPS057	10/16/2002	12:30	none		0				dry, time of observation estimated from time of sample collection at HHPS055
HHPS061	10/16/2002	12:42	none		0				No flow, standing water
HHPS062	10/16/2002	12:45	modUSGS-meter	>	0.14			0.68	Box culvert with dimensions 11.5 in wide and N/A in deep. Depth not recorded; assumed to be equal to 2.6 in as was observed at 1410. This is a low estimate so the result has been qualified as "greater than" value.
HHPS070	10/16/2002	12:57	pipemethod-meter		0.33	3.8	28	0.96	
HHPS070DUP	10/16/2002	12:57	pipemethod-meter		0.31	3.8	28	0.8867	Field duplicate of measurement at 10/16/02 1257.
HHPS015	10/16/2002	13:25	pipemethod-meter		0.56	3.9	42	1.24	
HHPS016	10/16/2002	13:30	pipemethod-meter		4.68	10.5	60	2.03	
HHPS016DUP	10/16/2002	13:34	pipemethod-meter		4.96	10.5	60	2.15	Field duplicate of measurement at 10/16/02 1330.
HHPS054	10/16/2002	13:51	none		0				dry, time of observation estimated from time of sample collection at HHPS055
HHPS055	10/16/2002	13:51	none			12			Box culvert with dimensions 30 in wide by 12 in deep. Flow, but too low to measure
HHPS057	10/16/2002	13:51	none		0				dry, time of observation estimated from time of sample collection at HHPS055
HHPS061	10/16/2002	14:05	none			1.1			flow, but too low to measure. Box culvert width 11.5" depth 1.1"
HHPS062	10/16/2002	14:10	none		0	2.6			standing water, no flow. Box culvert 14.8 wide by 2.6" deep
HHPS070	10/16/2002	14:40	pipemethod-meter		0.66	4.5	28	1.49	
HHPS015	10/16/2002	15:05	pipemethod-meter		0.72	4.6	42	1.26	
HHPS016	10/16/2002	15:20	pipemethod-meter		8.52	13.6	60	2.55	
HHPS054	10/16/2002	15:28	none		0				dry, time of observation estimated from time of sample collection at HHPS055
HHPS055	10/16/2002	15:28	modUSGS-meter		0.47	12.4		0.18	Box culvert of dimensions 30 in wide, 12.4 inches deep. Flow calculated by w*d*v

Station	Date	Time	Flow Method	Discharge Qualifier	Discharge (cfs)	Depth (in)	Diameter (in)	Velocity (ft/s)	Comments
HHPS057	10/16/2002	15:28	none		0				dry, time of observation estimated from time of sample collection at HHPS055
HHPS061	10/16/2002	15:40	none			2.8			Box culvert of dimensions 15.5 in wide, 2.8 inches deep. Flow not recorded, could not calculate discharge (assumed to be standing water?)
HHPS062	10/16/2002	15:40	modUSGS-meter		0.07	1.1		0.776	Box culvert of dimensions 11.5 in wide, 1.1 inches deep. Flow calculated by w*d*v
HHPS015	10/16/2002	16:05	pipemethod-meter		0.8	4.4	42	1.49	
HHPS016	10/16/2002	16:10	pipemethod-meter		7.57	12.8	60	2.47	
HHPS016DUP	10/16/2002	16:15	pipemethod-meter		7.6	12.8	60	2.48	Field duplicate of measurement at 10/16/02 1610.
HHPS054	10/16/2002	16:32	none		0				dry, time of observation estimated from time of sample collection at HHPS055
HHPS055	10/16/2002	16:32	modUSGS-meter		0.44	11.8		0.18	Box culvert of dimensions 30 in wide, 11.8 inches deep. Flow calculated by w*d*v
HHPS057	10/16/2002	16:32	none		0				dry, time of observation estimated from time of sample collection at HHPS055
HHPS061	10/16/2002	16:46	none		0	3			Box culvert of dimensions 15 in wide, 3 inches deep. No flow, standing water.
HHPS062	10/16/2002	16:47	modUSGS-meter		0.17	1.8		1.21	Box culvert of dimensions 11.5 in wide, 1.8 inches deep. Flow calculated by w*d*v
HHPS068	10/16/2002	10:12	none						high tide, standing water. Some flow was observed at this pipe (starting at 1030), but measurement was not attempted. Time of observation taken from lab login sheet.
HHPS069	10/16/2002	10:15	none						high tide, standing water. Measurement was not attempted. Time of observation taken from lab login sheet.
HHPS066	10/16/2002	10:20	none						high tide, standing water. Some flow was observed at this pipe, but measurement was not attempted. Time of observation taken from lab login sheet.
HHPS067	10/16/2002	10:20	none						high tide, standing water. Measurement was not attempted. Time of observation taken from lab login sheet.
HHPS069	10/16/2002	10:50	pipemethod-float		2.3	20.4	36	0.557	
HHPS068	10/16/2002	10:56	modUSGS-float		4.25	21		0.655	Box culvert of dimensions 44.5 in wide, 21 inches deep. Flow calculated by w*d*v
HHPS067	10/16/2002	11:10	none		0				dry, just a trickle. Time of observation estimated from time of sample collection at HHPS066
HHPS066	10/16/2002	11:15	pipemethod-float		1.6	15	36	0.573	oily sheen
HHPS069	10/16/2002	11:35	pipemethod-meter		2.03	7.75	36	1.82	lots of debris, strong flow

Station	Date	Time	Flow Method	Discharge Qualifier	Discharge (cfs)	Depth (in)	Diameter (in)	Velocity (ft/s)	Comments
HHPS068	10/16/2002	11:43	modUSGS-meter		1.82	8.667		0.636	Box culvert of dimensions 47.5 in wide, 8.667 inches deep. Flow calculated by w*d*v
HHPS066	10/16/2002	11:48	pipemethod-meter		0.83	4.625	36	1.56	debris and oily sheen
HHPS067	10/16/2002	12:00	pipemethod-float		0.05	1.125	12	1.37	
HHPS068	10/16/2002	13:25	modUSGS-meter		0.49	5.72		0.27	Box culvert of dimensions 46 in wide, 5.72 inches deep. Flow calculated by w*d*v
HHPS069	10/16/2002	13:30	pipemethod-meter		1.7	5.25	36	2.67	oily sheen
HHPS069DUP	10/16/2002	13:30	pipemethod-meter		1.34	5.25	36	2.1	Oily sheen. Field duplicate of measurement at 10/16/02 1330.
HHPS066	10/16/2002	13:35	pipemethod-meter		0.77	4.0625	36	1.76	oily sheen
HHPS067	10/16/2002	13:40	pipemethod-float		0.05	1.25	12	1.24	
HHPS069	10/16/2002	14:00	pipemethod-meter		1.82	5.5	36	2.67	oily sheen
HHPS068	10/16/2002	14:05	modUSGS-meter		0.75	5.575		0.42	Box culvert of dimensions 46.25 in wide, 5.575 inches deep. Flow calculated by w*d*v
HHPS067	10/16/2002	14:15	pipemethod-float		0.06	1.125	12	1.52	
HHPS066	10/16/2002	14:20	pipemethod-meter		0.91	4.125	36	2.02	
HHPS069	10/16/2002	15:00	pipemethod-meter		2.74	6.5	36	3.15	
HHPS068	10/16/2002	15:05	modUSGS-meter		1.61	6.875		0.71	Box culvert of dimensions 47.5 in wide, 6.875 inches deep. Flow calculated by w*d*v
HHPS069DUP	10/16/2002	15:06	pipemethod-meter		2.41	6.5	36	2.77	Field duplicate of measurement at 10/16/02 1500.
HHPS066	10/16/2002	15:10	pipemethod-meter		0.79	4.125	36	1.76	oily sheen
HHPS067	10/16/2002	15:15	pipemethod-float		0.07	1.375	12	1.4	turbid water
HHPS069	10/16/2002	15:45	pipemethod-meter		1.32	5.5	36	1.93	
HHPS068	10/16/2002	15:50	modUSGS-meter		1.29	5.9375		0.67	Box culvert of dimensions 46.75 in wide, 5.93 inches deep. Flow calculated by w*d*v
HHPS067	10/16/2002	16:00	pipemethod-float		0.04	1	12	1.15	
HHPS066	10/16/2002	16:05	pipemethod-meter		0.46	3.25	36	1.46	
HHPS069	10/16/2002	16:30	pipemethod-meter		1.3	5.25	36	2.03	
HHPS068	10/16/2002	16:35	modUSGS-meter		0.87	5.75		0.47	Box culvert of dimensions 46.5 in wide, 5.75 inches deep. Flow calculated by w*d*v
HHPS066	10/16/2002	16:45	pipemethod-meter		0.77	3.75	36	1.97	
HHPS067	10/16/2002	16:50	pipemethod-float		0.06	1.125	12	1.63	

Table D3: Stage height-flow relationship for HHT2

Date: 11/15/2002

Profile #	Time	Measured Flow (cfs)	Stage Ht (in)
Profile #1	10:05	41.80	45.25
Profile #2	10:41	37.06	35.38
Profile #3	11:15	26.09	25.86
Profile #4	12:05	9.81	18.80
Profile #5	12:50	4.51	16.26
Profile #6	13:42	3.36	15.50
Profile #7	14:31	2.15	15.00

Quadratic relationship: $y=-0.0434x^2 + 3.9401x - 47.712$

$y=$ flow (cfs)

$x=$ stage height (in)

Table D4: Flow through pump stations serving HHPS182

7/23/2002

Pipe	Pump station	Running Time Pump 1 (min)	Running Time Pump 2 (min)	Total (min)	Pump Rate (gal/min)	Total Flow (gal)
North Pipe	River Street	38	6	44	3750	165,000
	Ocean Blvd	25	10	35	3750	131,250
	Subtotal	NA	NA	NA	NA	296,250
South Pipe	Subtotal*	NA	NA	NA	NA	118,500
Both Pipes	TOTAL	NA	NA	NA	NA	414,750

10/16/2002

Pipe	Pump station	Running Time Pump 1 (min)	Running Time Pump 2 (min)	Total (min)	Pump Rate (gal/min)	Total Flow (gal)
North Pipe	River Street	38	32	70	3750	262,500
	Ocean Blvd	78	21	99	3750	371,250
	Total					633,750
South Pipe	Subtotal*	NA	NA	NA	NA	253,500
Both Pipes	TOTAL	NA	NA	NA	NA	887,250

* Estimated by mulitplying the total from the north pipe by 0.4, the ratio of the area drained by the south pipe to the area drained by the north pipe.

Table D5: Stormwater loading calculations for 7/23/02 and 10/16/02 sampling events.

Station	Date	Time	Instantaneous Loading Rate (bill org/day)	Interval Loading Rate (bill org/day)	Interval Duration (d)	Total Load (bill org)	Comments
HHPS015	7/23/2002	15:46	6.26	7.05	0.0285	1.7	Assumes flow at 15:46 and 16:27 were the same as the first reading at 17:46. Total load from this pipe will be higher because the flow remained high at the end of the sampling event.
	7/23/2002	16:27	7.83	17.62	0.0549		
	7/23/2002	17:46	27.40	16.96	0.0313		
	7/23/2002	18:31	6.51				
HHPS016	7/23/2002	15:48	10.13	22.79	0.0389	11.1	Assumes flow at 15:48 and 16:44 was the same as the first reading at 1755. Total load from this pipe will be higher because the flow remained high at the end of the sampling event.
	7/23/2002	16:44	35.45	53.18	0.0493		
	7/23/2002	17:55	70.91	254.01	0.0299		
	7/23/2002	18:38	437.10				
HHPS055	7/23/2002					0.0	Assumed to be negligible because there was never any significant flow.
HHPS056	7/23/2002					0.0	Assumed to be neglible because there was never any significant flow. High FC concentrations during the storm suggest a local source since they did not occur at HHPS055.
HHPS066	7/23/2002	15:13	0.05	108.18	0.0465	13.9	
	7/23/2002	16:20	216.30	134.87	0.0208		
	7/23/2002	16:50	53.44	111.14	0.0347		
	7/23/2002	17:40	168.83	86.37	0.0208		
	7/23/2002	18:10	3.91	13.80	0.0278		
	7/23/2002	18:50	23.69				
HHPS067	7/23/2002	15:18	0.00	0.00	0.0500	1.1	Uses flow times for interval. Inserted zero load for two entries at 1518 and 1630 which were recorded as "no flow".
	7/23/2002	16:30	0.00	0.07	0.0208		
	7/23/2002	17:00	0.15	9.54	0.0313		
	7/23/2002	17:45	18.94	19.26	0.0271		
	7/23/2002	18:24	19.57	11.99	0.0215		
	7/23/2002	18:55	4.40				
HHPS068	7/23/2002	15:02	0.00	0.00	0.0472	0.1	Dramatic change in concentrations without a change in flow. May be an underestimate.
	7/23/2002	16:10	0.00	0.00	0.0187		
	7/23/2002	16:37	0.00	0.00	0.0333		
	7/23/2002	17:25	0.00	2.01	0.0243		
	7/23/2002	18:00	4.01	2.89	0.0278		
	7/23/2002	18:40	1.76				

Station	Date	Time	Instantaneous Loading Rate (bill org/day)	Interval Loading Rate (bill org/day)	Interval Duration (d)	Total Load (bill org)	Comments
HHPS069	7/23/2002	15:04	0.05	0.80	0.0451	14.2	
	7/23/2002	16:09	1.54	135.35	0.0188		
	7/23/2002	16:36	269.15	253.75	0.0306		
	7/23/2002	17:20	238.35	135.57	0.0243		
	7/23/2002	17:55	32.79	20.25	0.0278		
	7/23/2002	18:35	7.71				
HHPS070	7/23/2002	15:39	0.15	0.15	0.0215	0.2	Assumes that flow at 15:39 was the same as at 16:10. Loading estimate is an underestimate because it only covers a short duration. Instantaneous load measurement at 1825 deleted because the duplicate FC results had an RPD of 118% which exceeded the data quality objective of 60%.
	7/23/2002	16:10	0.15	4.60	0.0535		
	7/23/2002	17:27	9.05				
	7/23/2002	18:25					
HHPS071	7/23/2002	15:45	0.00	4.40	0.0208	0.6	Uses flow times for interval. Inserted zero load for first entry at 1545 which was recorded as "no flow".
	7/23/2002	16:15	8.81	6.97	0.0521		
	7/23/2002	17:30	5.14	2.86	0.0417		
	7/23/2002	18:30	0.59				
HHPS072	7/23/2002	15:50	0.00	47.08	0.0208	5.2	Uses flow times for interval. Inserted zero load for the first entry at 1550 which was recorded as "no flow".
	7/23/2002	16:20	94.15	65.73	0.0507		
	7/23/2002	17:33	37.31	19.88	0.0431		
	7/23/2002	18:35	2.45				
HHPS182	7/23/2002	15:15				71.8	Based on total estimated discharge during the storm (414,750 gal) and average measured concentration (5,375 cfu/100ml).
	7/23/2002	16:30					
	7/23/2002	17:41					
	7/23/2002	18:52					
HHT2	7/23/2002	14:55	196.60	104.58	0.0757	9.7	
	7/23/2002	16:44	12.55	12.55	0.0472		
	7/23/2002	17:52	12.55	25.10	0.0493		
	7/23/2002	19:03	37.66				
HHPS054	7/23/2002					0.0	No flow
HHPS057	7/23/2002					0.0	No flow
HHPS015	10/16/2002	10:00	0.59	5.29	0.0660	10.8	Assumes flow at 1000 was the same as the flow measured at 1135.
	10/16/2002	11:35	9.98	20.06	0.0764		
	10/16/2002	13:25	30.15	73.21	0.0694		

Station	Date	Time	Instantaneous Loading Rate (bill org/day)	Interval Loading Rate (bill org/day)	Interval Duration (d)	Total Load (bill org)	Comments
	10/16/2002	15:05	116.27	92.39	0.0417		
	10/16/2002	16:05	68.51				
HHPS016	10/16/2002	10:15	2.15	8.61	0.0611	138.4	Assumes flow at 1015 was the same as the flow measured at 1143.
	10/16/2002	11:43	15.07	310.99	0.0743		
	10/16/2002	13:30	606.92	887.18	0.0764		
	10/16/2002	15:20	1167.44	1352.41	0.0347		
	10/16/2002	16:10	1537.38				
HHPS055	10/16/2002	10:30	0.27	1.88	0.0833	5.0	Assumes flow at 1030 and 1351 was the same as the flow measured at 1230.
	10/16/2002	12:30	3.50	5.52	0.0562		
	10/16/2002	13:51	7.54	29.07	0.0674		
	10/16/2002	15:28	50.60	57.60	0.0444		
	10/16/2002	16:32	64.60				
HHPS056	10/16/2002						HHPS056 should be the same as for HHPS055. Use loading estimate for HHPS055. Concentrations are the same for the two sites. These are not unique sources so they should be grouped.
HHPS057	10/16/2002					0.0	This pipe did not flow.
HHPS061	10/16/2002					0.0	This pipe did not flow.
HHPS062	10/16/2002	10:47	60.29	38.54	0.0819	4.1	Assumes flow at 1047 was the same as the flow measured at 1245.
	10/16/2002	12:45	16.79	8.39	0.0590		
	10/16/2002	14:10	0.00	2.48	0.0625		
	10/16/2002	15:40	4.97	5.81	0.0465		
	10/16/2002	16:47	6.66				
HHPS066	10/16/2002	10:20	11.74	41.11	0.0347	67.0	Assumes flow at 1020 was the same as the flow measured at 1110.
	10/16/2002	11:10	70.47	153.03	0.0278		
	10/16/2002	11:50	235.58	306.20	0.0729		
	10/16/2002	13:35	376.81	411.07	0.0313		
	10/16/2002	14:20	445.33	358.94	0.0347		
	10/16/2002	15:10	272.55	235.33	0.0382		
	10/16/2002	16:05	198.10	168.76	0.0278		
	10/16/2002	16:45	139.42				
HHPS067	10/16/2002	10:20	0.00	0.00	0.0000	10.0	Assigned load value of zero for 10:20 and 11:10 because pipe did not start to flow until 1200.
	10/16/2002	11:10	0.00	12.23	0.5000		
	10/16/2002	12:00	24.47	22.14	0.0694		
	10/16/2002	13:40	19.82	22.54	0.0243		

Station	Date	Time	Instantaneous Loading Rate (bill org/day)	Interval Loading Rate (bill org/day)	Interval Duration (d)	Total Load (bill org)	Comments
	10/16/2002	14:15	25.25	22.30	0.0417		
	10/16/2002	15:15	19.35	16.38	0.0313		
	10/16/2002	16:00	13.41	11.48	0.0347		
	10/16/2002	16:50	9.54				
HHPS068	10/16/2002	10:12	62.39	88.39	0.0333	24.0	Assumes flow at 1012 was the same as the flow measured at 1100.
	10/16/2002	11:00	114.39	81.69	0.0299		
	10/16/2002	11:43	48.99	32.29	0.0708		
	10/16/2002	13:25	15.59	19.72	0.0278		
	10/16/2002	14:05	23.86	114.35	0.0417		
	10/16/2002	15:05	204.85	190.81	0.0313		
	10/16/2002	15:50	176.76	162.89	0.0313		
	10/16/2002	16:35	149.01				
HHPS069	10/16/2002	10:15	73.16	73.16	0.0243	98.2	Assumes flow at 1015 was the same as the flow measured at 1050.
	10/16/2002	10:50	73.16	61.42	0.0313		
	10/16/2002	11:35	49.67	218.26	0.0729		
	10/16/2002	13:20	386.85	411.63	0.0278		
	10/16/2002	14:00	436.42	680.81	0.0417		
	10/16/2002	15:00	925.20	701.61	0.0313		
	10/16/2002	15:45	478.02	538.01	0.0313		
	10/16/2002	16:30	598.01				
HHPS070	10/16/2002	10:53	0.00	18.57	0.0826	14.7	
	10/16/2002	12:52	37.14	76.71	0.0556		
	10/16/2002	14:12	116.27	91.41	0.0507		
	10/16/2002	15:25	66.55	76.10	0.0563		
	10/16/2002	16:46	85.64				
HHPS071	10/16/2002	10:15	0.26	10.37	0.0521	4.7	Assumes flow at 1015 was the same as the flow measured at 1130.
	10/16/2002	11:30	20.48	17.09	0.0625		
	10/16/2002	13:00	13.70	25.15	0.0625		
	10/16/2002	14:30	36.60	23.95	0.0625		
	10/16/2002	16:00	11.30				
HHPS072	10/16/2002	10:23	0.00	1.03	0.4826	7.7	Assumes flow at 1135 was the same as the flow measured at 1305 and assigns a load value of zero for 1023 because pipe was reported as "dry".
	10/16/2002	11:35	2.06	4.37	0.0660		
	10/16/2002	13:05	6.68	44.69	0.0590		
	10/16/2002	14:35	82.70	68.93	0.0625		

Station	Date	Time	Instantaneous Loading Rate (bill org/day)	Interval Loading Rate (bill org/day)	Interval Duration (d)	Total Load (bill org)	Comments
	10/16/2002	16:05	55.15				
HHPS182	10/16/2002	10:30				245.7	Based on total estimated discharge during the storm (887,250 gal) and average measured concentration (8,600 cfu/100ml).
	10/16/2002	11:45					
	10/16/2002	13:15					
	10/16/2002	14:41					
	10/16/2002	16:08					
HHT2	10/16/2002	9:48	112.51	115.97	0.0896	25.6	Assumes flow at 0948 is equal to the highest measured flow because the stage was outside the calibration range.
	10/16/2002	11:57	119.44	103.83	0.0604		
	10/16/2002	13:24	88.22	67.36	0.0611		
	10/16/2002	14:52	46.51	79.81	0.0604		
	10/16/2002	16:19	113.10				
HHPS073	10/16/2002					0.0	No flow
HHPS054	10/16/2002					0.0	No flow